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HumeLink

Hydrology and Flooding Impact Assessment Addendum
Technical Report 11

HumeLink

Technical Report 11 - Hydrology and Flooding Impact Assessment Addendum

Transgrid

Reference: Project number

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Executive Summary

Transgrid proposes to increase the energy network capacity in southern New South Wales (NSW) though the development of around 365 kilometres (km) 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 involve construction of a new substation east of Wagga Wagga as well as connections 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).

An Environmental Impact Statement (EIS) was prepared in accordance with the requirements of Division 5.2 of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act). The EIS was placed on public exhibition by the NSW Department of Planning, Housing and Infrastructure (DPHI) (formerly the NSW Department of Planning and the Environment (DPE)) for a period of 42 days, between 30 August 2023 and 10 October 2023.

Transgrid has proposed amendments and refinements to the project as described in the EIS. This report has been prepared to assess the potential hydrology and flooding impacts associated with the amended project. This assessment adheres to the methodology used in *Technical Report 11 – Hydrology and Flooding Impact Assessment* prepared for the EIS.

Local and regional flood assessments were conducted for the amendments and refinements to the project and are included in this report. An initial desktop assessment based on local topography identified that Amended Honeysuckle Road compound (C07), Snubba Road Compound (C18), and Green Hills Road accommodation facility and compound (AC07) are located on high ground with no regional or local flood risk. Based on the initial desktop assessment, it is understood that the amendment to the footprint for Amended Memorial Avenue compound (C14) is minor without affecting the flood condition and therefore this compound was not considered for further local and regional flood investigation.

Due to their proximity to waterways and a potential upstream catchment, further investigations were undertaken at the Amended Gregadoo Road compound (C06), Amended Bannaby 500 kV substation compound (C12), Ardrossan Headquarters Road compound (C17), Gadara Road compound (C19), Ellerslie Road compound (C21), Tarcutta accommodation facility and compound (AC03), Adjungbilly accommodation facility and compound (AC04), Yass accommodation facility and compound (AC05) and Crookwell accommodation facility and compound (AC06).

In accordance with the methodology adopted in *Technical Report 11 – Hydrology and Flooding Impact Assessment* prepared for the EIS, construction compounds were assessed for 5% annual exceedance probability (AEP) and combined worker accommodation facilities and construction compounds were assessed for 2% AEP. Flood modelling identified that Gadara Road compound (C19), Adjungbilly accommodation facility and compound (AC05) and Crookwell accommodation facility and compound (AC06) would be most impacted by local flooding as there is local overland flooding through these sites. However, all construction compounds and combined worker accommodation facilities and construction compounds that have been considered for flood modelling show a potential to cause flood impacts in their respective flood events to some degree. In addition, local drainage would also require management through a site drainage and stormwater management plan. Refer to Chapter 7 (Management of impacts) for further detail on mitigation measures.

To assess flood risks during operation of the amended project, major waterway intersections within the amended transmission line corridor were identified using stream order analysis and modelled with a higher resolution to ensure accurate assessment. The assessment identified locations within the amended project footprint that would be impacted by the 1% AEP flood with high hazard. All new intersections with the amended transmission line corridor were considered to have minor flood risk with flooding contained with the waterway valleys.

Most waterways within the amended project footprint are minor streams. The proposed access tracks do not have flood immunity requirements which enable them to be developed at grade. Access tracks that are constructed at grade minimise their obstruction to flow and consequently minimises the potential for impacts on flood levels. This approach minimises the resulting influence on flooding, which would otherwise materialise if tracks were constructed to have flood immunity. The overall outcome of the impact assessment conducted for the amended project aligns with the conclusions presented in *Technical Report 11 – Hydrology and Flooding Impact Assessment* prepared for the EIS.

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Abbreviations

Abbreviation	Description
AEMO	Australian Energy Market Operator
AEP	annual exceedance probability
ARR	Australian Rainfall and Runoff
CEMP	Construction Environmental Management Plan
CSSI	Critical State Significant Infrastructure
DPHI	NSW Department of Planning, Housing and Infrastructure
EIS	Environmental Impact Statement
EP&A Act	*Environmental Planning and Assessment Act 1979*
km	kilometres
km^2	square kilometres
kV	kilovolt
LGA	Local Government Area
LiDAR	light detection and ranging
m	metres
m^3	cubic metres
mAHD	metres above the Australian Height Datum
NSW	New South Wales
PMF	probable maximum flood
SEARs	Planning Secretary's Environmental Assessment Requirements

Glossary of terms

Term	Description
access routes	Roads providing the access to and from the project footprint.
amended project (the)	The CSSI project "HumeLink", which is the subject of the Amendment Report and inclusive of the proposed amendments and project refinements to the project as described in the EIS. The project involves the construction and operation of high voltage transmission lines and associated infrastructure between Wagga Wagga, Bannaby and Maragle.
amended project footprint (the)	The area that has been assumed for the purpose of the Amendment Report 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.
amendment	A change in what the proponent is seeking approval for following the public exhibition of the EIS. It requires changes to the project description in the EIS and amendments to the associated infrastructure application.
afflux	Change in flood level between two scenarios.
annual exceedance probability	The annual exceedance probability (AEP) is the probability of an event occurring in any given year, ie. a one per cent (1%) AEP means there is a 1% chance in any given year of the event occurring.
Bannaby 500 kV substation	The existing 500 kV substation at Bannaby
brake and winch sites	A brake and winch site is a temporarily cleared area where plant and equipment are located to spool and winch conductors into place on transmission line structures. The locations of the brake and winch sites may or may not be within the nominated transmission line easement. These sites are only required for construction of the project and do not need to be maintained during operation.
construction compounds	Main construction compounds proposed for construction of the project. Each main construction compound would accommodate a range of facilities which may include (but not limited to): ■ laydown areas ■ site offices ■ amenities ■ construction support facilities such as vehicle and equipment storage, maintenance sheds, chemical/fuel stores and stockpile areas ■ concrete batching plants ■ helipads ■ crushing/screening plants ■ parking.
Critical State Significant Infrastructure	Critical State Significant Infrastructure (CSSI) projects are high priority infrastructure projects that are essential to the State for economic, social or environmental reasons.
EIS project (the)	The CSSI project "HumeLink", which was the subject of the Environmental Impact Statement. The project involves the construction and operation of high voltage transmission lines and associated infrastructure between Wagga Wagga, Bannaby and Maragle.
EIS project footprint (the)	The area that was assumed for the purpose of the 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.
flood immunity	Not affected by flooding for a specified flood event.
floodplain	Land that is subject to flooding up to the Probable Maximum Flood (PMF), which is the maximum possible flood that would reasonably be expected to ever occur.
future Maragle 500 kV substation	The future Maragle 500/330 kV substation that would be built under the approved Snowy 2.0 Transmission Connection Project, which is subject to a separate planning approval (reference SS1-9717, EPBC 2018/836).

Term	Description
Hack's stream order	The Hack's stream order classification is a 'down top' system in which streams of the first order have upgradient streams flowing into them. The main stream of every catchment is set to 1, and consequently all its tributaries receive order 2. Their tributaries receive order 3 etc. The order of every stream remains constant up to its initial link. The route of every main stream is determined according to the maximum flow length value of particular streams. So, the main stream of every sub catchment is the longest stream or stream with highest accumulation rate if accumulation map is used. (Jasiewicz, J., n.d.)
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.
hydrology and flooding study area	The hydrology and flooding study area encompasses the project footprint and the three main hydrological catchments intersected by the project footprint. These are the Murrumbidgee River, Lachlan River and the Wollondilly River catchments and all waterways within these catchments.
HumeLink	The project
landowners	People who own properties/land
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.
major crossings	Access tracks crossing watercourses classified as Strahler stream order 6
major stream	Flooding is mostly out of bank and more than 250 m in extent. Topography is generally flat. More challenging to manage flood impact in comparison to other identified 'minor' and 'moderate' flooding. 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
minor crossings	Access tracks crossing watercourses classified as Strahler stream order 4 or lower
minor stream	Flooding appears confined along the gully formation. Topography is generally steep with low risk to the project, manageable through design development
moderate crossings	Access tracks crossing watercourses classified as Strahler stream order 5
moderate stream	Flooding is mostly out of bank and less than 250 min extent. Topography is generally flat. Consideration of the impact on the amended project where proposed infrastructure is sensitive to being flooded
proponent	The entity seeking approval for the CSSI application, which for the HumeLink project is NSW Electricity Networks Operations Pty Ltd (referred to as Transgrid).
proposed Gugaa 500 kV substation	The new 500/330 kV substation proposed near Wagga Wagga.
refinement	Refinements to the project are defined as aspects of the project that generally fit within the limits set by the project description in the EIS. Refinements do not change what is being sought for approval or require an amendment to the infrastructure application for the project.
Strahler stream order	Strahler stream order classification is a 'top down' system in which streams of the first order have no upgradient streams flowing into them (DPE 2022). If two streams of the same order merge, the resulting stream is given a number that is one higher. If two rivers with different stream orders merge, the resulting stream is given the higher of the two numbers. Under the Strahler stream order classification, first to third order streams are typically headwater streams. Streams classified as fourth through sixth order are medium streams, and streams that are seventh order or larger are typically rivers.
substation bench	The switchyard within a substation needs to be accessible under most circumstances to allow fault response and access for operational and maintenance reasons. To assist with this requirement, the switchyard is located on a bench to provide a stable, dry weather trafficable and free-draining structure and provide a safe platform for workers, vehicles, cranes and trucks in order to facilitate the maintenance and operation of the switchyard for the duration of its operational life.
telecommunications hut	The proposed optical repeater telecommunications hut as part of HumeLink, which was required in the EIS project to boost the signal in the optical fibre ground wire.

Term	Description
Transgrid	The project is proposed to be undertaken by NSW Electricity Networks Operations Pty Ltd (referred to as Transgrid). Transgrid is the operator and manager of the main high voltage transmission network in NSW and the ACT and is the Authorised Network Operator for the purpose of an electricity transmission or distribution network under the provisions of the *Electricity Network Assets (Authorised Transactions) Act 2015*.
transmission line corridor	An area generally 200 metres wide that the transmission line route and easement would be located within
transmission line easement	A legal right attached to a parcel of land that enables the non-exclusive use of the land by a third party other than the owner. For transmission lines, an easement defines the corridor area where the lines are located and that allows access, construction and maintenance work to take place. The easements for the 500 kV transmission lines would typically be 70 metres wide. However, a few select locations would require wider easements up to 130 metres wide for specific engineering or property reasons. The easement grants a right of access and for construction, maintenance and operation of the transmission line and other operational assets.
transmission line route	The location of the transmission line structures along the middle of the transmission line easement.
transmission line structures	Proposed free standing structures to support the transmission lines.
transmission line corridor	An area generally 200 metres wide that the transmission line route and easement would be located within
TUFLOW	One and two-dimensional hydrodynamic modelling software
Wagga 330 kV substation	The existing 330/132 kV substation located in Wagga Wagga
waterway crossing	A crossing over water established for access
worker accommodation facilities	Temporary worker accommodation facilities that would be established for the construction workers.

1 Introduction

1.1 Background

Transgrid proposes to increase the energy network capacity in southern New South Wales (NSW) through the development of around 365 kilometres (km) 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 six Local Government Areas (LGAs) including Wagga Wagga City, Snowy Valleys, Cootamundra-Gundagai Regional, Upper Lachlan Shire, Yass Valley and Goulburn Mulwaree. HumeLink is a priority project for the Australian Energy Market Operator (AEMO) and the Commonwealth and NSW governments and has been declared as Critical State Significant Infrastructure (CSSI). 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.

An EIS was prepared in accordance with the requirements of Division 5.2 of the *NSW Environmental Planning and Assessment Act 1979* (EP&A Act). The EIS was placed on public exhibition by the NSW Department of Planning, Housing and Infrastructure (DPHI) (formerly the NSW Department of Planning and Environment (DPE)) for a period of 42 days, between 30 August 2023 and 10 October 2023.

Transgrid has proposed amendments and refinements to the project as described in the EIS. The amendments provide functional improvements to the design and construction methodology of the project. The proposed amendments take into account submissions received during the public exhibition of the EIS and ongoing design and construction methodology development following the selection of the construction contractors. Project refinements have also been made as part of the ongoing design and construction methodology development since the EIS was exhibited. These amendments and refinements have been described and considered in relevant impact assessments.

1.2 Key features of the project (as publicly exhibited)

The key components of the project as outlined and assessed in the EIS included:

- 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.

1.3 Overview of the proposed amendments and refinements

Since the public exhibition of the EIS, several amendments and refinements to the project have been proposed.

The proposed amendments to the project include:

- changes to the transmission line corridor, including the realignment of the route through Green Hills State Forest to the west of Batlow
- change to the number and location of construction ancillary facilities, including worker accommodation facilities and construction compounds
- nomination of access tracks to support the construction and operation of the project
- additional telecommunications connections to existing substations.

The proposed refinements to the project include:

- transmission line and substation design refinements at Gregadoo
- identification of areas where controlled blasting may be required
- use of approved water sources
- use of helicopters and drones.

Figure 1-1 shows the location of the amended project and Figure 1-2 shows the key components of the amended project.

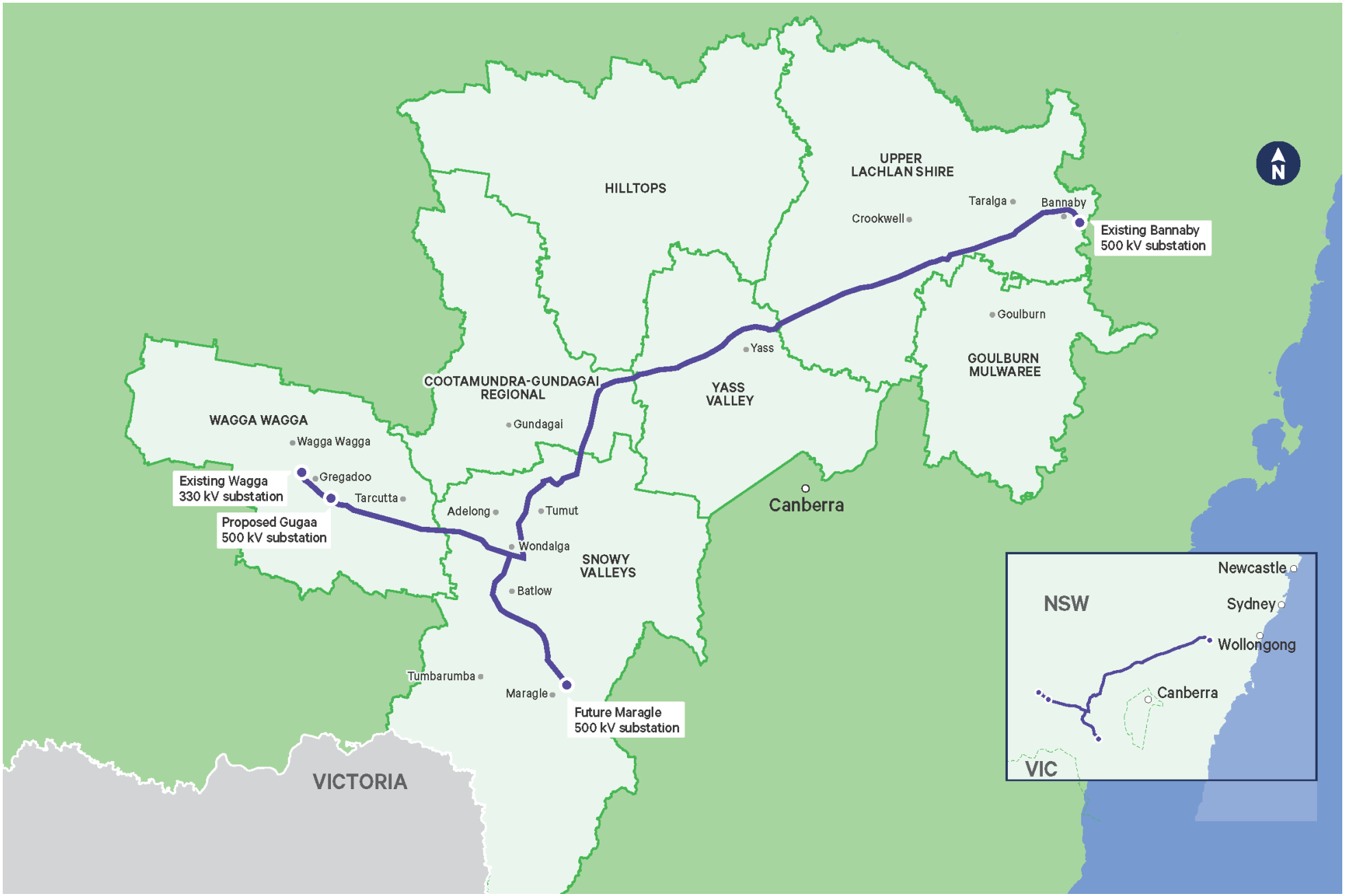
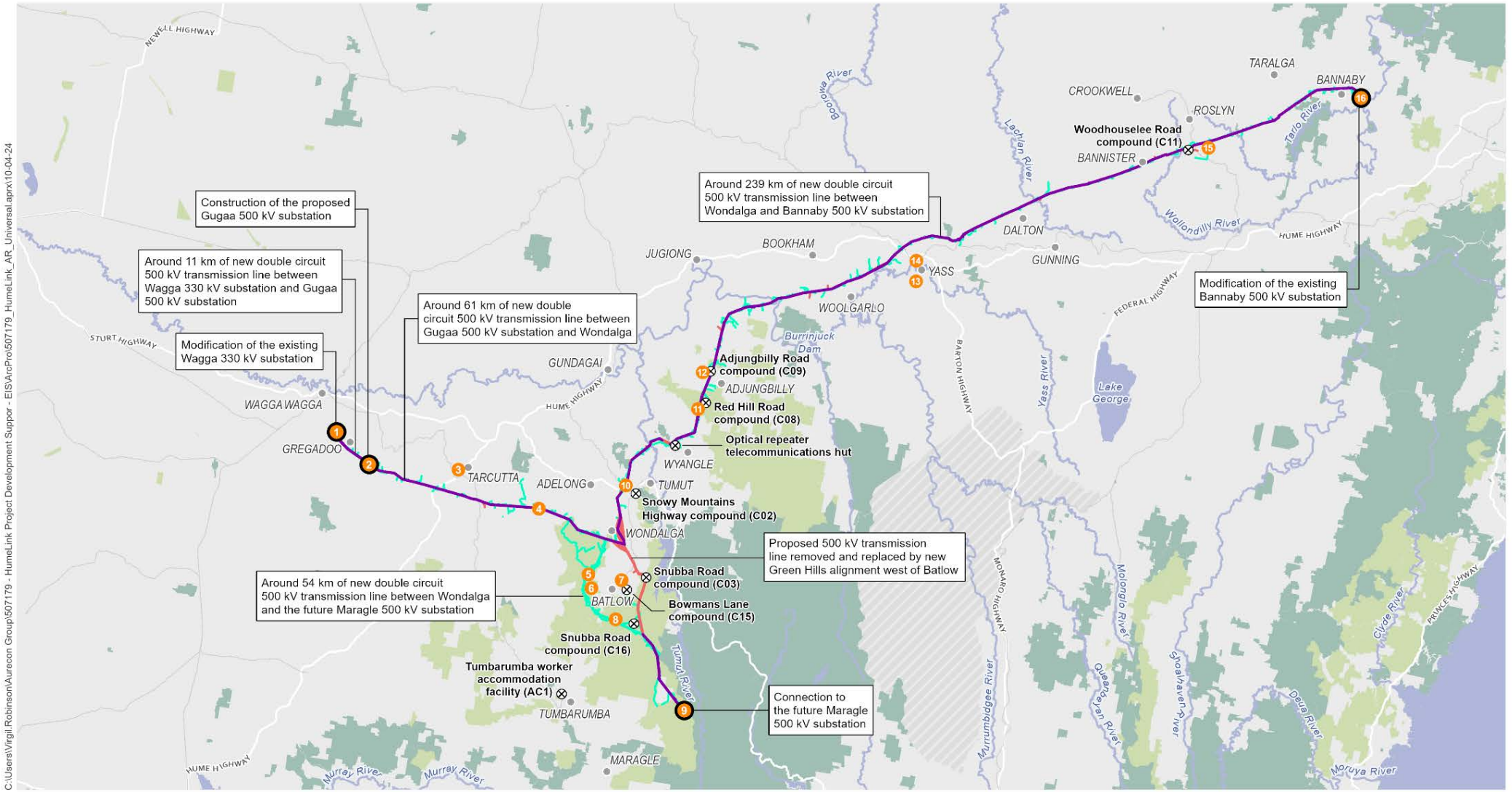


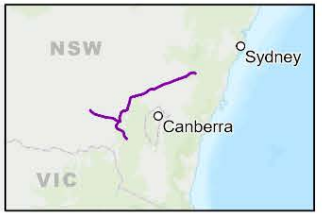
Figure 1-1 Overview of amended project location



EIS project footprint
Removed footprint
Amendments
Removed project facility
National park and reserve
State forest
Waterbody
Waterway
Major road
Railway

Construction ancillary facilities

1. Wagga 330 kV substation compound (C01)
2. Amended Gregadoo Road compound (C06)
3. Tarcutta accommodation facility and compound (AC03)
4. Ellerslie Road compound (C21)
5. Ardrossan Headquarters Road compound (C17)
6. Green Hills accommodation facility and compound (AC07)
7. Amended Memorial Avenue compound (C14)
8. Snubba Road compound (C18)
9. Maragle 500 kV substation compound (C05)
10. Gadara Road compound (C19)
11. Amended Honeysuckle Road compound (C07)
12. Adjungbilly accommodation facility and compound (AC04)
13. Yass substation compound (C10)
14. Yass accommodation facility and compound (AC05)
15. Crookwell accommodation facility and compound (AC06)
16. Amended Bannaby 500 kV substation compound (C12)



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

1:925,000
0 20 40km

Projection: GDA 1994 MGA Zone 55

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Figure 1-2: Key components of the amended project

1.4 Purpose and structure of this report

This report forms an addendum to *Technical Report 11 - Hydrology and Flooding Impact Assessment* prepared for the EIS. The purpose of this report is to support the HumeLink Amendment Report by assessing the potential impacts to hydrology and flooding associated with the proposed amendments and refinements to the project.

This report is structured as follows:

- Chapter 1 (Introduction) – provides an overview of the project, the proposed amendments and the purpose of this report.
- Chapter 2 (Summary of the proposed amendments and refinements) – provides a description of the proposed amendments and refinements relevant to this assessment.
- Chapter 3 (Legislative and policy context) – provides an outline of the key legislative requirements and policy guidelines relating to the proposed amendments to the project.
- Chapter 0 (Methodology) – provides an outline of the methodology used for the preparation of this report.
- Chapter 5 (Existing environment) – describes the existing environment with reference to the potential for impacts to hydrology and flooding.
- Chapter 6 (Assessment of impacts) – describes the potential construction and operation impacts associated with the proposed amendments and refinements of the project.
- Chapter 7 (Management of impacts) – outlines any new or revised mitigation measures for the proposed amendments to the project.
- Chapter 8 (Conclusion) – provides a conclusion of the potential impacts of the proposed amendments to the project with reference to the potential for hydrology and flooding impacts.
- Chapter 9 (References) – identifies the key information sources (including reports and documents) used to generate the assessment.

1.5 Key project terms

The key project terms used in this assessment include:

- Amended project – The CSSI project “HumeLink”, which is the subject of the Amendment Report and inclusive of the proposed amendments and project refinements to the project as described in the EIS. The project involves the construction and operation of high voltage transmission lines and associated infrastructure between Wagga Wagga, Bannaby and Maragle.
- Amended project footprint – The area that has been assumed for the purpose of the Amendment Report 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.
- EIS project – The CSSI project “HumeLink”, which was the subject of the EIS. The project involves the construction and operation of high voltage transmission lines and associated infrastructure between Wagga Wagga, Bannaby and Maragle.
- EIS project footprint – The area that was assumed for the purpose of the 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.

2 Summary of the proposed amendments and refinements

Transgrid has identified several proposed amendments and refinements to the project as described in the EIS. These amendments and refinements reflect functional improvements to the design and construction methodology of the project. They consider:

- feedback received from stakeholders prior to and during the public exhibition of the EIS
- comments made in formal submissions on the EIS
- ongoing design and construction methodology development by the construction contractors.

Amendments to the project are defined as changes in what the proponent is seeking approval for following the public exhibition of the EIS. Project amendments require changes to the project description in the EIS and amendments to the associated infrastructure application.

The proposed amendments to the project include:

- changes to the transmission line corridor including the realignment of the route through Green Hills State Forest to the west of Batlow
- changes to the number and location of construction ancillary facilities including worker accommodation facilities and construction compounds
- nomination of access tracks to support the construction and operation of the project
- additional telecommunications connections to existing substations.

Refinements to the project are defined as aspects of the project that generally fit within the limits set by the project description in the EIS. Refinements do not change what is being sought approval for or require an amendment to the infrastructure application for the project. For completeness, these refinements have been considered in this report.

The proposed refinements to the project include:

- transmission line and substation design refinements at Gregadoo
- identification of areas where controlled blasting may be required
- use of approved water sources
- use of helicopters and drones.

Table 2-1 describes the proposed amendments and refinements relevant to this technical report. A full description of the amended project is provided in Chapter 3 (Description of the amended project) of the Amendment Report. The construction contractors will continue to refine and confirm the design and construction methodology during detailed design and construction planning.

Table 2-1 Proposed amendments and refinements relevant to this assessment

Amendment / refinement	Description
Amendments	
Changes to the transmission line corridor	The amended project includes the preferred western route through Green Hills State Forest. The new 32.5 km route extends from Wondalga through the Green Hills State Forest before travelling to the west and south of Batlow and connecting to the EIS project transmission line corridor in Bago State Forest. In addition, the following minor changes have been made to the transmission line corridor following design considerations and feedback from landholders: ■ 1.4 km realignment of the corridor to the north between Ashfords Road to Ivydale Road, Gregadoo ■ 2.5 km realignment of the corridor to the south across Kyeamba Creek and Tumbarumba Road, Book Book ■ 2.7 km realignment of the corridor to the east near Snowy Mountains Highway, Gadara ■ 1.4 km realignment of the corridor to the east adjacent Minjary National Park at Gocup ■ 5.9 km realignment of the corridor from north of the crossing of Tumut River to south of the crossing of Killimicat Creek, Killimicat (including a minor 50 m shift to the north for 2.1 km and a 2.6 km shift to the south from Brungle Road to before the crossing of Killimicat Creek) ■ 0.4 km realignment of the corridor to the north at Bannister, about 2.7 km west of Crookwell Road/Goulburn Road ■ narrowing of the project footprint at Wondalga, Gobarralong and Bowning.
Updates to construction ancillary facilities including worker accommodation facilities and construction compounds	**Changes to construction compounds** Following further construction planning and consultation with landowners, the following compounds described and assessed in the EIS have been removed from the project: ■ Snowy Mountains Highway compound (C02) ■ Snubba Road compound (C03) ■ Red Hill Road compound (C08) ■ Adjungbilly Road compound (C09) ■ Woodhouselee Road compound (C11) ■ Bowmans Lane compound (C15) ■ Snubba Road compound (C16). These have been replaced with the following compounds: ■ Ardrossan Headquarters Road compound (C17) – located about 7.6 km west of Batlow ■ Snubba Road compound (C18) – located about 7.7 km south of Batlow ■ Gadara Road compound (C19) – located about 4.9 km west of Tumut ■ Ellerslie Road compound (C21) – located about 13.1 km south-west of Adelong. The proposed footprint for the Gregadoo Road compound (C06), Honeysuckle Road compound (C07), Bannaby substation compound (C12) and Memorial Avenue compound (C14) have also been revised. Following these changes, there are now 11 standalone construction compounds proposed. **Changes to accommodation facilities** The Tumbarumba accommodation facility (AC01) is no longer required. The amended project includes the following new combined worker accommodation facilities and compounds: ■ Tarcutta accommodation facility and compound (AC03) – located about 1.5 km south-west of Tarcutta ■ Adjungbilly accommodation facility and compound (AC04) – located about 21.7 km east of Gundagai ■ Yass accommodation facility and compound (AC05) – located on the north-western outskirts of the Yass township ■ Crookwell accommodation facility and compound (AC06) – located off Graywood Siding Road, about 18.1 km north of Goulburn ■ Green Hills accommodation facility and compound (AC07) – located about 6.5 km west of Batlow.
Nomination of access tracks	New access tracks or upgrades to existing access tracks are proposed to connect construction areas and the transmission line easement to the existing road network. Existing unsealed local roads, forest roads, and tracks proposed for use as part of the access arrangements may also require minor improvement work, such as grading or resurfacing, or drainage work.

3 Legislative and policy context

There has been no change to the legislative and policy context presented in *Technical Report 11 - Hydrology and Flooding Impact Assessment* prepared for the EIS.

4 Methodology

4.1 Key tasks

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

- review of the proposed amendments and refinements to the project
- topological and hydrological data collection
- desktop assessment to identify the requirements for flood modelling
- hydraulic (flood) modelling
- assessment of the flood risk associated with the amendments and refinements to the project, including:
  - new and amended construction compounds and combined worker accommodation facilities and construction compounds
  - the modified layout of the proposed Gugaa 500 kV substation
  - the amended transmission line corridor
  - nominated access tracks.

Hydraulic models were developed to simulate the flood behaviour for the amended project. This included the simulation and assessment using local hydraulic models, and the regional scale model developed as part of the EIS to assess the flood risk (refer to Figure 4-1). Further details on the modelling methodology are presented in Section 4.2.

4.2 Modelling methodology

The hydraulic analysis of flood behaviour across the amended 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 flood behaviour during construction and operation where a desktop assessment was not suitable.

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

The amended project elements assessed at each scale are as follows:

- **regional model**: amended transmission line corridor
- **local model**: amended / new construction compounds and combined worker accommodation facilities and construction compounds.

Note:

- The proposed Gugaa 500 kV substation has been assessed in a separate flood assessment report (Lyall & Associates, 2023) (refer to Attachment G).
- The Amended Memorial Avenue compound (C14) was not modelled due to the small-scale nature of the proposed amendments at the site. The impacts would be consistent with the findings detailed in *Technical Report 11 - Hydrology and Flooding Impact Assessment* prepared for the EIS.
- Further detail on the model development methodology, parameters and assumptions for the amended project are provided in prepared for the EIS with specific updates relevant to the amended project presented in Attachment A of this report.

4.2.1 Regional model

The regional hydraulic model developed for the Murrumbidgee catchment as part of the EIS project was used to assess the new 32.5 kilometre corridor from Wondalga through the Green Hills State Forest. The regional model assists in understanding the extent and characteristics of regional scale flooding through this area. Details of the model development can be found in *Technical Report 11 – Hydrology and Flooding Impact Assessment* prepared for the EIS.

The regional flood impact assessment was limited to the extent of the amended transmission line corridor and not its respective design elements. As such, 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.

4.2.2 Local model

The local hydraulic models were created to understand the flood extent and characteristics for the revised and new construction compounds and the new combined worker accommodation facilities and construction compounds. The flood data for the proposed Gugaa 500 kV substation and the nearby Amended Gregadoo Road compound (C06) was informed by a separate flood assessment report prepared by Lyall & Associates (refer to Attachment G).

Flood modelling was undertaken only for new and amended construction compounds and combined worker accommodation facilities and construction compounds with the potential to experience overland flooding as per the initial desktop assessment. The initial desktop assessment was undertaken based on the local topography and existence of a waterway near the construction compound or combined worker accommodation facility and construction compound, and these factors determined whether flood modelling was required for the respective local catchments.

Based on the above assessment, new local models were developed or existing EIS models were re-run for new compounds and amended compounds respectively. These were developed to assess the impact of the construction compounds, proposed Gugaa 500 kV substation, and the combined worker accommodation facilities and construction compounds. The local models provide greater definition of flood behaviour at a localised catchment scale.

Due to limited civil design data and flood complexity, no earthwork filling of the amended and new construction compound and combined accommodation facilities and construction compound footprints was modelled. Modelling to determine more specific impact extents and magnitudes will be assessed during further detailed design, which will allow more site-specific layouts and flood management measures to be investigated.

The local models identify the characteristics of overland flow at the local catchment scale. Based on the characteristics of the overland flow, it can be classified as either 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 extend beyond the immediate area.

4.2.3 Stream classification methodology

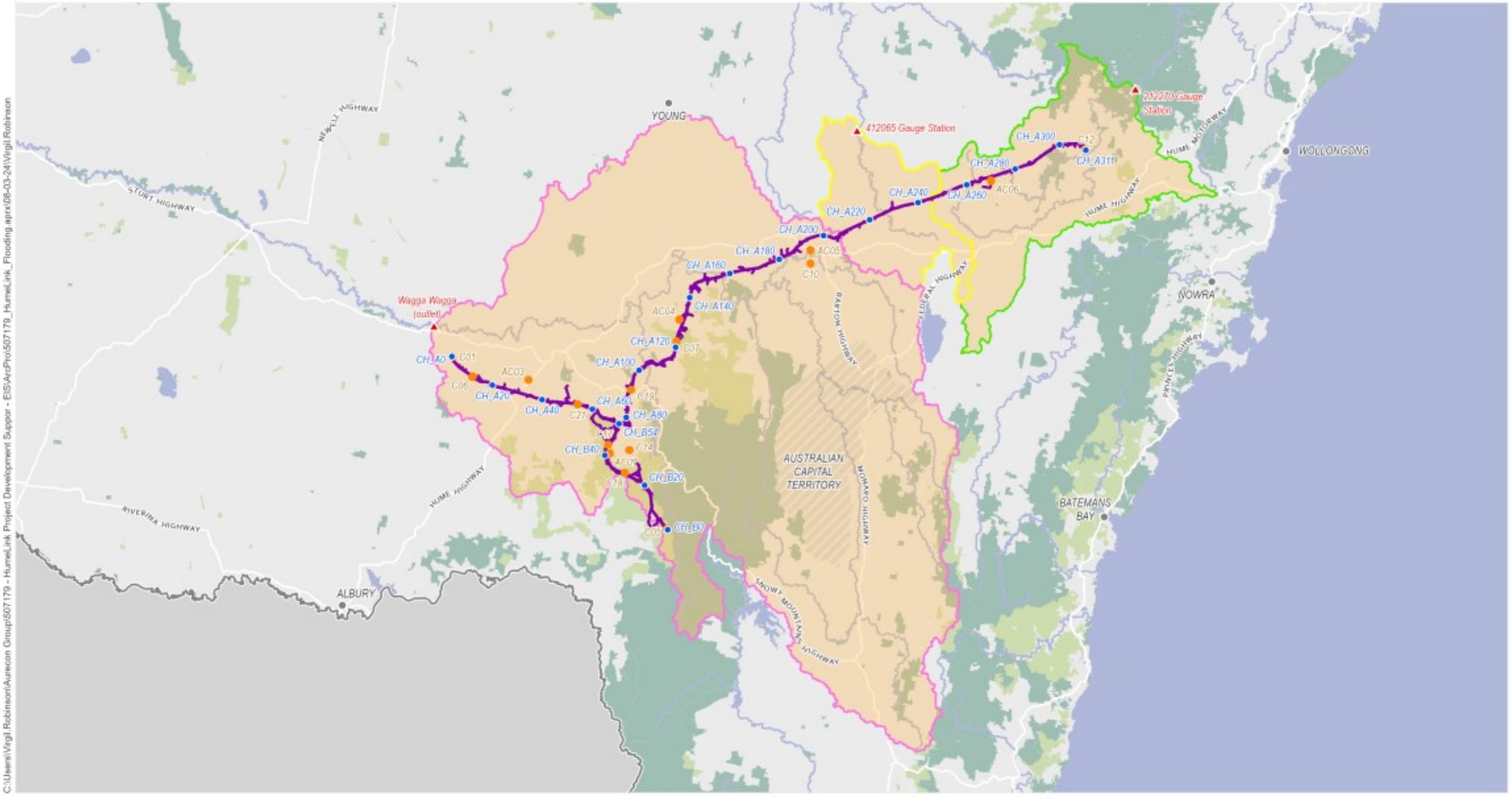
The Hack and Strahler stream order methodologies were adopted for the stream classification for the amended project. A subjective approach for the selection of stream order classification was applied based on the advantages and disadvantages of the stream order classification method and its suitability for the assessment component.

- The biggest advantage of the Hack stream order methodology is the ability to compare and analyse the topology upstream, according to the main streams, which is crucial when identifying the major flood risk from the entire Murrumbidgee catchment. Therefore, the Hack stream order methodology was used for assessing the impacts of flooding during operation for the amended project.

- The biggest limitation of the Hack stream order methodology is with the comparison of sub-catchment topography of the same order. Sub-catchments of the same order may be both highly branched and widespread in the catchment area or small with only one stream. This posed a limitation to effectively classifying the nominated access track crossings in their respective categories based on a desktop assessment. This limitation was overcome with the use of the Strahler stream order classification for the hydrology assessment of access tracks.
- A desktop assessment was conducted to identify the number of new access track crossings and the corresponding waterway stream order. Waterway stream order was determined using the 2017 NSW Hydro-lines spatial data. The access tracks were then grouped into the following categories 'major crossings", "moderate crossings", and "minor crossings" to facilitate the assessment of flood risk. Outcomes for this assessment are summarised in Section 6.2.1.2.
- Flood modelling for the 1% annual exceedance probability (AEP) was conducted to understand the flood risk to the transmission line structures and nominated access tracks for the amended project. The Hack stream order methodology was then used to classify the related watercourses of the Murrumbidgee catchment into "major streams", "moderate streams" and "minor streams" based on the 1% AEP flood extent. For locations where the 1% AEP flood extent of a major watercourse inundated the amended project footprint, these locations were further assessed for flood risk using results with higher resolution. A summary of these results is discussed in Section 6.2.2.2.

4.3 Study area

Figure 4-1 shows the flooding and hydrology study area along the amended project footprint. Refer to Chapter 5 for additional detail on the existing environment and topographic characteristics for the flooding and hydrology study area.



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

1:1,500,000

0 30 60km

Projection: GDA 1994 MGA Zone 55

HumeLink **Hydrology and Flooding**

FIGURE 4-1: Study area and primary catchment extents

4.4 Criteria adopted

The adopted flood immunity criteria are consistent with those used in *Technical Report 11 – Hydrology and Flooding Impact Assessment* prepared for the EIS, which are:

- transmission line structures – 1% AEP (1 in 100) event
- construction compounds – 5% AEP (1 in 20) event
- combined worker accommodation facilities and construction compounds – 2% AEP (1 in 50) event
- substation benches – 1% AEP (1 in 100) event.

4.5 Limitations and uncertainty

The assessment methodology does have several limitations and a level of uncertainty. These limitations and uncertainties are consistent with flood modelling in the industry. The identified limitations and areas of uncertainty include the following:

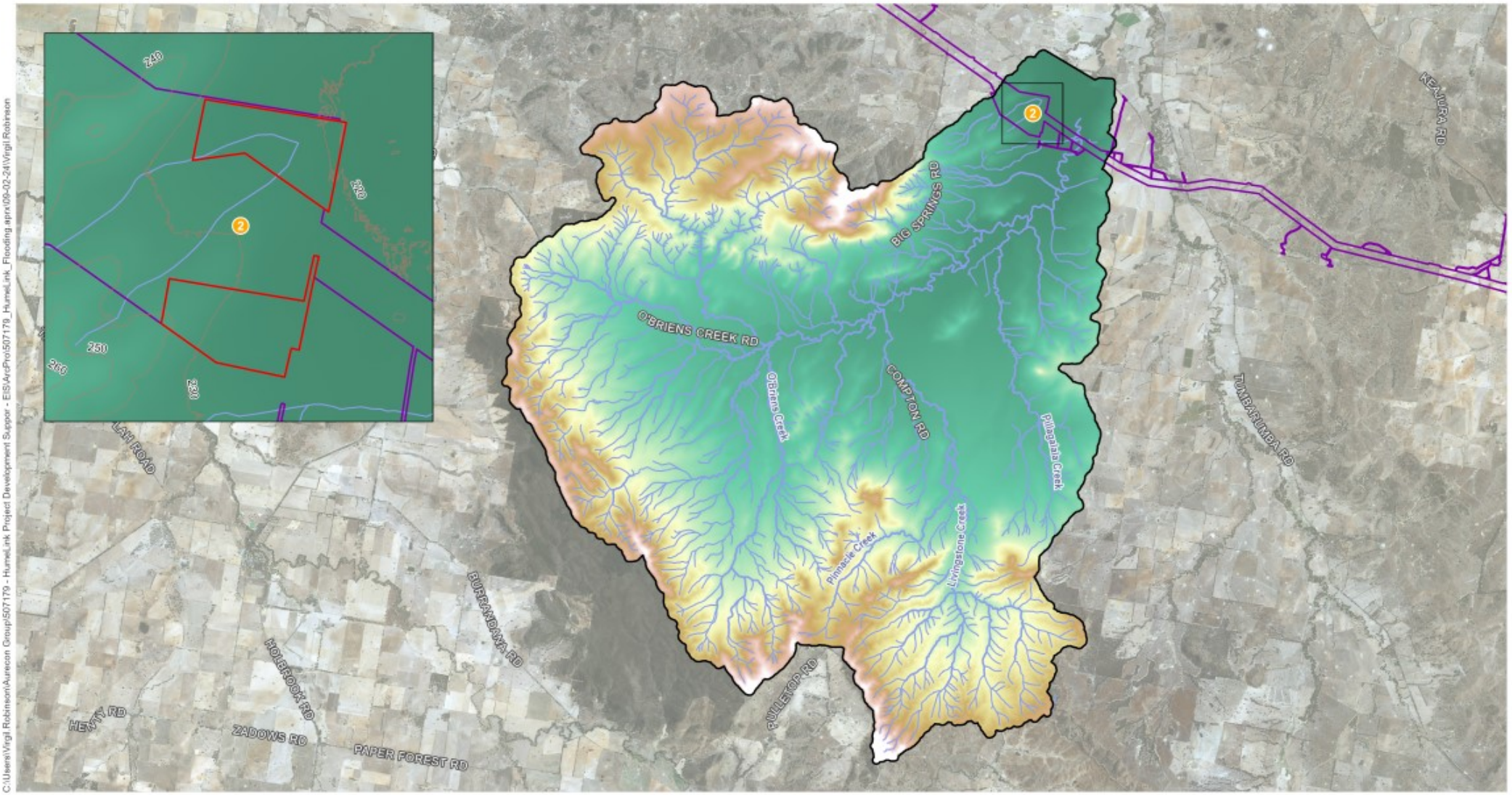
- The accuracy of the flood risk information is commensurate with the accuracy of the input data. This includes the underlying light detection and ranging (LiDAR) data and uncertainties associated with design rainfall estimations.
- The regional model topography was based on Shuttle Radar Topographic Mission data and is limited to the resolution and accuracy of this dataset. Where the regional model has been refined at key locations along the project, freely available LiDAR data has been used. No detailed survey data for the amended project footprint has been represented.
- A sampling distance of 50 metres (m) has been adopted in the modelling. This will likely limit the representation of smaller hydraulic features such as small channels and hydraulic controls. From a regional flooding context, these features are not considered critical. Review of the definition of the smaller hydraulic features should be undertaken during the detailed design stage should the modelling be further refined.
- Structures such as bridges, road embankments or culverts have not been explicitly represented due to limited structure data availability across the amended study area. Where the representation of drainage structures is required, engineering judgment has been adopted for the determination of the structure size.
- The access tracks have been assumed to be at grade and have not been explicitly modelled due to the scale and definition compared to the regional model. Should the access roads require earthworks, the resultant impact on flooding would be considered negligible given the remote location of the access roads with no adjacent development, and their width. However, appropriate local drainage design would be required to manage any local flood impacts on the access road infrastructure.
- Hydraulic modelling assumes catchment development conditions at the time of the study and is based on latest freely available aerial imagery.
- All results presented are subject to the limitations of the modelling packages and current best practice methods adopted and applied. It is acknowledged that these methods may change over time.
- The flood impact management measures in Chapter 7 are based on the flood behaviour observed in this assessment and apply to the project amendments and refinements only. Any changes to the flood behaviour or new locations being impacted by flooding in future studies will require further assessment.

5 Existing environment

This section outlines the existing environment, topographic characteristics and the catchment areas for the amended construction compounds, new combined worker accommodation facilities and construction compounds and the proposed Gugaa 500 kV substation.

5.1 Amended Gregadoo Road compound (C06)

The Amended Gregadoo Road compound (C06) is located approximately 900 metres to the east of O'Briens Creek which flows in a south-north direction. The construction compound is adjacent to Livingstone Gully Road and abuts the proposed Gugaa 500 kV substation along the north, east and south. The catchment area for the Amended Gregadoo Road compound (C06) is shown in Figure 5-1 and is estimated to be approximately 211 square kilometres.



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

1:102,500

0 2 4km

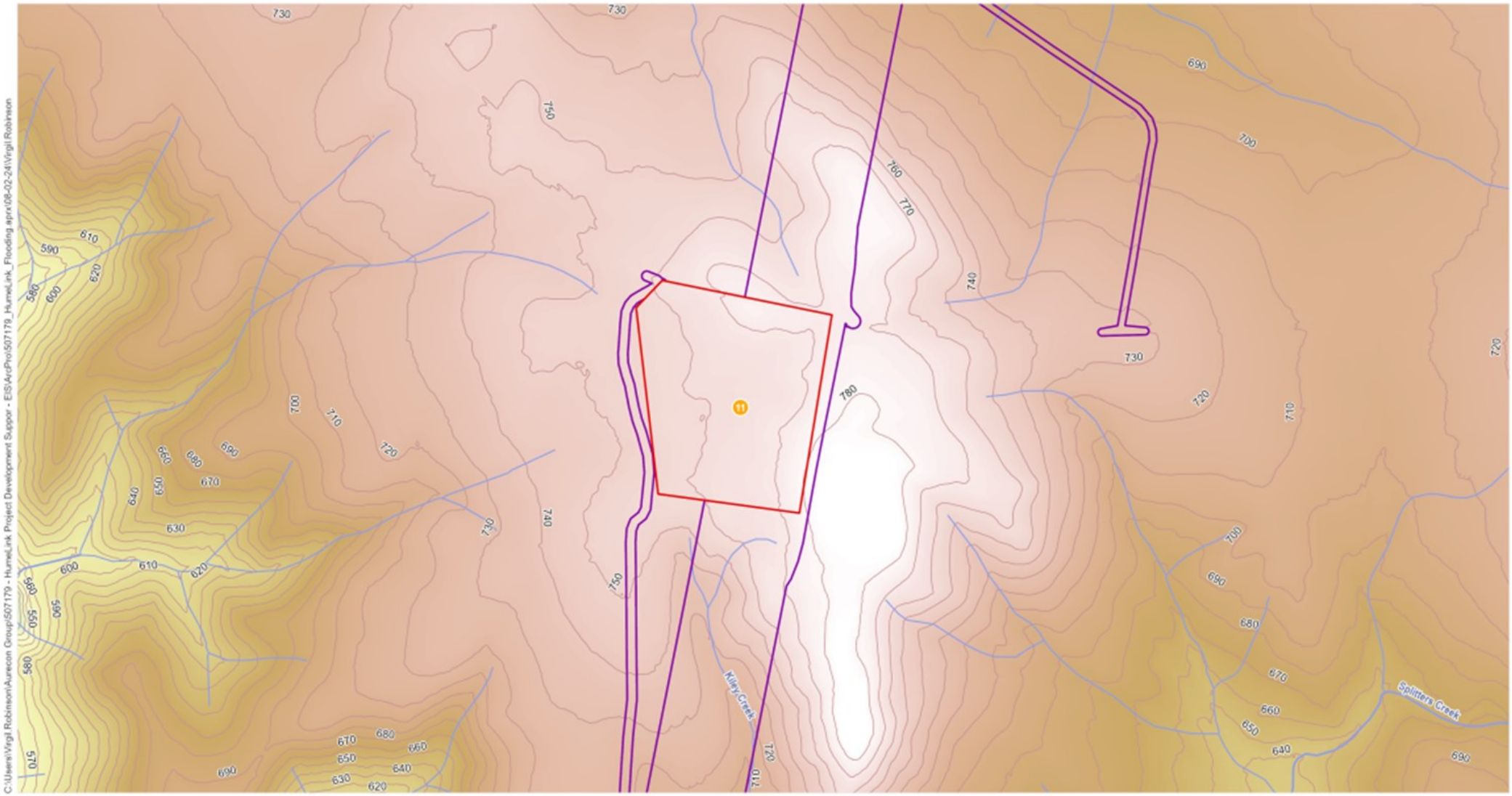
Projection: GDA 1994 MGA Zone 55

HumeLink **Hydrology and Flooding**

FIGURE 5-1: Local catchment for the Amended Gregadoo Road compound (C06)

5.2 Amended Honeysuckle Road compound (C07)

The Amended Honeysuckle Road compound (C07) is located within the Red Hill State Forest. The site is situated south of Honeysuckle Road and to the east of Kileys Creek Road. The construction compound is located near a topographic ridge at an approximate elevation of 755 to 780 metres above the Australian Height Datum (mAHD). Figure 5-2 depicts the Amended Honeysuckle Road compound (C07) footprint overlaid on the local topography.

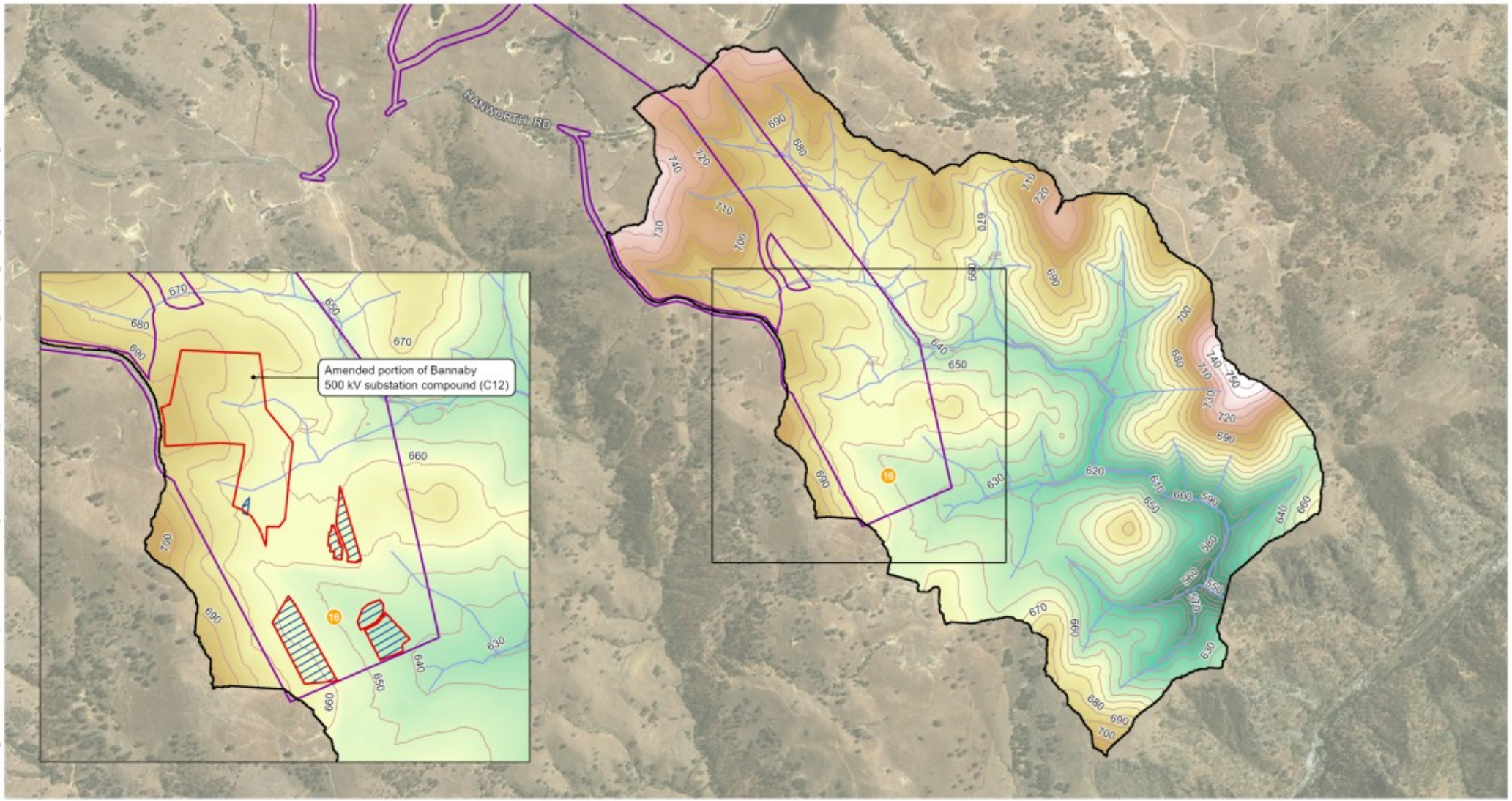


HumeLink **Hydrology and Flooding**

FIGURE 5-2: Local Topography and layout for the Amended Honeysuckle Road compound (C07)

5.3 Amended Bannaby 500 kV substation compound (C12)

The Amended Bannaby 500 kV substation compound (C12) is located around the existing Bannaby substation. Topographically the construction compound is located to the south-west of a local creek which has its confluence with the Wollondilly River approximately 3.5 kilometres downstream of the site (in a south-easterly direction). The catchment area for the Amended Bannaby 500 kV substation compound (C12) is shown in Figure 5-3 and is estimated to be approximately 3.6 square kilometres.



Amended project footprint
Construction compound
Construction compound (EIS)
Surface level contour
(10m AHD interval)
Waterway

LiDAR Topography (mAHD)

766
523

Construction ancillary facilities

16 Amended Bannaby 500 kV substation compound (C12)

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

1:15,000
0 350 700m

Projection: GDA 1994 MGA Zone 55

HumeLink **Hydrology and Flooding**

FIGURE 5-3: Local catchment for the Amended Bannaby 500kV substation compound (C12)

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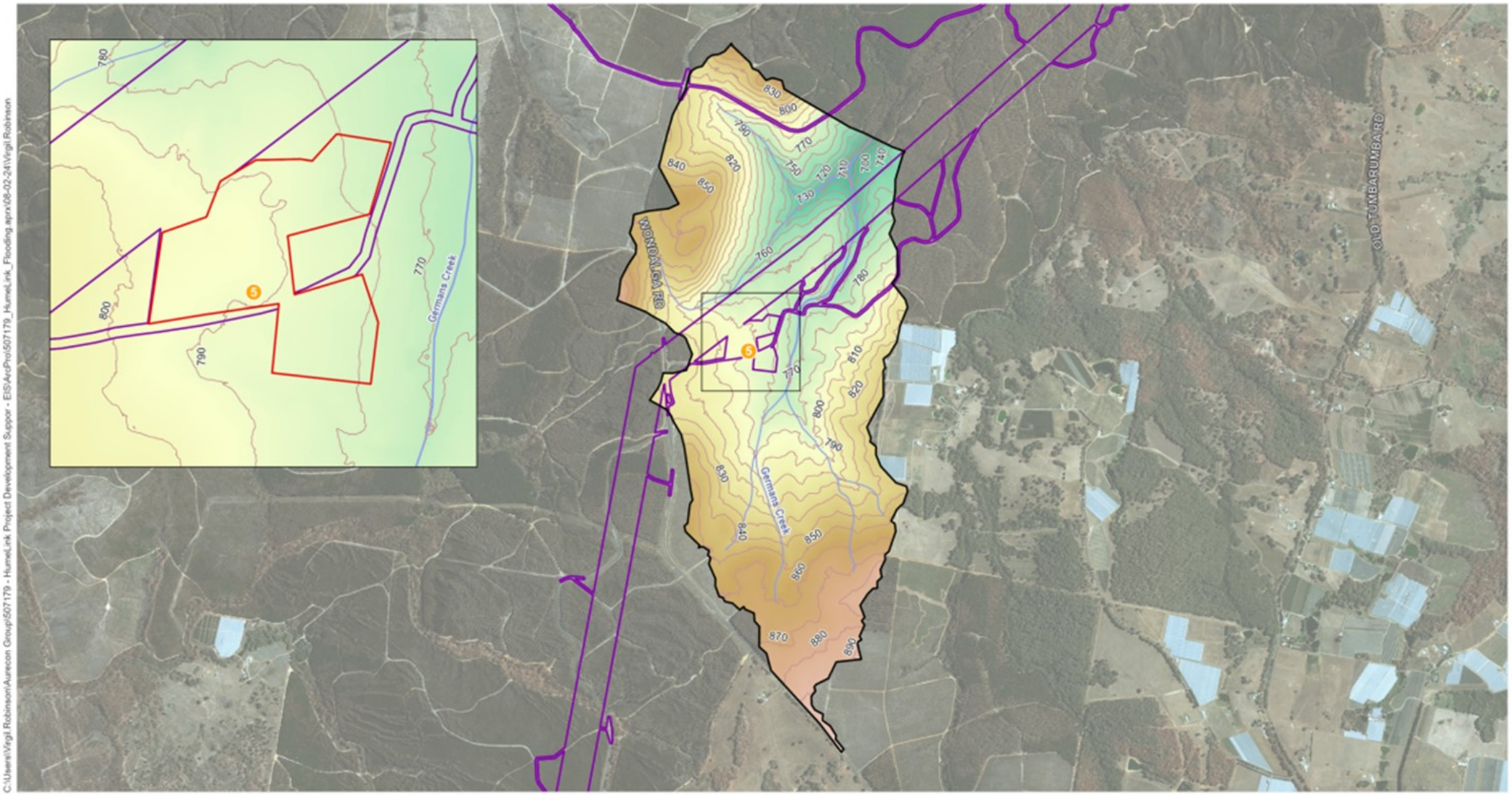
5.4 Ardrossan Headquarters Road compound (C17)

The Ardrossan Headquarters Road compound (C17) is located approximately 100 metres to the east of Germans Creek. The Ardrossan Headquarters Road is located south-west of the construction compound and Back Camp Road passes through the construction compound footprint. The catchment area for the Ardrossan Headquarters Road compound (C17) is shown in Figure 5-4. The upstream catchment contributing to the flow at the site is estimated to be approximately 2.4 square kilometres.

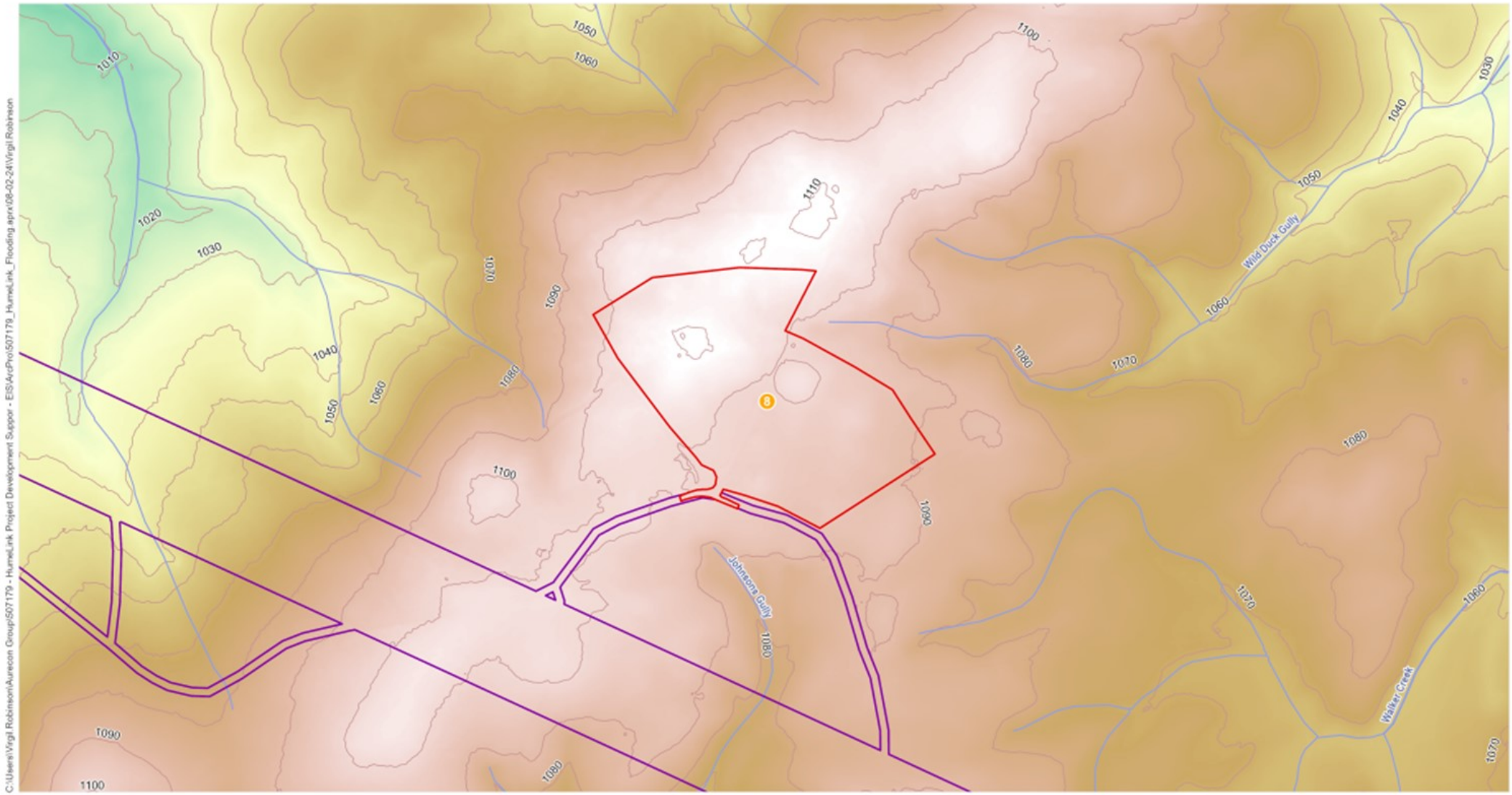


HumeLink **Hydrology and Flooding**

FIGURE 5-4: Local catchment for the Ardrossan Headquarters Road compound (C17)

5.5 Snubba Road compound (C18)

The Snubba Road compound (C18) is in the Bago State Forest. The construction compound is located north of the intersection of Kopsens Road and Bago Forest Way. Bago Forest Way continues in a northerly direction, passing through the construction compound. The construction compound is located near a topographic ridge which is at an elevation of 1,100 mAHD. The construction compound does not have an upstream catchment, as the proposed construction compound is located on a mountain ridge line. The site layout is shown in Figure 5-5.



Amended project footprint

Construction compound

Surface level contour (10m AHD interval)

Waterway

LiDAR Topography (mAHD)

1119

939

Construction ancillary facilities

8 Snubba Road compound (C18)

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

1:7,000

0 150 300 m

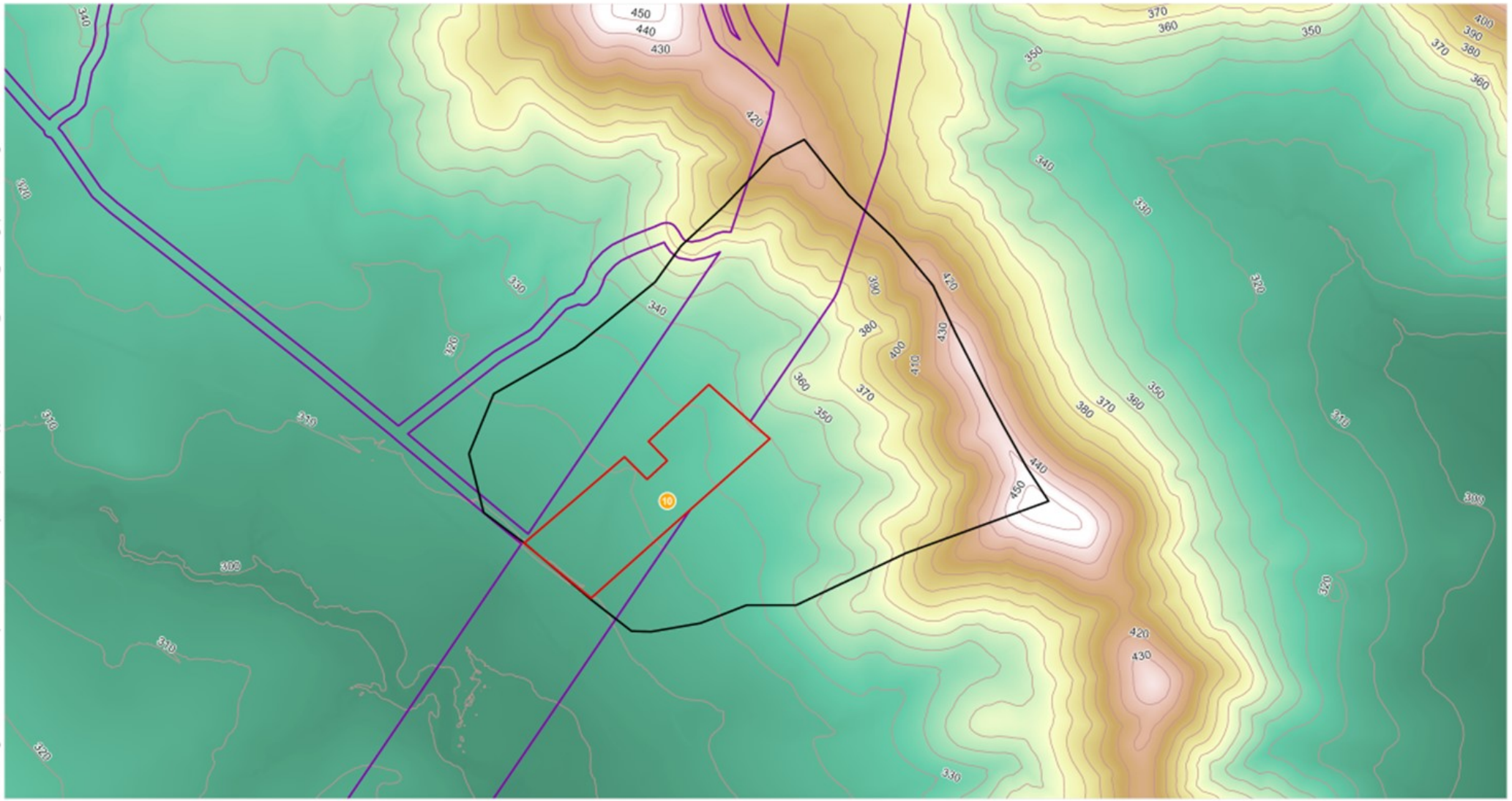
Projection: GDA 1994 MGA Zone 55

HumeLink **Hydrology and Flooding**

FIGURE 5-5: Local Topography and layout for the Snubba Road compound (C18)

5.6 Gadara Road compound (C19)

The Gadara Road compound (C19) is located north of Gadara Road within a hillside open field. Sandy Creek is approximately 300 metre south-west of the site's southern boundary. Topographically the site is located downstream of a local mountain ridge line that creates local overland flow paths approaching the construction compound from the northern boundary and eventually conveying the overland water towards Sandy Creek (south of the site). The upstream catchment contributing to the site is shown in Figure 5-6 and is estimated to be approximately 0.44 square kilometres.

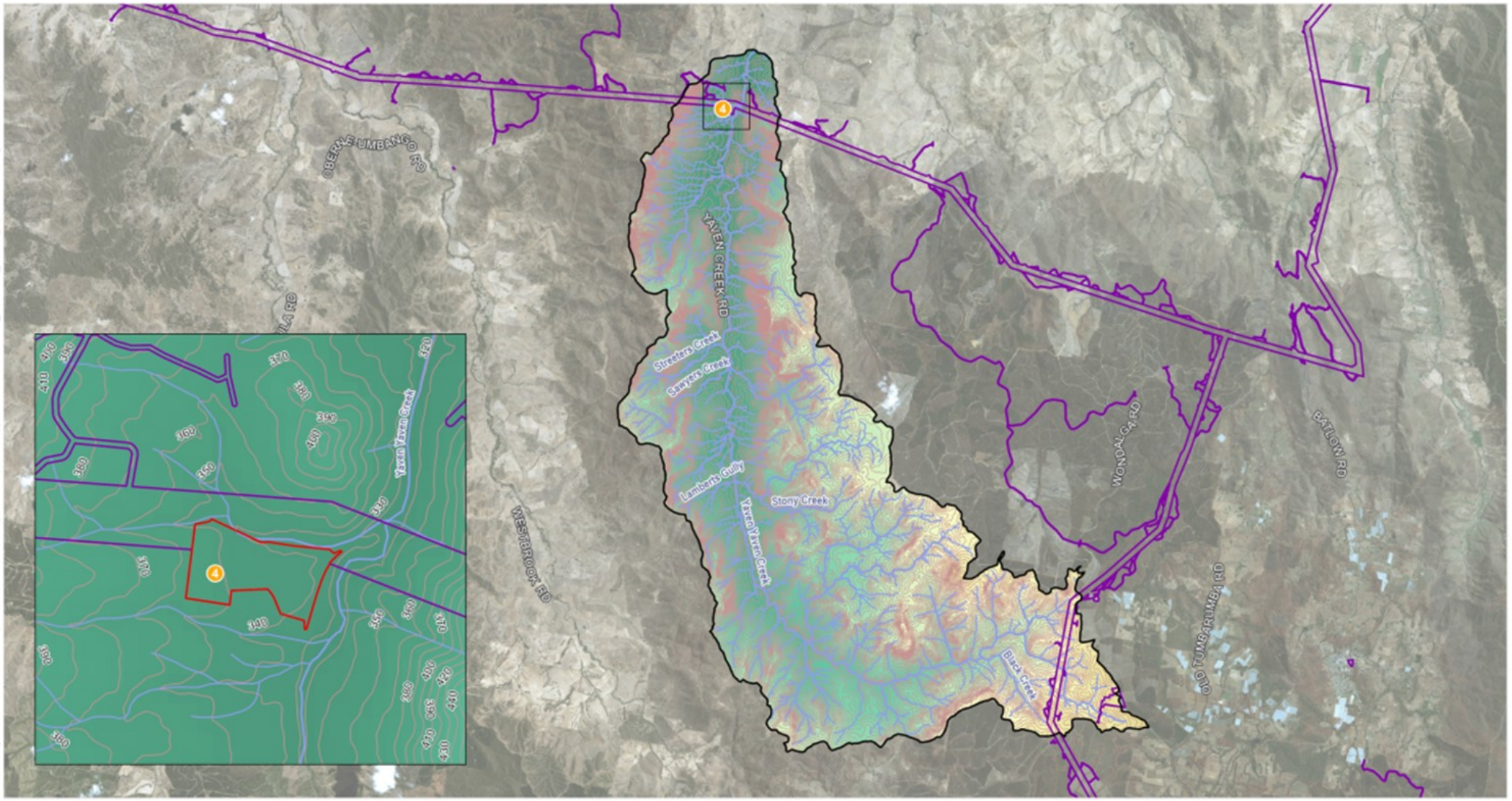


HumeLink **Hydrology and Flooding**

FIGURE 5-6: Local catchment for the Gadara Road compound (C19)

5.7 Ellerslie Road compound (C21)

The Ellerslie Road compound (C21) is located to the northwest of the Green Hills State Forest. The site is located at the intersection of Ellerslie Road and Yaven Creek Road. The eastern boundary of the site is approximately 50 to 60 metres from Yaven Yaven Creek which flows in a south-north direction. The site topography slopes from west to east draining the overland flow into Yaven Yaven Creek. The catchment area for the Ellerslie Road compound (C21) is shown in Figure 5-7 and is estimated to be approximately 155 square kilometres.



Amended project footprint
Construction compound
Catchment area
Surface level contour (10m AHD interval)
Waterway

LiDAR Topography (mAHD)

1438
241

Construction ancillary facilities

4 Ellerslie Road compound (C21)

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

1:125,000
0 2.5 5km

Projection: GDA 1994 MGA Zone 55

HumeLink **Hydrology and Flooding**

FIGURE 5-7: Local catchment for the Ellerslie Road compound (C21)

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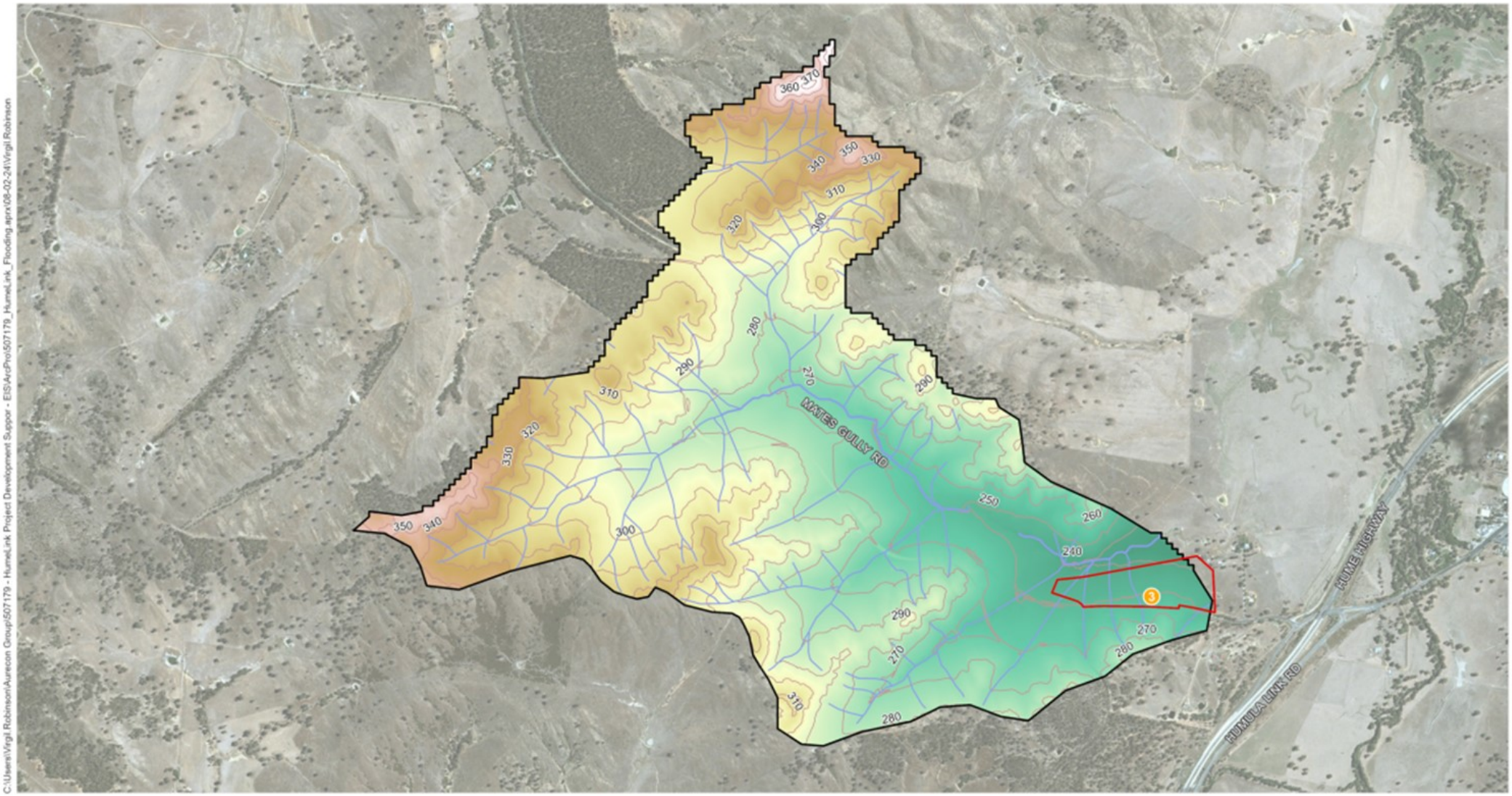
5.8 Tarcutta accommodation facility and compound (AC03)

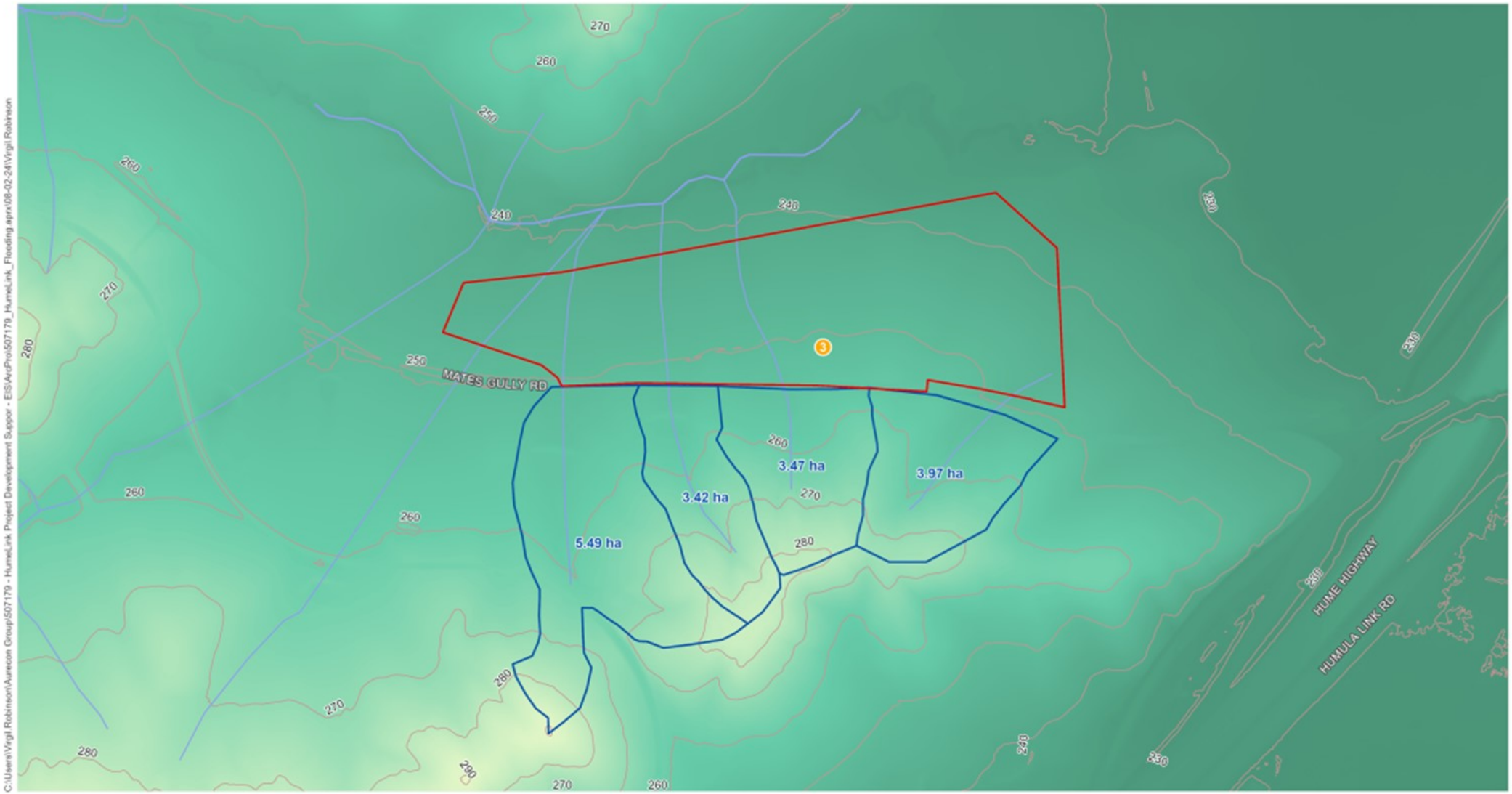
The Tarcutta accommodation facility and compound (AC03) is located north of Mates Gully Road and 450 metres west of Hume Highway. The site is south of Tarcutta Creek. The site has a series of local roadside catchments to the south and the larger catchment of Tarcutta Creek (approximately 7.4 square kilometres) to the north of the site (refer to Figure 5-9).

The catchment area for the Tarcutta accommodation facility and compound (AC03) is shown in Figure 5-8 and is estimated to be approximately 5.5 square kilometres. The estimated areas for the roadside catchments to the south of the site are depicted in Figure 5-9.



HumeLink **Hydrology and Flooding**

FIGURE 5-8: Local catchment for the Tarcutta accommodation facility and compound (AC03)



Construction compound

Subcatchment

Surface level contour (10m AHD interval)

Waterway

LiDAR Topography (mAHD)

412

222

Construction ancillary facilities

3 Tarcutta accommodation facility and compound (AC03)

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

1:4,850

0 80 160 m

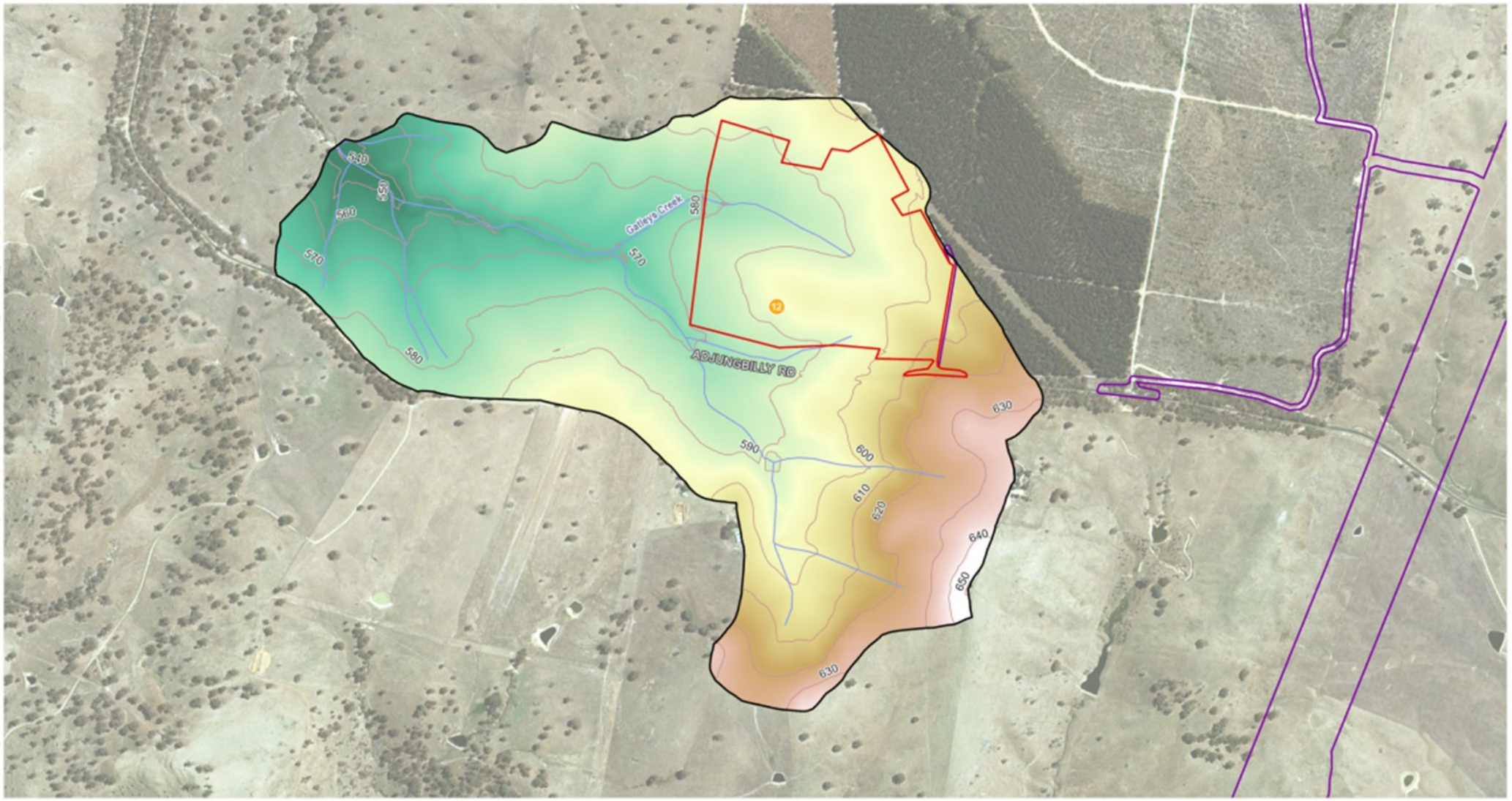
Projection: GDA 1994 MGA Zone 55

HumeLink **Hydrology and Flooding**

FIGURE 5-9: Tarcutta accommodation facility and compound (AC03) local drainage catchments

5.9 Adjungbilly accommodation facility and compound (AC04)

The Adjungbilly accommodation facility and compound (AC04) is located north of Gobarralong Adjungbilly Road. It is in the upstream area of the Gatleys Creek catchment with the Creek's origin located along the western boundary of the site. The site is in the upstream area of the Gatleys Creek catchment and the topography of the site slopes from east to west towards Gatleys Creek. A local storage dam is present within the site, along its western boundary. The catchment area for Adjungbilly accommodation facility and compound (AC04) is shown in Figure 5-10 and is estimated to be approximately two square kilometres.



Amended project footprint
Construction compound
Catchment area

Surface level contour (10m AHD interval)
Waterway

Construction ancillary facilities

12 Adjungbilly accommodation facility and compound (AC04)

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

1:10,500
0 250 500 m

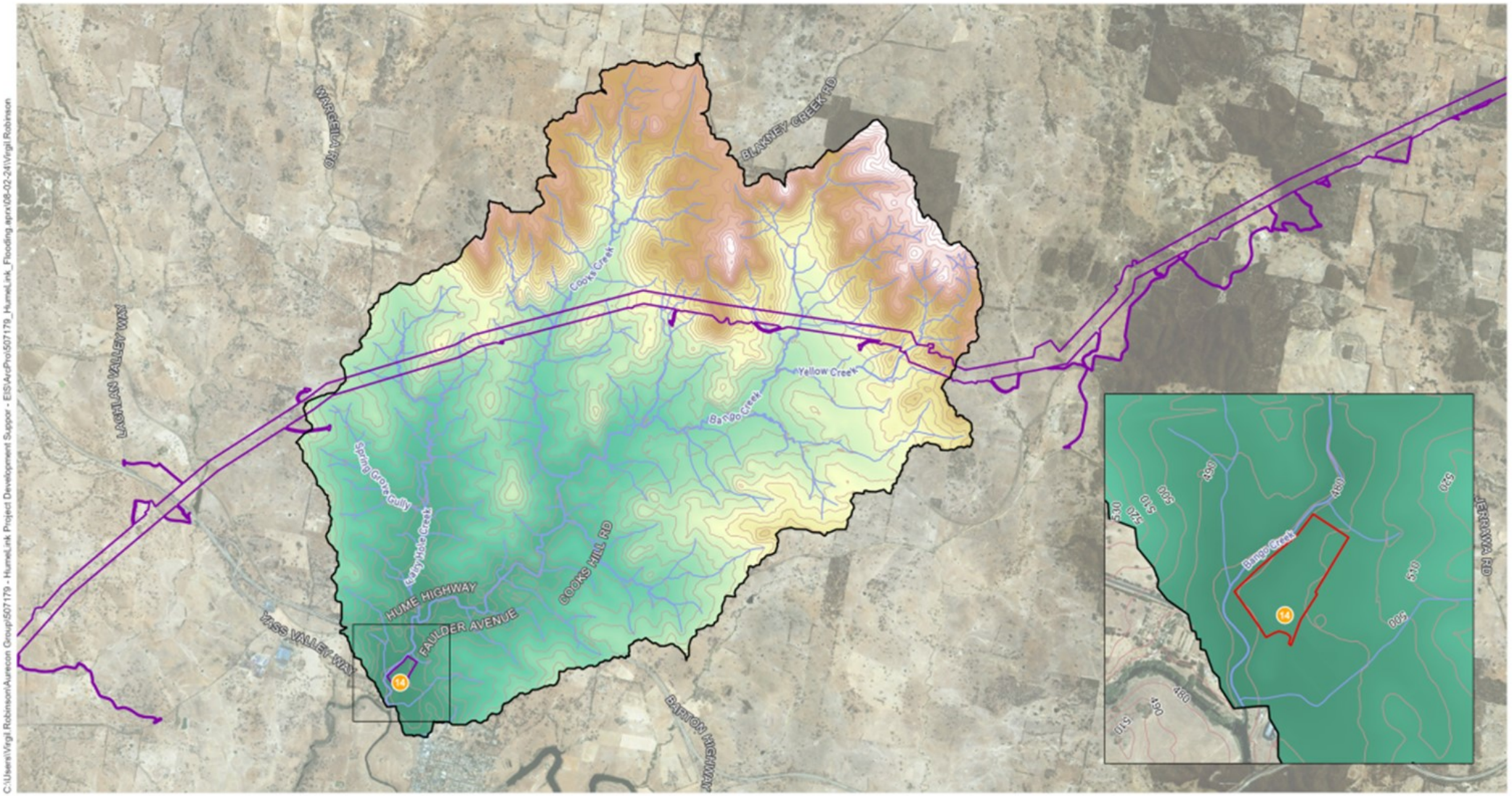
Projection: GDA 1994 MGA Zone 55

HumeLink **Hydrology and Flooding**

FIGURE 5-10: Local catchment for the Adjungbilly accommodation facility and compound (AC04)

5.10 Yass accommodation facility and compound (AC05)

The site is located immediately south-east of Bango Creek, approximately 550 metres upstream of its confluence with the regional Yass River. The topography within the site is irregular and consists of a local drainage channel that slopes east to west discharging into Bango Creek. The catchment area for the Yass accommodation facility and compound (AC05) is shown in Figure 5-11 and is estimated to be approximately 66 square kilometres.



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

1:60,000

0 1 2km

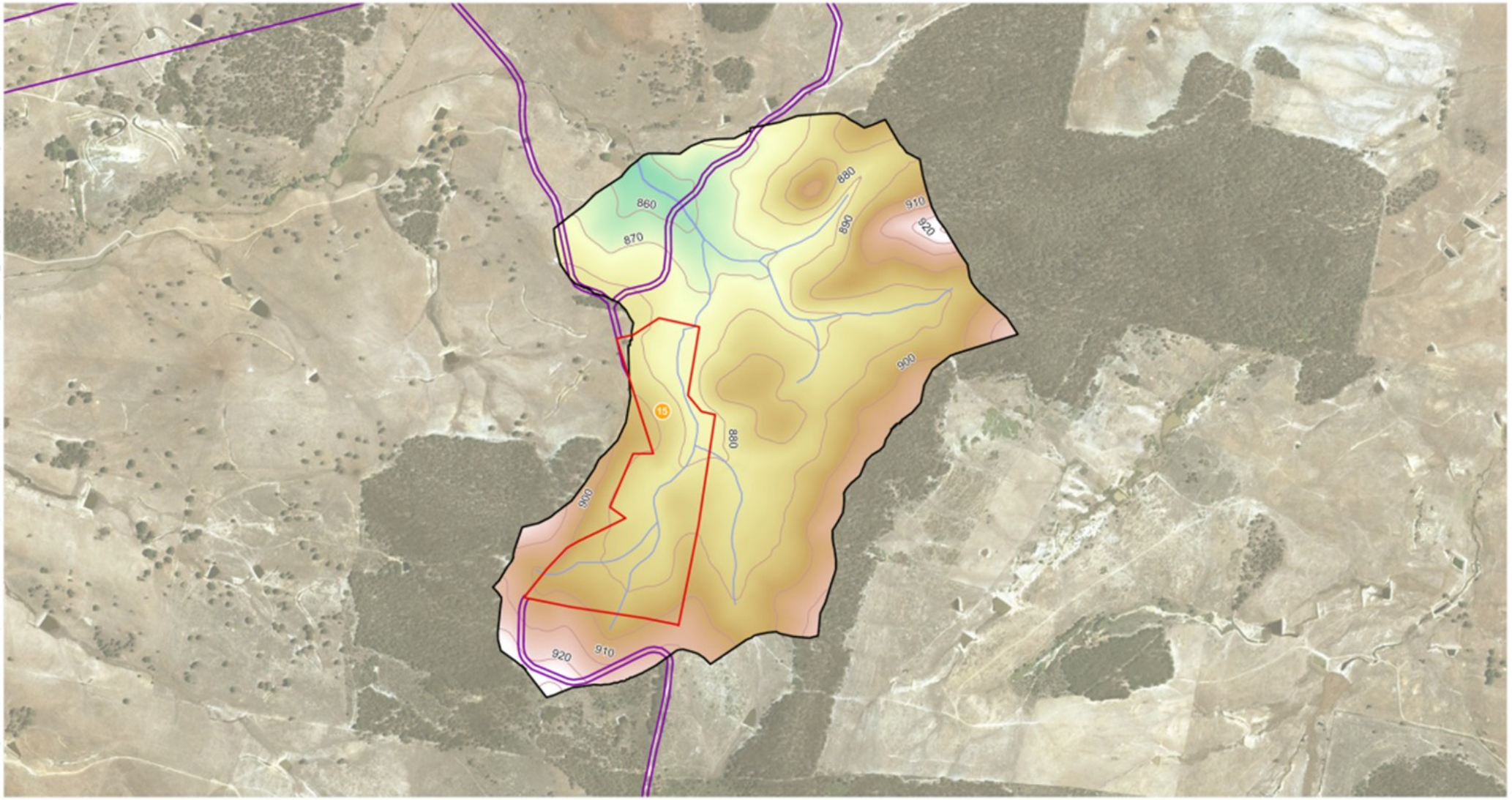
Projection: GDA 1994 MGA Zone 55

HumeLink **Hydrology and Flooding**

FIGURE 5-11: Local catchment for the Yass accommodation facility and compound (AC05)

5.11 Crookwell accommodation facility and compound (AC06)

The site is located approximately one kilometre south-east of Steeves Creek. Topographically the site is enveloped by a series of mountain ridges along the south, south-west, and east. This creates potential overland flow paths through the site from south to north, contributing to an unnamed tributary that eventually discharges into Steeves Creek (approximately 1.2 kilometres downstream of the site). The catchment area for the Crookwell accommodation facility and compound (AC06) is shown in Figure 5-12 and is estimated to be approximately 1.4 square kilometres.



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Amended project footprint
Construction compound
Catchment area
Surface level contour (10m AHD interval)
Waterway

LiDAR Topography (mAHD)

940
810

Construction ancillary facilities

15 Crookwell accommodation facility and compound (AC06)

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

1:11,250
0 225 450m

Projection: GDA 1994 MGA Zone 55

HumeLink **Hydrology and Flooding**

FIGURE 5-12: Local catchment for the Crookwell accommodation facility and compound (AC06)

5.12 Green Hills accommodation facility and compound (AC07)

The site is located within the Kunama region, within the Murrumbidgee catchment area. Yaven Yaven Creek is located to the south of the site. The Green Hills Access Road is adjacent to the eastern boundary of the site. Topographically the site is proposed on a local mountain ridge at an approximate elevation of 880 to 900 mAHD, and therefore an upstream catchment was not identified for the combined worker accommodation facility and construction compound (refer to Figure 5-13).

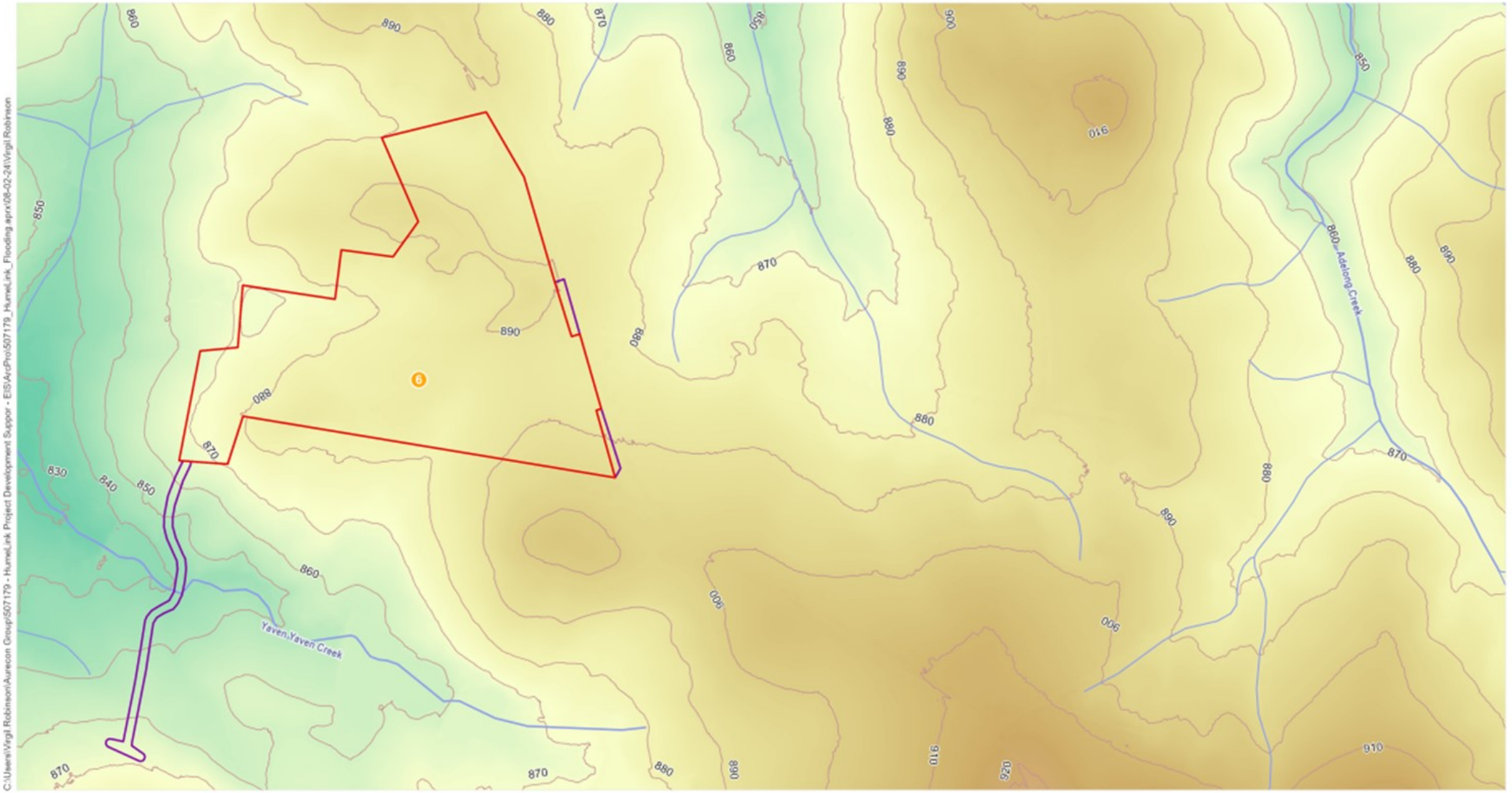


FIGURE 5-13: Local Topography and layout for the Green Hills accommodation facility and compound (AC07)

5.13 Proposed Gugaa 500 kV substation

The proposed Gugaa 500 kV substation is approximately 11 kilometres south-east of the existing Wagga 300 kV substation. The proposed Gugaa substation is orientated in such a way that it is surrounded by the Amended Gregadoo Road compound (C06) as a part of the amended project. The site is situated approximately 1,000 metres west of O'Briens Creek which discharges to Kyeamba Creek, approximately two kilometres north of Gregadoo East Road (refer to Figure 5-14).

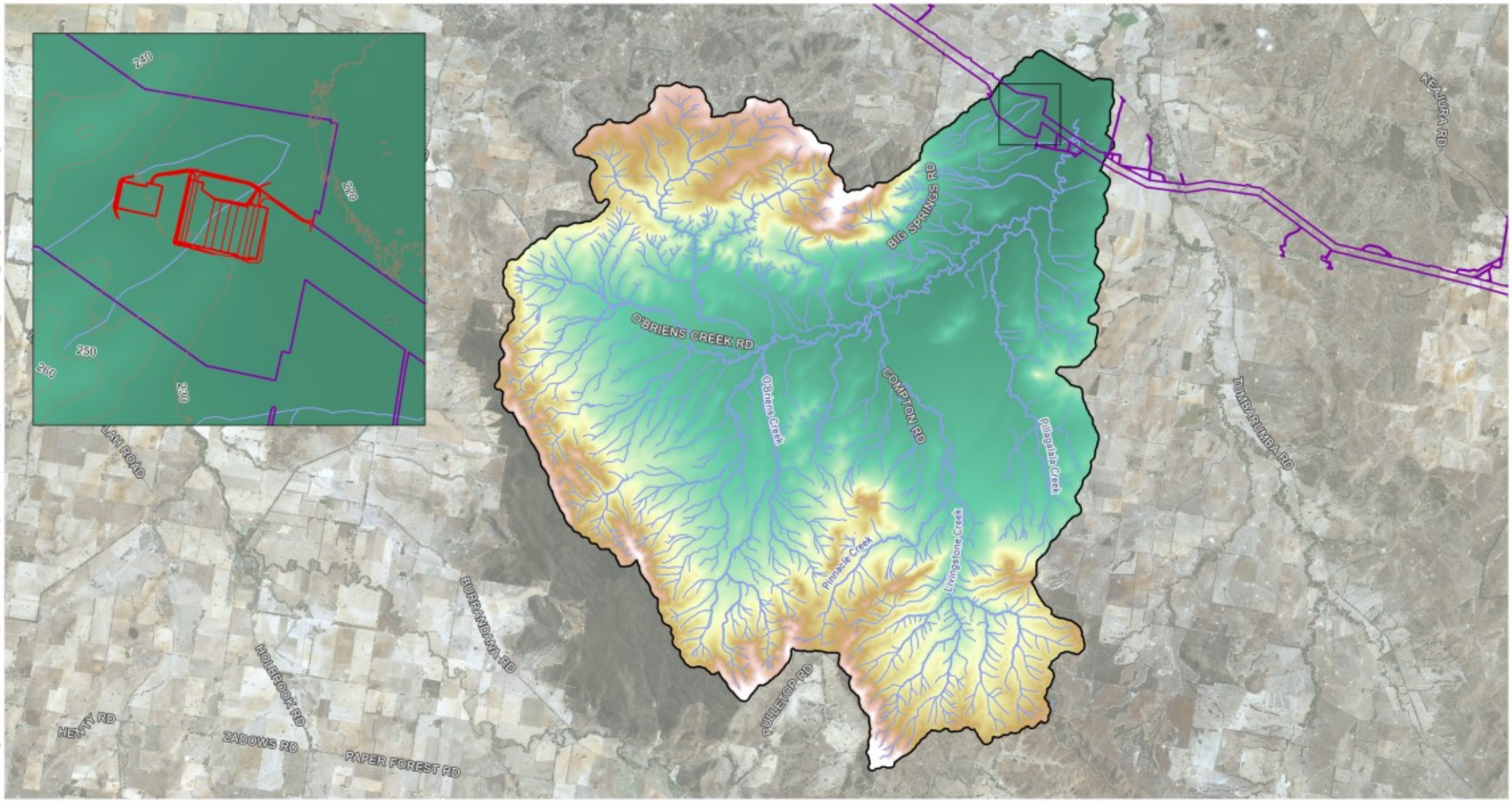


FIGURE 5-14: Local catchment for the Gugaa 500 kV substation

6 Assessment of impacts

6.1 Construction impacts

The assessment of flood impacts during construction can occur as:

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

Both types of impacts are expected where construction activities are located within the flood extent of major waterways. Each new or amended construction compound and combined worker accommodation facility and construction compound has been assessed for each type of impact on a site-by-site basis.

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 crossing for access tracks) and/or by flooding and drainage that then impacts on the 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 eroding temporary roads. Appropriate scour protection, and sediment and erosion control management planning need to be considered to avoid or minimise any potential flood impact or changes in flood characteristics.

The assessment of flood risk has identified that none of the construction compounds and combined worker accommodation facilities and construction compounds that form part of the amended project are at risk of regional flooding.

Regional flood risk and flood hazard for the amended transmission line corridor has been assessed for the 1% AEP event and is limited to only operational impacts (refer to Section 6.2). The timeframe for construction activities at individual towers is estimated to be approximately four weeks. Flooding resulting in impacts in this timeframe would be considered unlikely. Any local flood risks and the management of these during construction would be incorporated into the Construction Environmental Management Plan (CEMP).

An assessment of local flood risk for the construction compounds and combined worker accommodation facilities and construction compounds is presented in the following sections.

The extent of the construction compounds and combined worker accommodation facilities and construction compounds presented in the flood maps (refer to figures in Section 6.1, Section 6.2, and Attachment C) are indicative only and their use, boundaries and layout would be confirmed during detailed design by the construction contractors.

The classification of flood hazards is established through the aggregation of hazard curves derived from the *Australian Rainfall and Runoff* (ARR) 2019 guidelines, detailed in Attachment B. These curves establish thresholds for hazards, correlating to the risk faced by communities and infrastructure in flood scenarios. The hazard data is categorised into specific levels of risk, corresponding to the thresholds of vulnerability outlined in Table 6-1. Note that the hazard classifications also apply during operation.

Table 6-1 Hazard vulnerability thresholds

Hazard Vulnerability Classification	Description
H1	Generally safe for vehicles, people and buildings.
H2	Unsafe for small vehicles.
H3	Unsafe for vehicles. children and the elderly
H4	Unsafe for vehicles and people.
H5	Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust buildings subject to failure.
H6	Unsafe for vehicles and people. All building types considered vulnerable to failure.

6.1.1 Impact of construction activities on flooding

Construction activities have the potential to affect flood behaviour and impact 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 include:

- excavations for substations and transmission line structure foundations
- establishment of new tracks and upgraded tracks
- stockpiling of material
- modifications of existing surface levels for construction compounds and combined worker accommodation facilities and construction compounds.

Construction activities at each transmission line structure site would involve excavations up to five metres deep for the installation of foundations, which would be backfilled at completion. As mentioned in the preceding section, timing for the construction activities for transmission line structures would be in the order of four weeks, which is deemed too short a period for flood risk resulting in impacts.

Excavations during construction for the proposed Gugaa 500 kV substation would be relatively minimal. Excavation activities would include levelling around the individual structure foundations, drainage and grading. Overall, changes to local area flood characteristics would likely be minor and localised.

Areas at risk of flooding, including construction compounds and combined worker accommodation facilities and construction compounds, are assessed and discussed in the following sections.

6.1.1.1 Construction compound sites

The flood modelling assessments at the amended construction compounds were carried out for the 5% AEP event in accordance with the flood immunity criteria. A summary of the type of assessment undertaken for each construction compound and the impacts are provided in Table 6-2.

Table 6-2 Summary of construction compound impacts on local and regional flooding

Construction compound	Assessment undertaken	Flood Impact in a 5% AEP event
Amended Gregadoo Road compound (C06)	Two-dimensional flood modelling	Regional flood risk from O'Briens Creek remains unchanged in comparison to *Technical Report 11 - Hydrology and Flooding Impact Assessment* prepared for the EIS. The compound consists of an existing overland flood extent that can be impacted as result of construction activities.
Amended Honeysuckle Road compound (C07)	Desktop assessment based on topography	Located on high ground. No regional flood risk. Local flooding risk is unlikely.
Amended Bannaby 500 kV substation compound (C12)	Two-dimensional flood modelling	No regional flood risk. Shallow local drainage through the site is predicted.
Ardrossan Headquarters Road compound (C17)	Two-dimensional flood modelling	No regional flood risk. A shallow overland flow path is located south of the site; however, it poses minimal risk to flood impacts.
Snubba Road compound (C18)	Desktop assessment based on topography	Located on high ground. No regional flood risk. Local flooding risk is unlikely.
Gadara Road compound (C19)	Two-dimensional flood modelling	No regional flood risk. Existing shallow overland flow path located along the northern site boundary which traverses through the site as it flows south. Extent of local flooding is confined allowing for development of the remaining flood free portion of the site.
Ellerslie Road compound (C21)	Two-dimensional flood modelling	No regional risk. Minor encroachment of local flooding from a tributary of Yaven Yaven Creek along the northern boundary of the site. Provided construction activities are minimised along the northern boundary of the site, no local flooding impacts are expected.

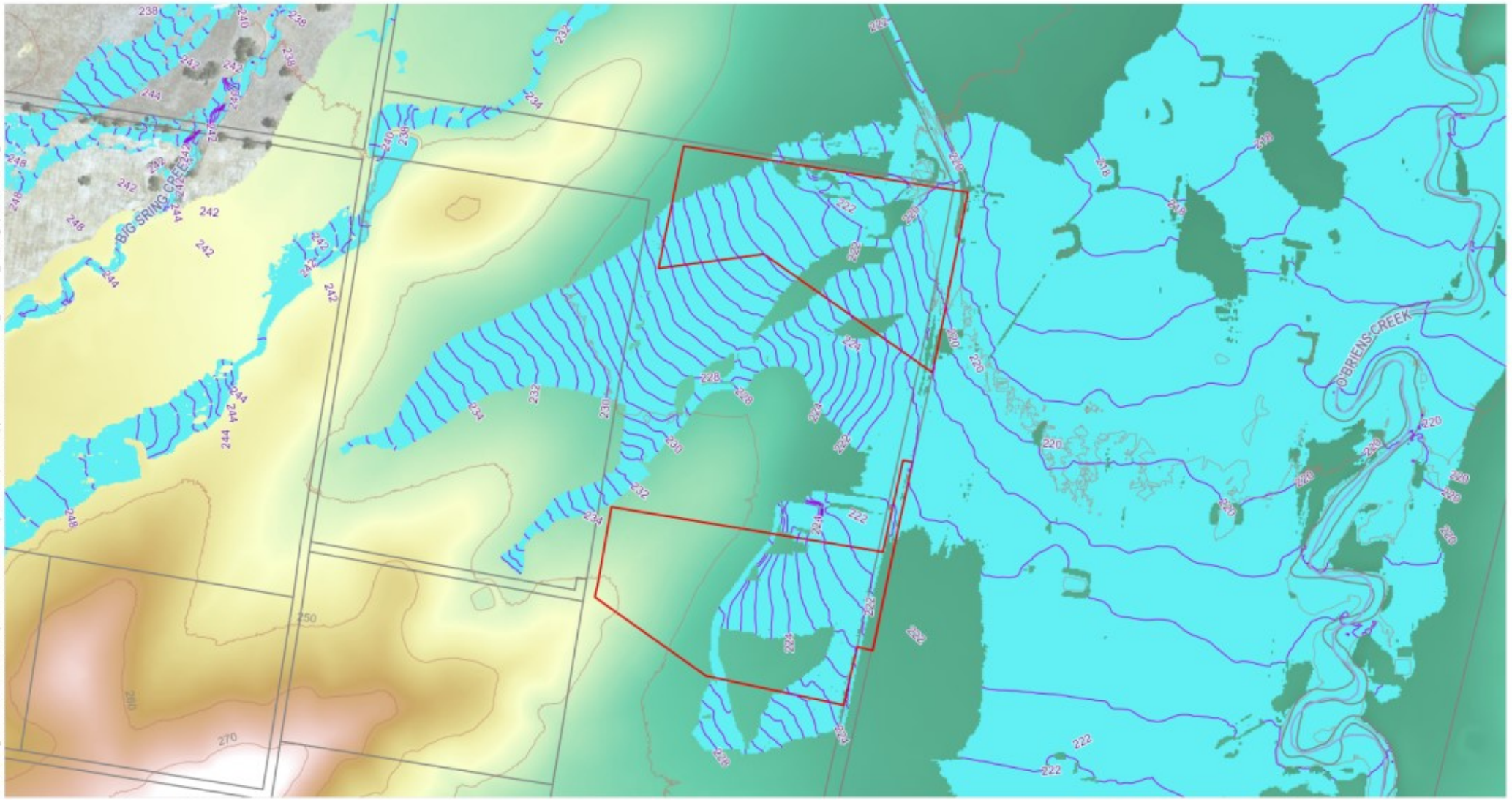
6.1.1.1.1 Amended Gregadoo Road compound (C06)

The evaluation of the Amended Gregadoo Road compound (C06) is based on local flood modelling conducted by Lyall & Associates for the proposed Gugaa 500 kV substation (refer to Attachment G). The construction compound is located north and south of the proposed Gugaa 500 kV substation. Both the substation and the compound proposed at this location carry the potential to impact local flood behaviour, given the presence of overland flow within the construction areas (refer to Figure 6-1).

The current assessment relies on the 5% AEP flood extent under existing conditions. However, the 5% AEP flood extent is subject to change following construction of the proposed Gugaa 500 kV substation, as it influences flood behaviour across the Amended Gregadoo Road compound. Depending on the construction timeline for the construction of the proposed Gugaa 500 kV substation, a review of the impacts on flooding at the Amended Gregadoo Road compound (C06) may need to be undertaken.

There is an unnamed channel traversing the southern portion of the construction compound from south to north. A considerable area to the east of this channel is prone to overland flooding (with water levels up to 230 mAHD). Construction activities that impede the natural flow path of the unnamed channel and associated overland flow have the potential to affect local flood behaviour. The implementation of local drains and easements in this area can serve as effective measures to manage these potential flood impacts.

A substantial section of the northern portion of the construction compound is subject to overland flow (with water levels up to 230 mAHD), moving in a north-easterly direction and eventually feeding into O'Briens Creek. Construction activities that impede these natural overland flow paths carry the potential for local flood impacts. To manage this risk, construction of a channel within the compound, coupled with local drainage systems to redirect this water, would mitigate the extent of overland flow within the construction compound and minimise the resulting flood impact. The impact assessment outcome for construction activities on flooding at the Amended Gregadoo Road Compound (C06) aligns with the conclusions presented in *Technical Report 11 – Hydrology and Flooding Impact Assessment* prepared for the EIS.



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

Projection: GDA 1994 MGA Zone 55

HumeLink **Hydrology and Flooding**

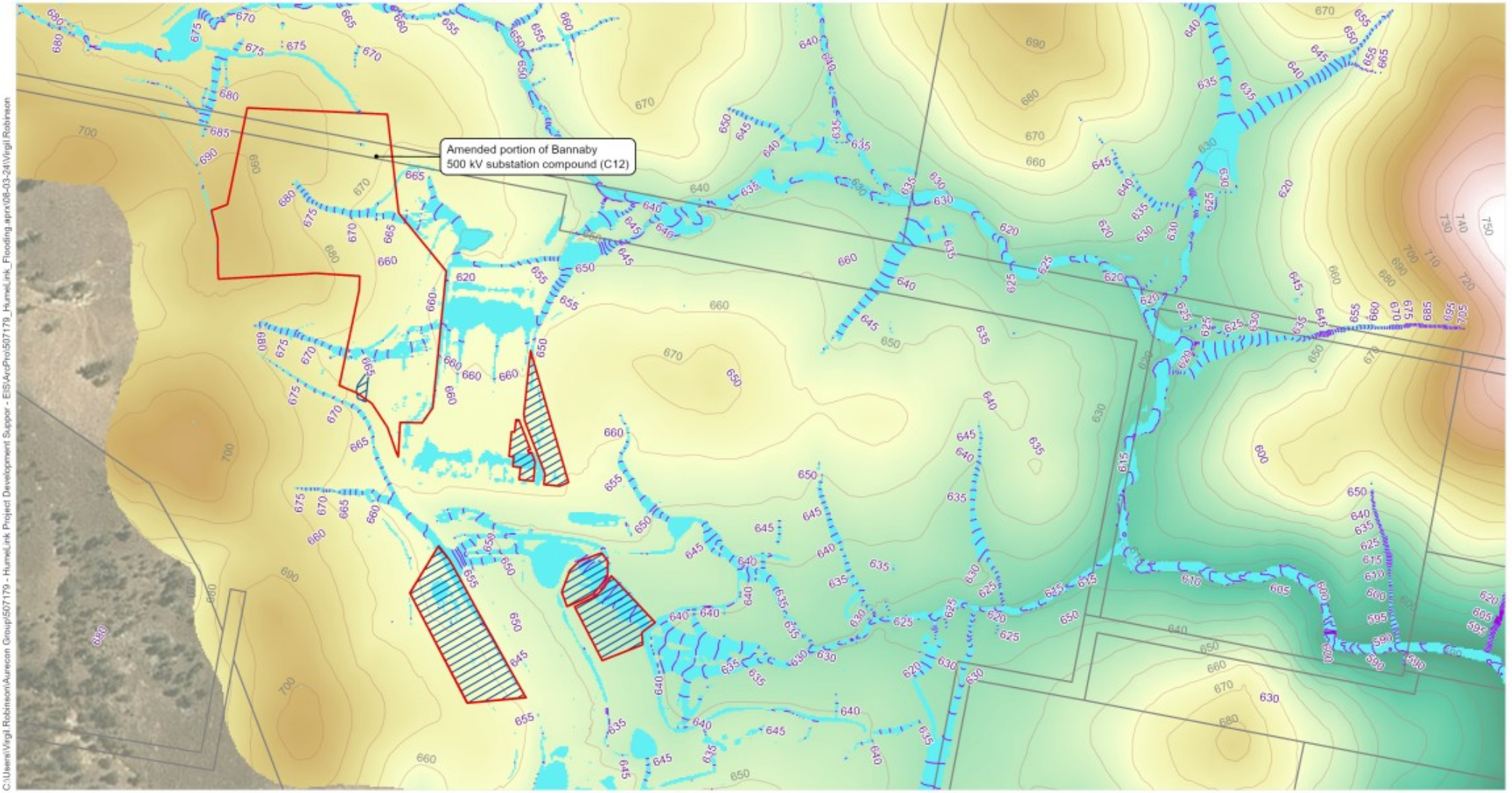
FIGURE 6-1: Amended Gregadoo Road compound (C06) existing 5% AEP peak flood level

6.1.1.1.2 Amended Honeysuckle Road compound (C07)

With a minor upstream catchment area, the Amended Honeysuckle Road compound is unlikely to be at risk of local flooding and any precipitation that does fall on the catchment area can be readily managed via site drainage measures. Therefore, the construction compound is not expected to impact the local flooding characteristics. The impact assessment outcome for construction activities on flooding at the Amended Honeysuckle Road compound (C07) aligns with the conclusions presented in *Technical Report 11 – Hydrology and Flooding Impact Assessment* prepared for the EIS.

6.1.1.1.3 Amended Bannaby 500 kV substation compound (C12)

The amended project proposes an additional construction compound area to the north-west of the existing Bannaby 500 kV substation. Local flood modelling at the new construction compound indicates two shallow overland flow paths, one in the northern portion and one in the southern portion, conveying localised surface runoff from west to east in a 5% AEP event (refer to Table 6-2). There is potential for construction activities along these flow paths to result in minor local flooding. As these overland flow paths are minor drainage lines, they can be managed on site with an appropriate stormwater management plan to be developed as part of detailed design. The impact assessment outcome for construction activities on flooding at the Amended Bannaby 500 kV substation compound (C12) aligns with the conclusions presented in *Technical Report 11 – Hydrology and Flooding Impact Assessment* prepared for the EIS.



Construction compound

Construction compound (EIS)

Flood level (m AHD)

Cadastre

Surface level contour (10m AHD interval)

Flood level contour (1m AHD interval)

LiDAR Topography (mAHD)

766

523

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

1:5,000

0 110 220m

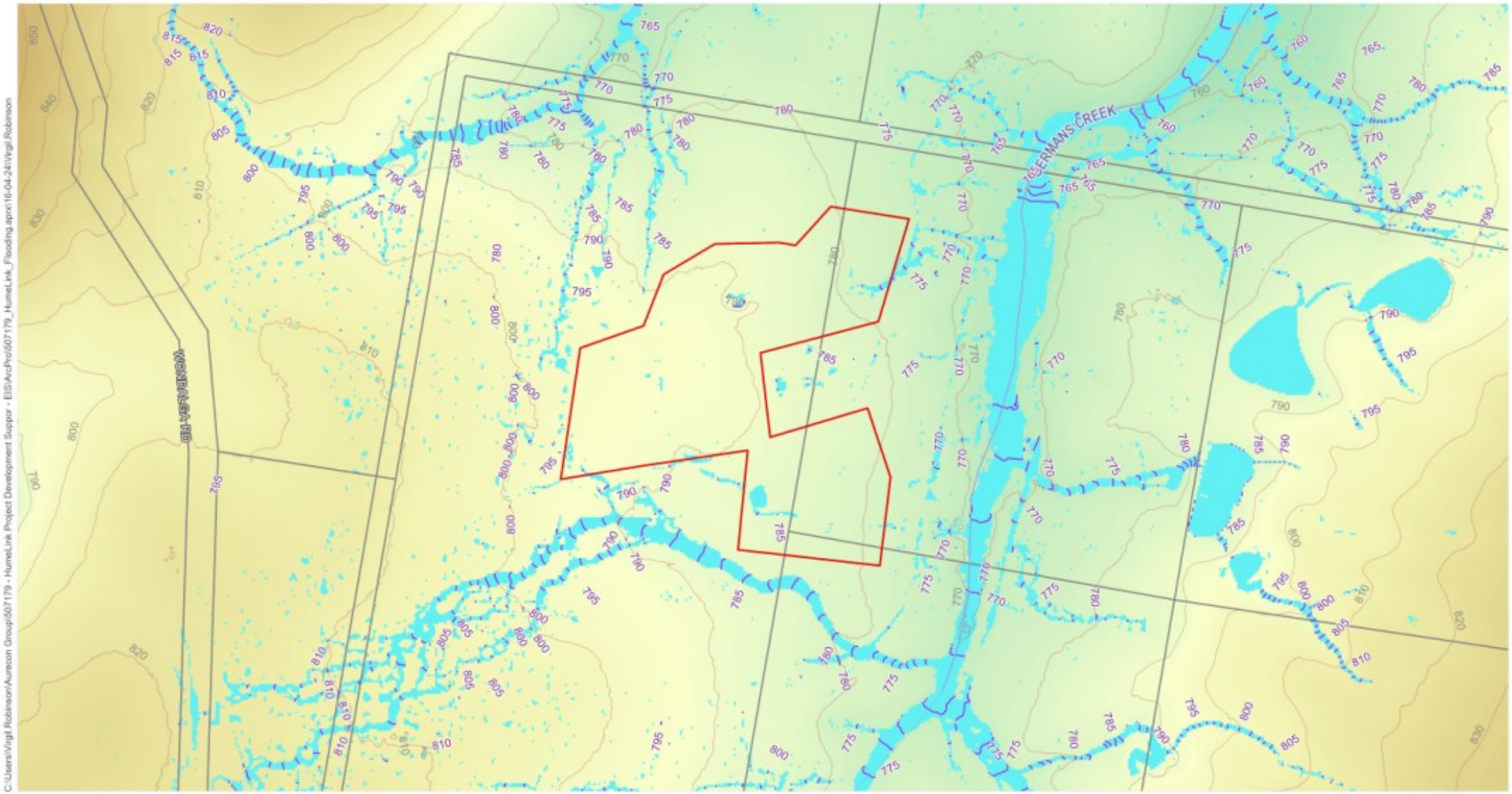
Projection: GDA 1994 MGA Zone 55

HumeLink **Hydrology and Flooding**

FIGURE 6-2: Amended Bannaby 500 kV substation compound (C12) existing 5% AEP peak flood level

6.1.1.1.4 Ardrossan Headquarters Road compound (C17)

Germans Creek is located approximately 90 metres from the construction compound. The local flood modelling results indicate that the construction compound site is outside the Germans Creek flood risk area. There are some minor overland flows within the construction compound that can be managed by the site stormwater management plan. A local unnamed creek is observed south of the construction compound which has its confluence with German Creek (south-east of the compound). However, the construction compound is outside the flood extent of this local creek in a 5% AEP flood event (refer to Figure 6-3). Construction activities are not expected to impact local flooding behaviour.



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

1:4,000

0 90 180m

Projection: GDA 1994 MGA Zone 55

HumeLink **Hydrology and Flooding**

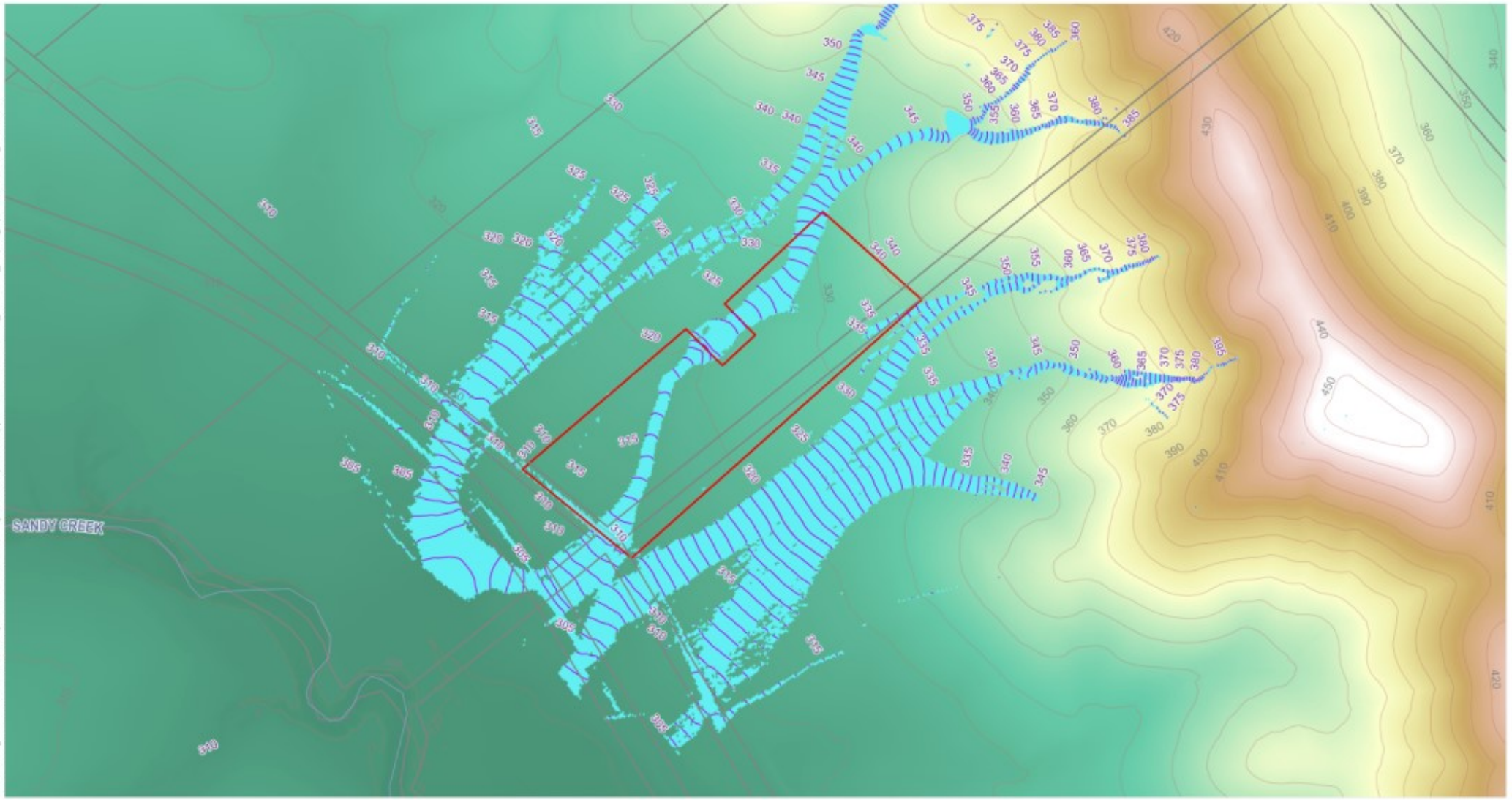
FIGURE 6-3: Ardrossan Headquarters Road compound (C17) existing 5% AEP peak flood level

6.1.1.1.5 Snubba Road compound (C18)

Construction activities are not expected to impact the local flooding characteristics at the Snubba Road compound. With a minor upstream catchment area, the construction compound is unlikely to be at risk of local flooding and any precipitation that does fall on the catchment area would be appropriately managed by the site stormwater management plan (refer to Figure 5-5).

6.1.1.1.6 Gadara Road compound (C19)

No regional flood risk from Sandy Creek is predicted for the Gadara Road compound, which is located approximately 300 to 400 metres from the construction compound site. The local flood modelling results indicate a shallow overland flow path conveying localised surface runoff through the construction compound in a 5% AEP event (refer to Figure 6-4). This overland flow path inundates the site from the north-west corner and traverses through the length of the construction compound towards Sandy Creek. Maintaining construction activities outside this overland flow path would result in no flood impacts.



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Construction compound
Flood level (m AHD)
Cadastre

Surface level contour (10m AHD interval)
Flood level contour (1m AHD interval)
Named waterway

LiDAR Topography (mAHD)
458
283

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

1:4,000
0 90 180m

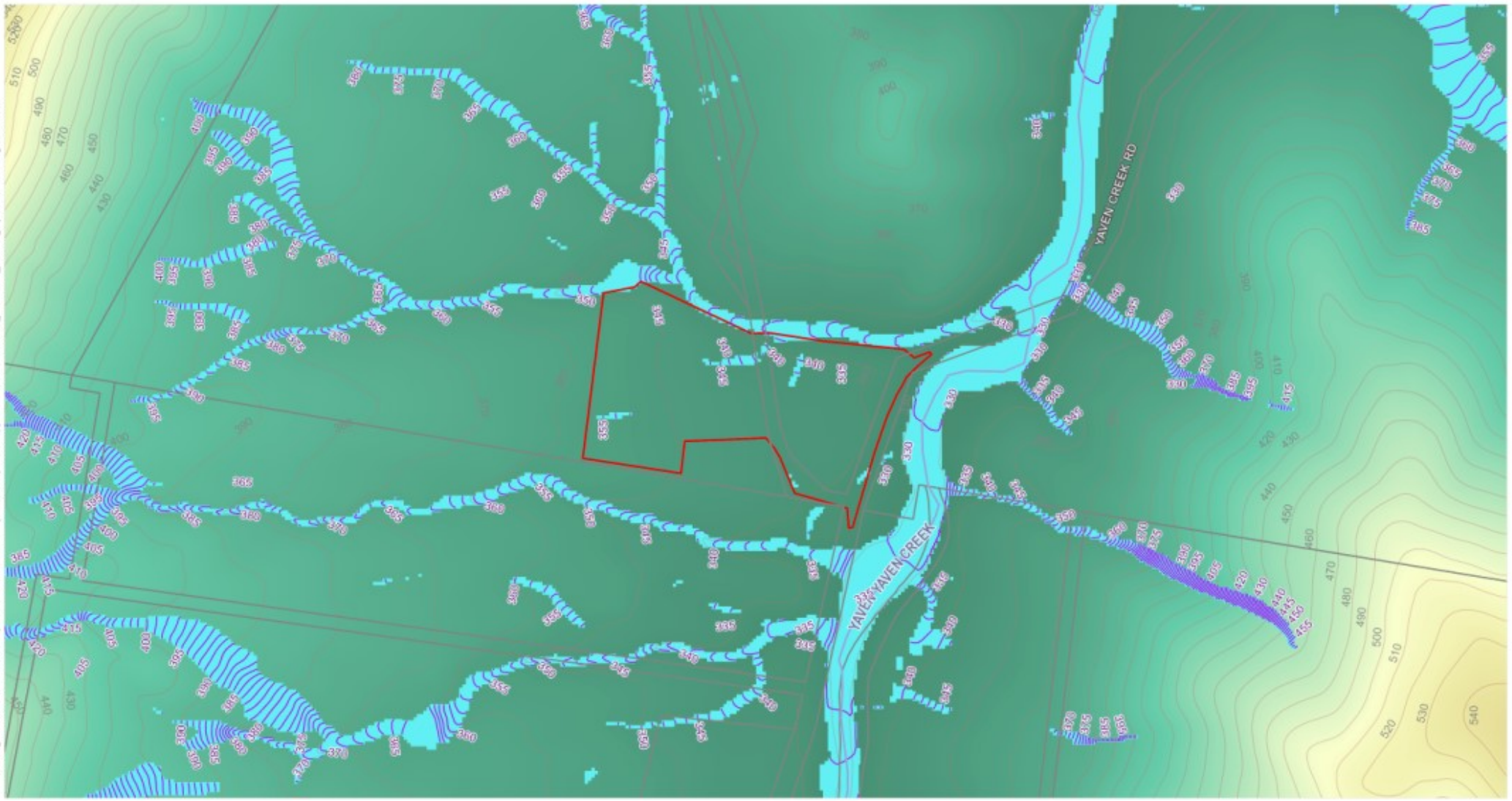
Projection: GDA 1994 MGA Zone 55

HumeLink **Hydrology and Flooding**

FIGURE 6-4: Gadara Road compound (C19) existing 5% AEP peak flood level

6.1.1.1.7 Ellerslie Road compound (C21)

The flood modelling assessment indicates the site is not at risk of regional or local flooding (refer to Figure 6-5); however, the northern boundary of the site partially encroaches flood water from a minor tributary of Yaven Yaven Creek. The encroachment extends into the site by about five to 10 metres and is unlikely to be impacted by construction activities given the minor extent of the encroachment.



Construction compound
Flood level (m AHD)
Cadastre

Surface level contour (10m AHD interval)
Flood level contour (1m AHD interval)
Named waterway

LiDAR Topography (mAHD)
708
317

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 6-5: Ellerslie Road compound (C21) existing 5% AEP peak flood level

6.1.1.2 Combined accommodation facilities and construction compounds

Flood modelling assessments at these locations were carried out for the 2% AEP flood event in accordance with the adopted immunity criteria. The type of assessment undertaken for each site and the flood impact is summarised in Table 6-3.

Table 6-3 Summary of combined accommodation facilities and construction compounds impacts on local flooding

Combined accommodation facility and construction compound	Assessment undertaken	Flood Impact in a 2% AEP event
Tarcutta accommodation facility and compound (AC03)	Desktop assessment based on topography	Unlikely to be impacted by regional flooding from Tarcutta Creek. Based on the estimated peak 2% AEP flood level, the site is at least 4.5 m above the water level, providing significant flood immunity.
Adjungbilly accommodation facility and compound (AC04)	Two-dimensional flood modelling	No regional flood risk. Local overland flow path within the construction compound extent observed just upstream of Gatleys Creek. Earthwork filling, stockpiling or civil structures within this overland flow path could result in an impact on flooding.
Yass accommodation facility and compound (AC05)	Two-dimensional flood modelling	No regional flood risk. Local flooding risk from Bango Creek along the western and southern boundary of the compound. Any earthwork filling, stockpiling or civil structures along these boundaries have the potential to cause flood impacts within the site.
Crookwell accommodation facility and compound (AC06)	Two-dimensional flood modelling	No regional flood risk. Local flooding risk from the local catchment. The site has an overland flow path conveying localised surface runoff through the middle of the site. The flood extent divides the site, isolating flood free areas. Any earthwork filling, stockpiling or civil structures in the middle of the site have the potential to cause flood impacts within the site.
Green Hills accommodation facility and compound (AC07)	Desktop assessment based on topography	Located on high ground, the site does not have a considerable catchment upstream for flooding. Construction activities within the compound footprint are not predicted to have an impact on flooding.

6.1.1.2.1 Tarcutta accommodation facility and compound (AC03)

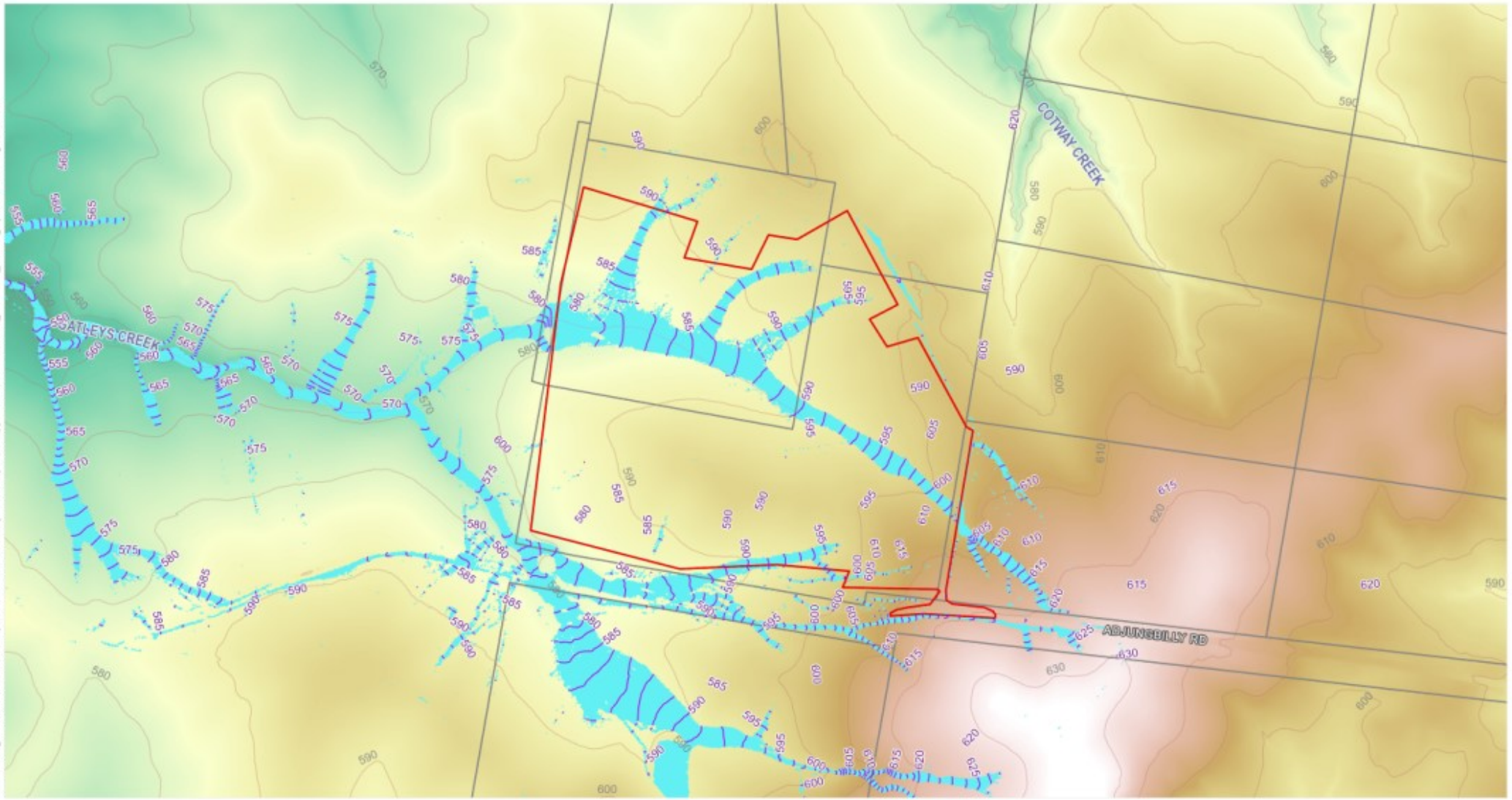
The accommodation facility and compound are unlikely to impact regional flooding from Tarcutta Creek. Estimated peak flood levels in a 2% AEP event are about 4.5 metres below the site level. The adopted methodology for this location is outlined in Attachment E. Small local catchments south of the site discharge to Mates Gully Road. Based on the available information, it is not clear whether any local drainage passes under the road or travels along the road to consolidated crossing locations. Given the smaller size of the local catchments, the risk to construction activities at this location impacting on local flooding is unlikely.

Figure 5-8 depicts the footprint of the Tarcutta accommodation facility and compound (AC03) over the local topography for the regional and local catchments.

6.1.1.2.2 Adjungbilly accommodation facility and compound (AC04)

The flood modelling assessment at Adjungbilly accommodation facility and compound (AC04) was carried out for the 2% AEP. The assessment predicted the general flood behaviour to be overland within the construction compound with a flow path in an east-west direction towards the local storage dam and then into Gatleys Creek (refer to Figure 6-6).

Based on the modelled 2% AEP flood risk, any earthwork filling or civil structures proposed along or across the observed overland flow path within the site has the potential to result in impacts on flooding. Given the size of the site and flood extent, potential flood impacts would be contained within the site.



Construction compound

Flood level (m AHD)

Cadastre

Surface level contour (10m AHD interval)

Flood level contour (1m AHD interval)

Named waterway

LiDAR Topography (mAHD)

639

521

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

1:6,250

0 140 280m

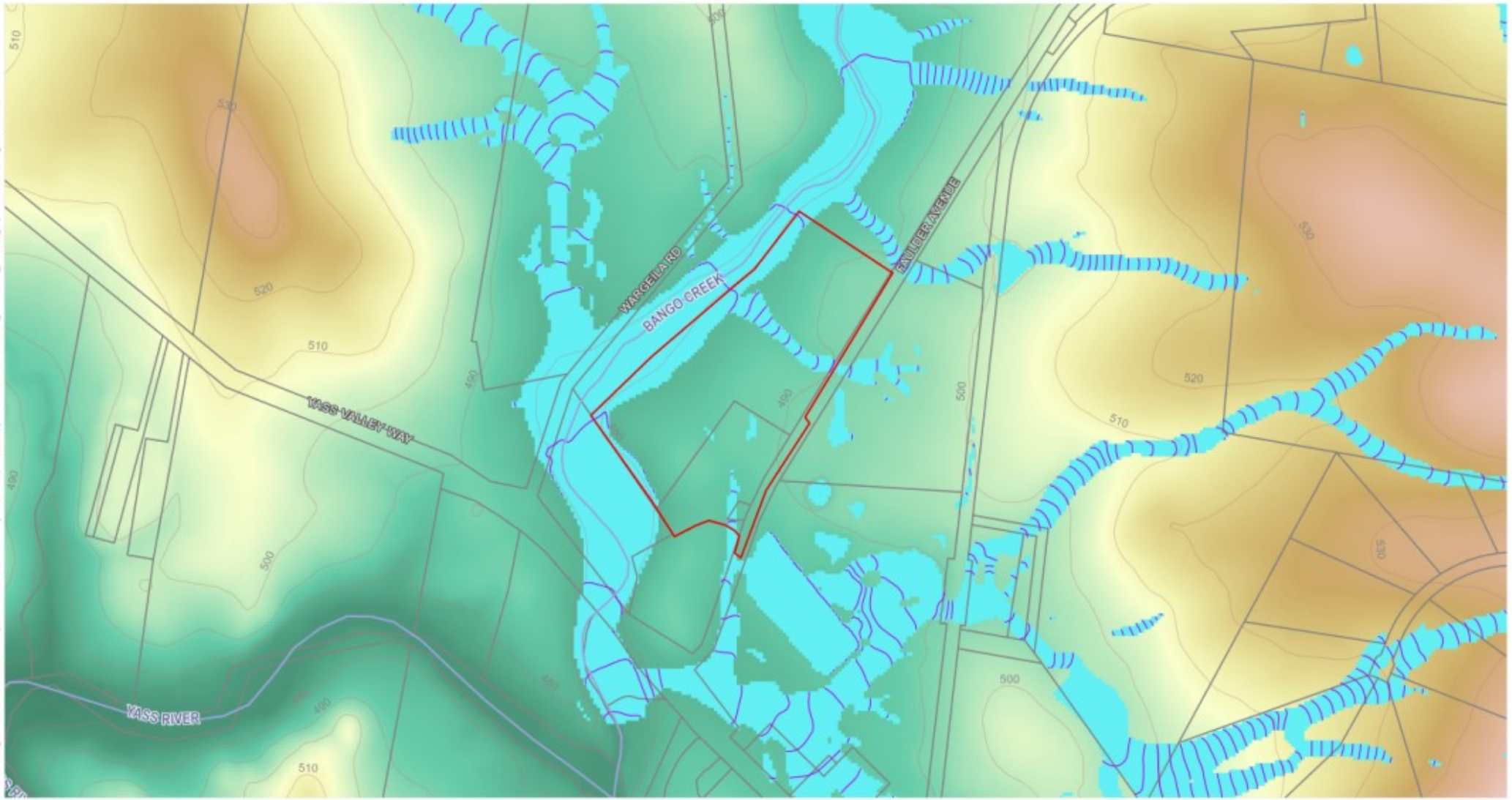
Projection: GDA 1994 MGA Zone 55

HumeLink **Hydrology and Flooding**

FIGURE 6-6: Adjungbilly accommodation facility and compound (AC04) existing 2% AEP peak flood level

6.1.1.2.3 Yass accommodation facility and compound (AC05)

No regional flood risk from Yass River is predicted. The local modelling results indicated that the site is at risk of flooding from Bango Creek in the 2% AEP event, which is located approximately 15 metres from the site. The flooding encroaches into the site by approximately 30 to 50 metres and flows along the length of the western and southern boundaries of the construction compound (refer to Figure 6-7). Any earthworks or civil structures along the western and southern boundaries are expected to result in impacts on local flooding that will be managed within the site.



Construction compound
Flood level (m AHD)
Cadastre

Surface level contour (10m AHD interval)
Flood level contour (1m AHD interval)
Named waterway

LiDAR Topography (mAHD)
553
463

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

1:6,000
0 140 280m

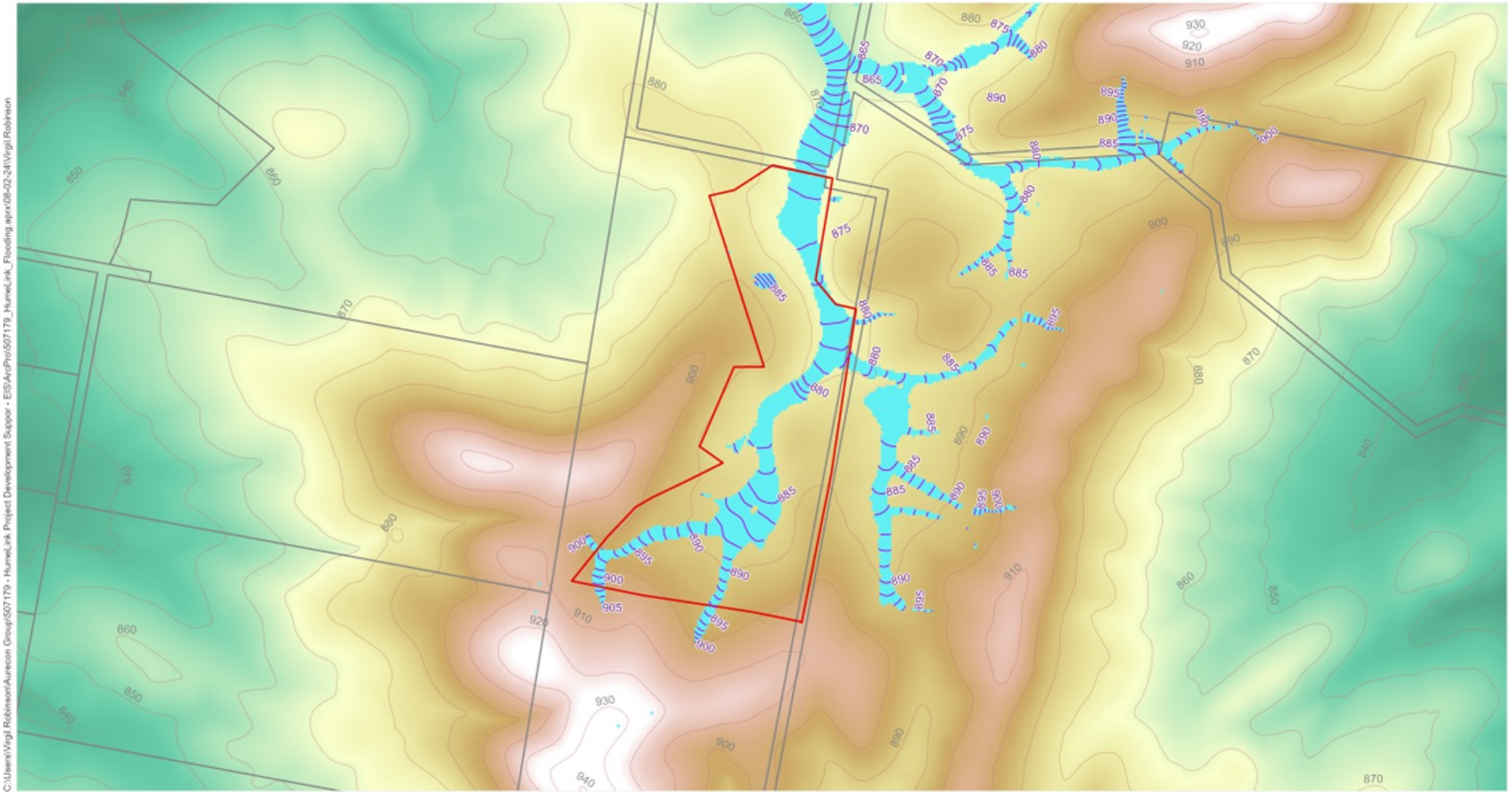
Projection: GDA 1994 MGA Zone 55

HumeLink **Hydrology and Flooding**

FIGURE 6-7: Yass accommodation facility and compound (AC05) existing 2% AEP peak flood level

6.1.1.2.4 Crookwell accommodation facility and compound (AC06)

The site is not at risk of regional flooding. The local flood modelling indicated that the site is subject to local flooding from the local catchment. An overland flow path conveying localised surface runoff flows through the middle of the site in a 2% AEP event and divides the site isolating northern and southern flood free areas (refer to Figure 6-8). Any earthworks or civil structures within the flood prone areas (ie the middle of the site) are expected to result in impacts on local flooding.



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

1:7,500
0 175 350m

Projection: GDA 1994 MGA Zone 55

HumeLink **Hydrology and Flooding**

FIGURE 6-8: Crookwell accommodation facility and compound (AC06) existing 2% AEP peak flood level

6.1.1.2.5 Green Hills accommodation facility and compound (AC07)

The flood risk for this site is predicted to be local drainage and managed through the site stormwater management plan. As a result, construction activities are not expected to impact the local flooding.

6.1.2 Impact of flooding on construction activities

Flooding has the potential to impact construction activities including the construction of the proposed Gugaa 500 kV substation, transmission line structures, access track work, and modification of existing substations. Potential flooding impacts are present where work is proposed in flood prone areas. During construction, stockpiled spoil, topsoil, materials, equipment and machinery have the potential to be washed away or scoured out by overland flows in a flood event, particularly if located near waterways and drainage lines. Excavations could potentially become filled with flood water, requiring dewatering, and embankments may become unstable. These site-based risks would be managed through a CEMP that would outline practices and risk management measures to mitigate site specific risks from flooding.

6.1.2.1 Construction compound sites

The flood modelling assessments at the new and amended construction compounds were carried out for the 5% AEP event in accordance with the flood immunity criteria. A summary of the type of assessment undertaken for each construction compound and the impacts of flooding on construction activities are provided in Table 6-4.

Table 6-4 Summary of local and regional flooding on construction activities for construction compounds

Construction compound	Assessment undertaken	Impact on construction activities in a 5% AEP event
Amended Gregadoo Road compound (C06)	Two-dimensional flood modelling	Regional flood risk from O'Briens Creek remains unchanged in comparison to *Technical Report 11 – Hydrology and Flooding Impact Assessment* prepared for the EIS. Local overland flooding observed through the site could result in impacts on construction activities.
Amended Honeysuckle Road compound (C07)	Desktop assessment based on topography	Located on high ground. No regional flood risk. Unlikely to cause impacts on construction activities.
Amended Bannaby 500 kV substation compound (C12)	Two-dimensional flood modelling	Located on the hillside of the local catchment. No regional flood risk. Local drainage management required for the extended area to the west as part of the amended project.
Ardrossan Headquarters Road compound (C17)	Two-dimensional flood modelling	Located on the hillside of the local catchment. No regional flood risk. Local drainage management required.
Snubba Road compound (C18)	Desktop assessment based on topography	Located on high ground. No regional flood risk. Unlikely to cause impacts on construction activities. Local drainage management likely required.
Gadara Road compound (C19)	Two-dimensional flood modelling	No regional flood risk. Local overland flooding observed through the site that could result in impacts on construction activities.
Ellerslie Road compound (C21)	Two-dimensional flood modelling	No regional flood risk. Minor encroachment of local flooding expected along the northern boundary of the site. Unlikely to impact construction activities due to minor extent of encroachment.

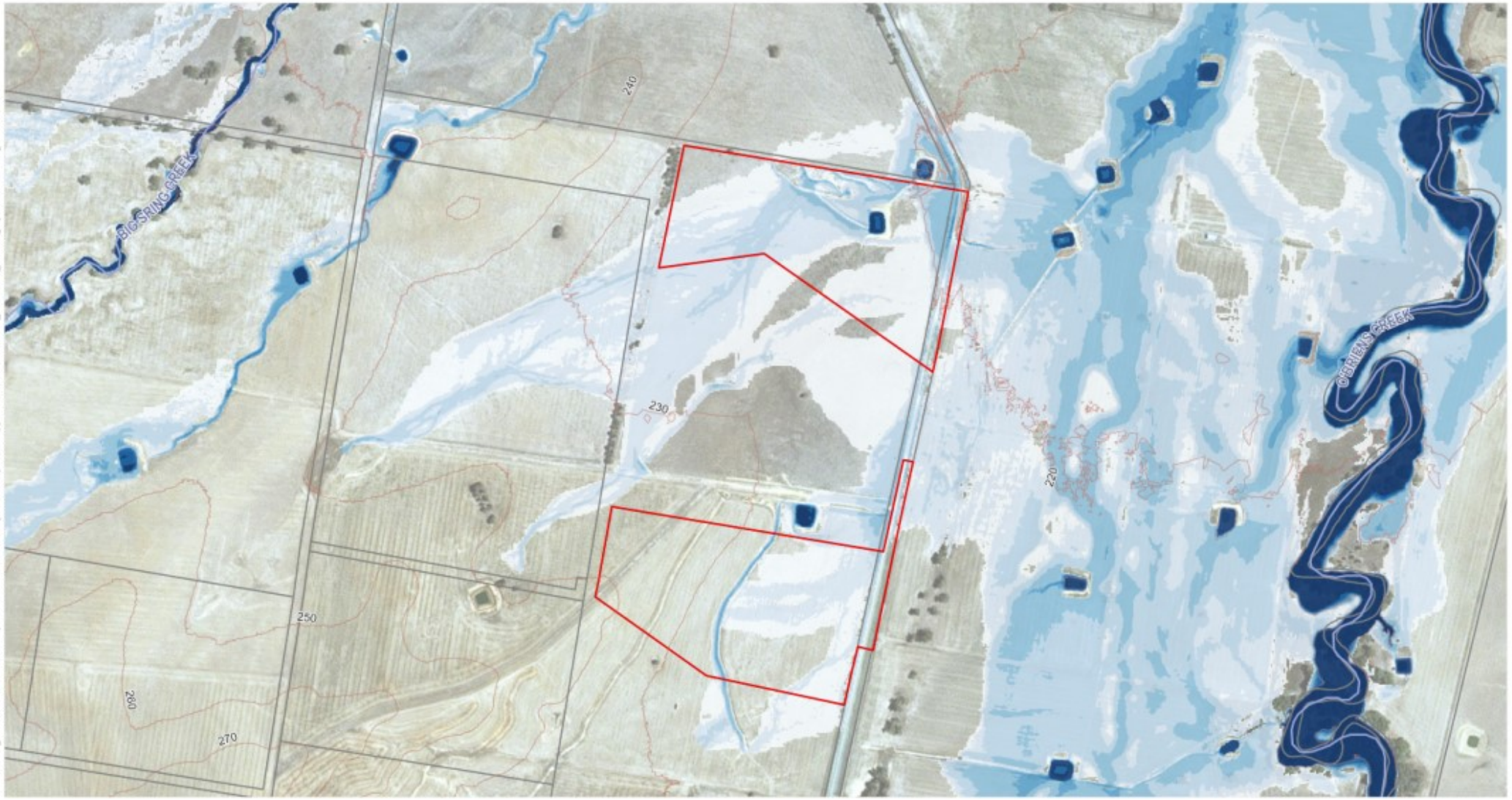
6.1.2.1.1 Amended Gregadoo Road compound (C06)

As detailed in Section 6.1.1.1.1, the Amended Gregadoo Road compound (C06) comprises of a northern and southern portion. Both portions of the construction compound are susceptible to overland flooding in the 5% AEP flood event (refer Figure 6-9). Undertaking construction activities without considering local flood management options has the potential to impact construction activities. Most of the northern portion of the construction compound is subject to flooding. In contrast, the southern portion of the construction compound has some flood free area to the west of the unnamed channel dividing the site.

Flood hazard classification for the Amended Gregadoo Road Compound is shown in Attachment C. The majority of the flood extent observed for the amended compound is classified under the 'H1' category of ARR2019 Flood Hazard Classification (refer to Attachment D) which generally safe for people, vehicles, and buildings.

The assessment, as mentioned in Section 6.1.1.1, is based on the 5% AEP flood extent under existing conditions. Depending on the construction timeline for the construction of the proposed Gugaa 500 kV substation, a review of the impacts on flooding at the Amended Gregadoo Road compound (C06) may need to be undertaken.

The impact assessment outcome for construction activities on flooding at the Amended Gregadoo Road Compound (C06) aligns with the conclusions presented in the *Technical Report 11 – Hydrology and Flooding Impact Assessment* prepared for the EIS.



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

Flood Depth (m)

<= 0.03
0.03 - 0.1
0.1 - 0.25
0.25 - 0.5
0.5 - 0.75
0.75 - 1
1 - 1.5
> 1.5

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

1:8,000
0 180 360m

Projection: GDA 1994 MGA Zone 55

HumeLink **Hydrology and Flooding**

FIGURE 6-9: Amended Gregadoo Road Compound (C06) existing 5% AEP peak flood depth

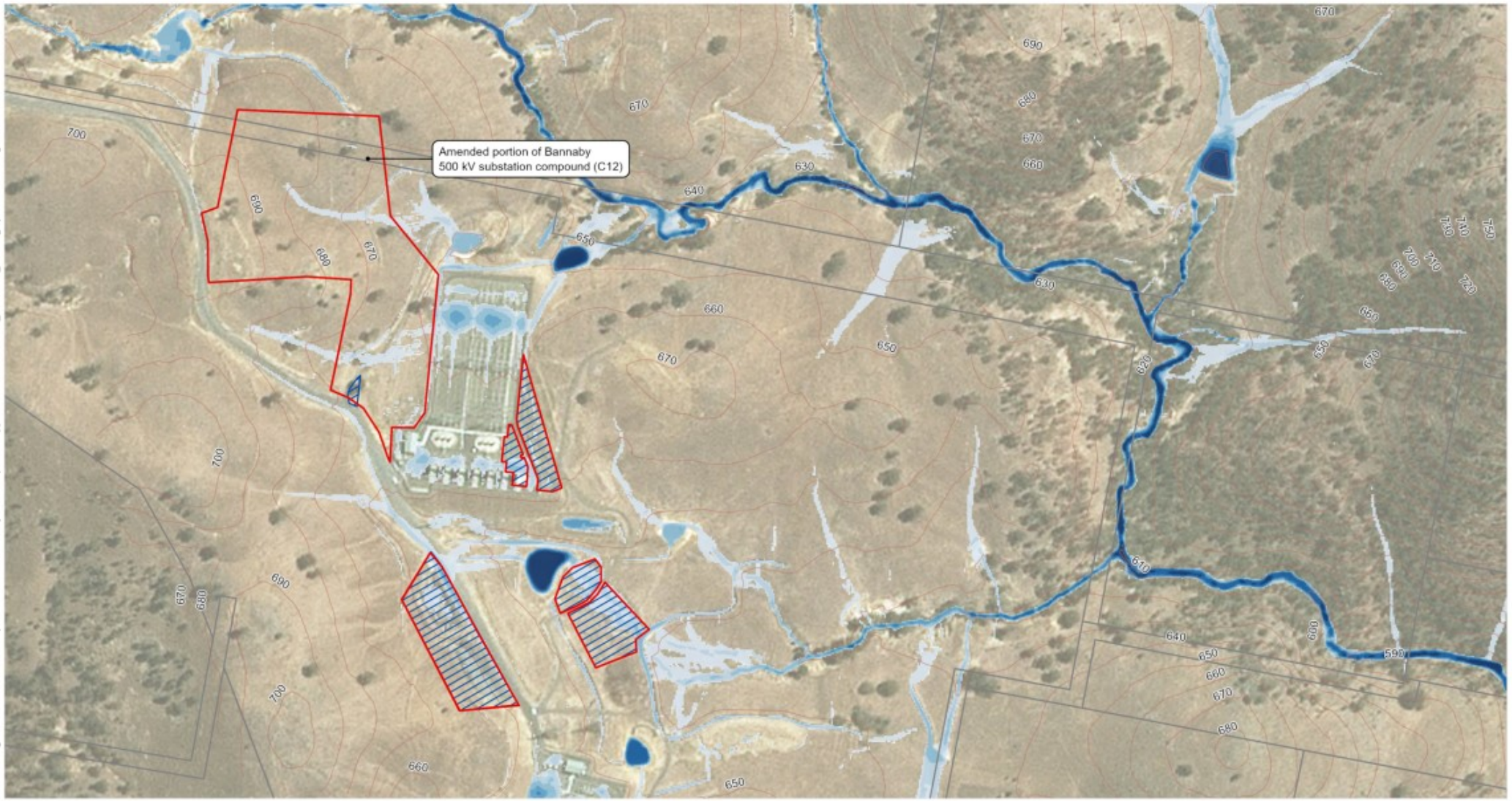
6.1.2.1.2 Amended Honeysuckle Road compound (C07)

With a minor upstream catchment area, there are no major waterways around the construction compound (refer to Figure 5-2). Further investigation of the regional flood modelling results shows that the risk of local flooding at this compound location is unlikely. The impact assessment outcome for construction activities on flooding at the Amended Honeysuckle Road compound (C07) aligns with the conclusions presented in *Technical Report 11 – Hydrology and Flooding Impact Assessment* prepared for the EIS.

6.1.2.1.3 Amended Bannaby 500 kV substation compound (C12)

As mentioned in Section 6.1.1.1, the amended Bannaby 500 kV substation compound introduces an additional compound area to the north-west of the existing Bannaby 500 kV substation. No changes to the flooding and drainage risk management are proposed for the areas previously assessed in the EIS. The local flood modelling predicts that the additional area in the amended footprint has two shallow overland land flow paths flowing west to east that have the potential to impact the construction activities within the observed 5% AEP flood event (refer to Figure 6-10). Local drainage management will be required to limit impacts on construction activities. Flood hazard classification for the amended Bannaby 500 kV substation compound is shown in Attachment C. The majority of the flood extent observed for the amended compound is classified under the 'H1' category of ARR2019 Flood Hazard Classification (refer to Attachment B) which is generally safe for people, vehicles, and buildings.

The impact assessment outcome for construction activities on flooding at the Amended Bannaby 500 kV substation compound (C12) aligns with the conclusions presented in the *Technical Report 11 – Hydrology and Flooding Impact Assessment* prepared for the EIS.



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

Flood Depth (m)

<= 0.03
0.03 - 0.1
0.1 - 0.25
0.25 - 0.5
0.5 - 0.75
0.75 - 1
1 - 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 6-10: Amended Bannaby 500 kV substation compound (C12) existing 5% AEP peak flood depth

6.1.2.1.4 Snubba Road compound (C18)

The site is located near the catchment ridge with an undulating topography ranging from approximately 1,090 to 1,110 mAHD (refer to Figure 5-5). Waterways around the site are therefore draining away from the construction compound. The construction activities are unlikely to be affected by regional flooding at 1% AEP. As the construction compound footprint is located near the catchment ridge, it may be subject to some shallow overland flow within the footprint but is unlikely to have any flood risk to construction activities at a local catchment level. The risk of overland flow can be managed by maintaining local drainage.

6.1.2.1.5 Ardrossan Headquarters Road compound (C17)

The site is located to the west of Germans Creek. Regional modelling indicated there is no risk of flooding; however, the local flood risk to the site was investigated further through the development of a local flood assessment.

The local flood assessment also indicated that the site is not at risk of local flooding; however, several minor drainage lines cross the site. These local drainage lines may require onsite drainage management subject to the final site layout. The local 5% AEP flood depths are shown in Figure 6-11.

HumeLink **Hydrology and Flooding**

FIGURE 6-11: Ardrossan Headquarters Road compound (C17) existing 5% AEP peak flood depth

6.1.2.1.6 Gadara Road compound (C19)

No regional flood risk from Sandy Creek is predicted. The local flood assessment predicts that the site is at risk of local flooding in the 5% AEP event (refer to Figure 6-12). An overland flow path is observed along the north-western boundary of the construction compound which traverses through the site and exits at the southern boundary. This overland flow path has the potential to affect all construction activities planned within the extent of the flow path. To manage potential impacts, there is need for a drainage easement through the site to maintain the existing drainage behaviour or a stormwater management plan to manage the potential impacts. These management measures would be considered further during ongoing design development.

Flood hazard classification for the Gadara Road Compound is shown in Attachment C. Majority of the flood extent observed for the proposed compound is classified under the 'H1' category of ARR2019 Flood Hazard Classification (refer to Attachment B) which is generally safe for people, vehicles, and buildings. A 'H2' hazard classification is seen in a portion within the observed overland channel traversing through the compounds that indicates an area which is unsafe for small vehicles.

Construction compound
Cadastre
Surface level contour (10m AHD interval)
Named waterway
Flood Depth (m)
<= 0.03
0.03 - 0.1
0.1 - 0.25
0.25 - 0.5
0.5 - 0.75
0.75 - 1

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

1:4,000
0 90 180m

Projection: GDA 1994 MGA Zone 55

HumeLink **Hydrology and Flooding**

FIGURE 6-12: Gadara Road compound (C19) existing 5% AEP peak flood depth

6.1.2.1.7 Ellerslie Road compound (C21)

Local flood modelling was carried out for Ellerslie Road compound (C21) for the 5% AEP flood event (refer to Figure 6-13). Results from this assessment indicate minor inundation along the northern boundary which could impact construction activities in this area. To minimise the impact from local flooding, any construction activities along the northern boundary should be avoided.

FIGURE 6-13: Ellerslie Road compound (C21) existing 5% AEP peak flood depth

6.1.2.2 Combined accommodation facilities and compounds

The flood modelling assessments at the combined worker accommodation facilities and construction compounds were carried out for the 2% AEP event in accordance with the flood immunity criteria. A summary of the type of assessment undertaken for each combined worker accommodation facility and construction compound and the impacts of flooding on construction activities are provided in Table 6-5.

Table 6-5 Summary of local flooding on construction activities for the combined accommodation facilities and construction compounds

Combined accommodation facilities and construction compounds	Assessment Undertaken	Impact on construction activities in a 2% AEP event
Tarcutta accommodation facility and compound (AC03)	Desktop assessment based on topography	No regional or local flood risk. Local drainage management will be required.
Adjungbilly accommodation facility and compound (AC04)	Two-dimensional flood modelling	No regional flood risk. Local overland flow paths observed passing through the site have the potential to cause impacts on construction activities.
Yass accommodation facility and compound (AC05)	Two-dimensional flood modelling	No regional flood risk. Site compound and accommodation facility has the potential for minor encroachment of local flooding from Bango Creek along the north-western and southern boundary of the site. Construction activities within this area could be affected by flooding.
Crookwell accommodation facility and compound (AC06)	Two-dimensional flood modelling	No risk from regional flooding. Local flooding is expected through the site, isolating flood free areas. Local flooding has the potential to affect construction activities.
Green Hills accommodation facility and compound (AC07)	Desktop assessment based on topography	No regional or local flood risk. Local drainage management will be required.

6.1.2.2.1 Tarcutta accommodation facility and compound (AC03)

Local catchments to the south of Mates Gully Road were investigated for local flood risk (refer to Section 5.8 and Figure 5-9). Based on the expected magnitude of runoff and the limited drainage information available at this stage, it was determined that impacts to construction activities at the combined worker accommodation facilities and construction compound would be minor and manageable via site drainage management. A detailed explanation of the adopted methodology for this location is outlined in Attachment E.

6.1.2.2.2 Adjungbilly accommodation facility and compound (AC04)

Local flood modelling was carried out for the Adjungbilly accommodation facility and compound (AC04) site. Results from this assessment indicate that the site is subjected to localised overland flooding via an overland flow path in the 2% AEP flood event (refer to Figure 6-14). This flow path traverses through the site in an east-west direction. There are also multiple drainage lines along the northern side of the main overland flow path and one along the southern boundary. Construction activities and people living at the combined worker accommodation facility and construction compounds have the potential to be impacted and require consideration in the site layout and drainage management design. Flood impacts would be considered during development of the site layout design to avoid and/or minimise impacts.

Flood hazard classification for the Adjungbilly Accommodation Facility and Compound is shown in Attachment C. Majority of the flood extent observed for the proposed compound is classified under the 'H1' category of ARR2019 Flood Hazard Classification (refer to Attachment B) which is generally safe for people, vehicles, and buildings. A 'H2' and 'H3' classification is seen within existing reservoir extent at the compound's western boundary. 'H2' classification extent indicates the area, which is unsafe for small vehicles, whereas the 'H3' classification extent indicates the area which is unsafe for vehicles, children, and elderly.

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

Flood Depth (m)

<= 0.03
0.03 - 0.1
0.1 - 0.25
0.25 - 0.5
0.5 - 0.75
0.75 - 1
1 - 1.5
> 1.5

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

1:6,250
0 140 280m

Projection: GDA 1994 MGA Zone 55

HumeLink **Hydrology and Flooding**

FIGURE 6-14: Adjungbilly accommodation facility and compound (AC04) existing 2% AEP peak flood depth

6.1.2.2.3 Yass accommodation facility and compound (AC05)

Local flood modelling was carried out for the Yass accommodation facility and compound (AC05) site. Results from this assessment indicate that the site is inundated along the north-western and southern boundary due to the flooding of Bango Creek in the 2% AEP flood event, which is located approximately 15 metres from the site. The inundation along these boundaries is observed in the 2% AEP event (refer to Figure 6-15).

Flood hazard classification for the Yass accommodation facility and compound is shown in Attachment C. The overland flow channel extent observed for the proposed compound is classified under the 'H1' category of ARR2019 Flood Hazard Classification (refer to Attachment B) which generally safe for people, vehicles, and buildings. However, the observed flood extent along the western boundary and southern boundary of the compound is classified up to 'H5' hazard category, which is considered unsafe for people and vehicles, all buildings vulnerable to structural damage. Some less robust building types vulnerable to failure.

Construction activities and workers residing at the Yass accommodation facility and compound may be impacted by flooding. Flood impacts would be considered during development of the site layout design to avoid and/or minimise impacts.

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FIGURE 6-15: Yass accommodation facility and compound (AC05) existing 2% AEP peak flood depth

6.1.2.2.4 Crookwell accommodation facility and compound (AC06)

Local flood modelling was carried out for the Crookwell accommodation facility and compound (AC06). The results show that an overland flow path traverses the site, dividing the site and isolating areas within the combined worker accommodation facility and construction compound in the 2% AEP event. This has the potential to impact aspects such as the site layout and area available for construction activities. Flood impacts would be considered during development of the site layout design to avoid and/or minimise impacts.

Given that this site would also be used as a worker accommodation facility, internal access and emergency egress is critical to consider as part of site planning. The 2% AEP flood depths across the site are shown in Figure 6-16.

Flood hazard classification for the Crookwell Accommodation Facility and Compound is shown in Attachment C. Majority of the flood extent observed for the proposed compound is classified under the 'H1' category of ARR2019 Flood Hazard Classification (refer to Attachment B) which is generally safe for people, vehicles, and buildings. The central water body has a classification of 'H4' which indicates that it is unsafe for people and vehicles.

6.1.2.2.5 Green Hills accommodation facility and compound (AC07)

The Green Hills accommodation facility and compound (AC07) was identified as being free from local and regional flooding due to its high elevation (refer Figure 5-13). As a result, no impact of flooding on construction activities is predicted; however consideration of local drainage may be required in the site design for any shallow overland flow.

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

1:7,500
0 175 350m

Projection: GDA 1994 MGA Zone 55

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FIGURE 6-16: Crookwell accommodation facility and compound (AC06) existing 2% AEP peak flood depth

6.2 Operational impacts

6.2.1 Impact of operations on flooding

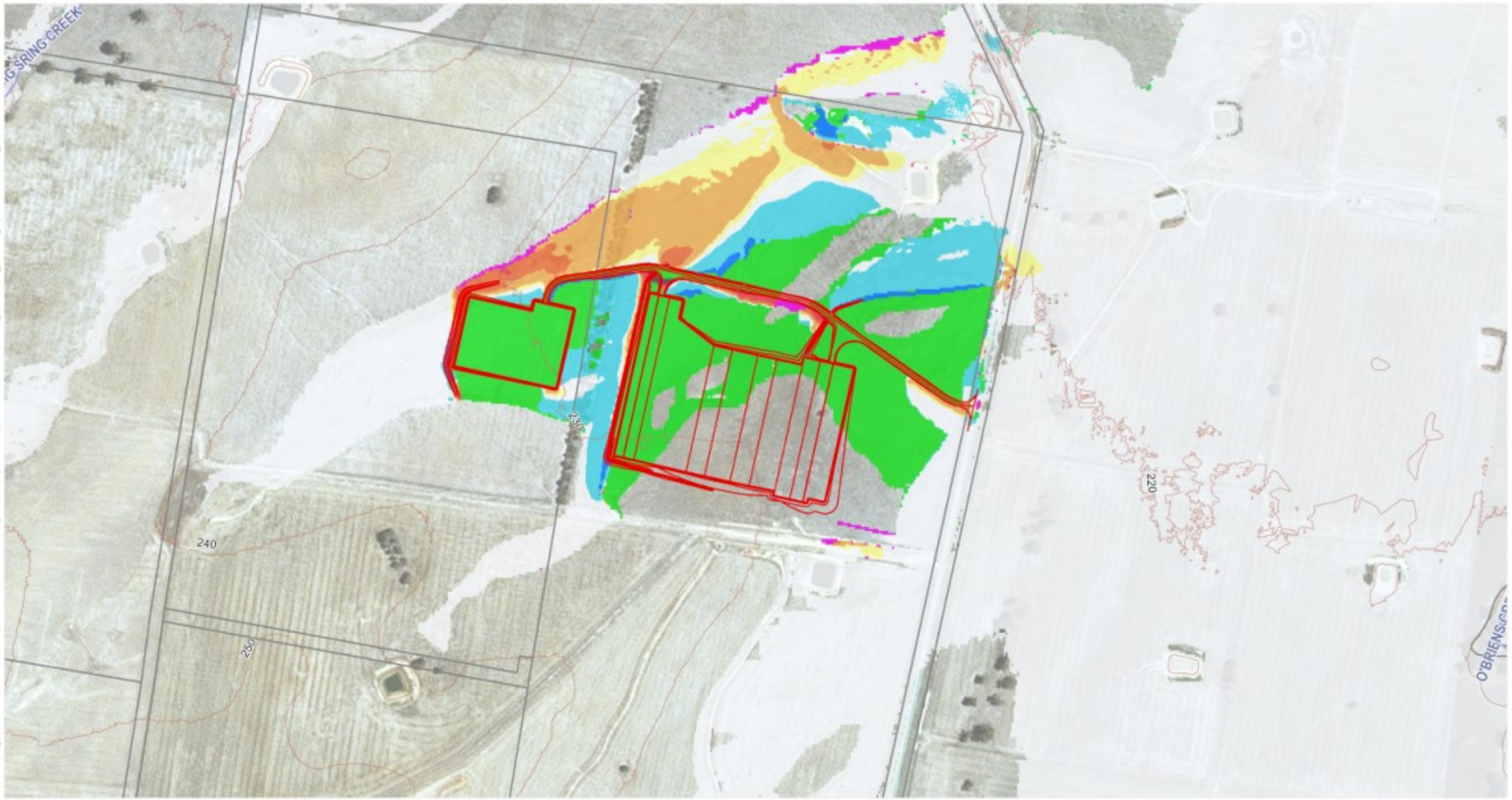
6.2.1.1 Proposed Gugaa 500 kV substation

The flood investigation undertaken by Lyall & Associates investigated the impact of the proposed Gugaa 500 kV substation on flooding (refer to Attachment G).

The flood investigation determined that the flooding condition on the wider O'Briens Creek floodplain remains unchanged from the previous Lyall & Associates assessment (October 2022) as presented in the EIS. Therefore, the impacts described below for the proposed Gugaa 500 kV substation are based on the nature of flooding in the immediate vicinity of the proposed substation. Based on observed flood behaviour, potential impacts due to the revised layout of the Gugaa 500 kV substation include:

- The potential obstruction of two existing overland flow paths that originate from the south-western corner of the proposed substation.
- A concentration of flow in the north-western corner of the small (west) and large (east) elevated bench area that further increases depth and velocities in the areas downstream.
- Minor increases in flood levels to privately owned land to the north. Increases in flood levels are in the order of 0.03 metres in the 1% AEP flood event. Peak velocities would also increase up to 0.13 m/s for the same event.
- A similar minor increase in depth and velocity is observed in the flow over Livingstone Gully Road adjacent to the north-eastern corner of the substation during the 1% AEP flood. Flood levels would increase by less than 0.04 metres in this area along with flow velocities over the road increasing up to 0.4 m/s for the same event.

Overall, the impacts on flooding due to the proposed Gugaa 500 kV substation are minor in magnitude and no dwellings are affected on the impacted adjacent properties. Flood hazard is unchanged on Livingstone Gully Road. The impact on flood levels (afflux) in the 1% AEP are presented in Figure 6-17. Other related flood mapping is presented in Attachment F.



Substation extent
Cadastre
Surface level contour (10m AHD interval)
Named waterway

Flood Afflux (m)

< -0.1
-0.01 - -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 Dry Now Wet
Was Wet Now Dry

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

1:6,000
0 140 280m

Projection: GDA 1994 MGA Zone 55

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FIGURE 6-17: Gugaa 500kV Substation 1% AEP peak flood afflux

6.2.1.2 Transmission line structures and access tracks

The amended project includes a new 32.5 kilometre transmission line corridor which extends from Wondalga through the Green Hills State Forest before travelling to the west and south of Batlow and connecting to the EIS project transmission line route in Bago State Forest (refer to Figure 1-2).

As per *Technical Report 11 – Hydrology and Flooding Impact Assessmen*t prepared for the EIS, flooding is unlikely to be impacted due to the form and height of the transmission line structures.

Access to the easement during operation would be mostly through existing public and private roads, and existing tracks and new tracks. New tracks would be created for construction where required and may be retained during operation of the amended project to provide safe access to infrastructure for maintenance activities. At this stage, it is not known which access tracks would be temporary or permanent as this is subject to landholder consultation. For the purposes of this assessment, a conservative approach has been taken and it is assumed that all access tracks would be permanent.

The access tracks which cross or are near waterways have the potential to impact flooding. No flood immunity requirements are currently proposed for the access tracks. Therefore, they can be developed at existing grade and cross watercourses at low depths with suitable cross drainage to minimise their obstruction to flow. By minimising the flow obstruction, the consequential impact on flood behaviour would be minimised. However, if required, the design of these access tracks should consider the necessary elevation to achieve a desired level of flood immunity and suitable cross drainage to minimise impacts on flooding.

Impacts on flooding due to the operation and utilisation of access tracks would be minimal and localised.

Table 6-6 provides a summary of the anticipated number of new access track crossings based on the following classification:

- **major crossing**: access tracks crossing watercourses classified as Strahler stream order 6
- **moderate crossing**: access tracks crossing watercourses classified as Strahler stream order 4
- **minor crossing**: access tracks crossing watercourses classified as Strahler stream order 4 or lower.

Table 6-6 Summary of access tracks crossing watercourses.

Crossing Classification	Major	Moderate	Minor
New access track crossings	4	5	75

Note: Assessment is based on preliminary access track alignments. Multiple crossings of the same stream order for the same section of access track has not been accounted for in the summary of access track crossings.

The assessment indicated that most new crossings traverse minor order waterways and as such would have limited to no discernible impact on flooding. All crossings are in remote locations with no known sensitive infrastructure nearby that would be impacted by the changes in flood behaviour. Overall, it is anticipated that the new tracks would only have a minor to negligible impact on flooding.

New access track crossings would be reassessed as a part of detailed design when the cross-drainage structures and access track levels are better understood to ensure flood mitigation measures are incorporated, if required.

6.2.2 Impact of flooding on operations

6.2.2.1 Proposed Gugaa 500 kV substation

As outlined in Section 6.2.1.1, the proposed Gugaa 500 kV substation has the potential to obstruct two overland flow paths that discharge into O'Briens Creek, east of the substation. This obstruction could result in the following flood-related impacts on the operation of the proposed substation:

- The proposed substation would result in a slight increase in water levels, potentially causing additional overtopping of Livingstone Gully Road to the north-east of the substation. This could have potential implications for accessing the substation via Gregadoo East Road and Livingstone Gully Road. Nevertheless, this elevation is limited to 0.04 metres in the 1% AEP flood event and can be considered minor, given the current flooding impacts during this flood event at this location.
- The access road (west entrance to the large, elevated bench) shows an increase in flood level (up to 420 millimetres) in the 1% AEP flood event. This can cause limited access to the substation during the 1% AEP flood event, noting however that Transgrid substations are unattended and operated remotely.
- In the probable maximum flood (PMF) event, the access road to the substation has a significant increase in water level (up to 950 millimetres). During this event, the flood extent would inundate the north-western corner of the large, elevated bench to a maximum depth of approximately 0.5 metres, noting however that Transgrid substations are unattended, operated remotely and some access and local roads such as Livingstone Gully Road would also be inundated.
- Flood hazard classification for the Gugaa 500 kV substation is shown in Attachment C. The majority of the flood extent observed for the proposed substation is classified under the 'H1' category of ARR2019 Flood Hazard Classification (refer to Attachment B) which is generally safe for people, vehicles, and buildings.

A review of the impacts on operations should be undertaken during detailed design to confirm any changes to the impacts are still considered manageable. Refer to Attachment F and Attachment G.

6.2.2.2 Transmission line structures and access tracks

As per *Technical Report 11 – Hydrology and Flooding Impact Assessment* prepared for the EIS, flooding is unlikely to impact the operation of the transmission line structures due to their form and height.

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.

A summary of the assessment of the regional flood risk is presented in Table 6-7. Regional flood depth and hazard mapping for each location have been provided in Attachment D.

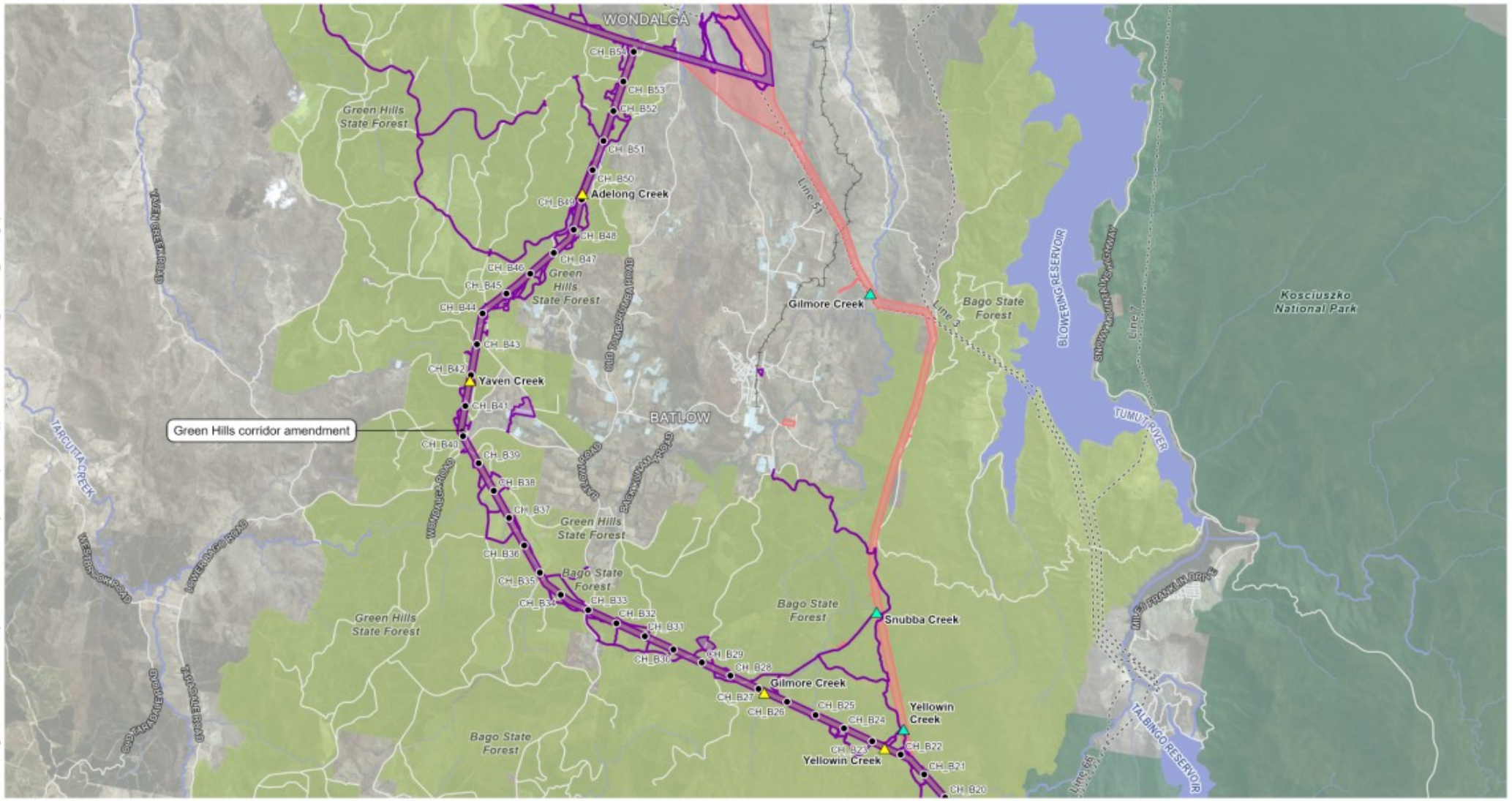
The amended project includes the preferred western route through Green Hills State Forest. The new 32.5 kilometre route extends from Wondalga through the Green Hills State Forest before travelling to the west and south of Batlow and connecting to the EIS project transmission line corridor in Bago State Forest. The assessment of the amended transmission line route identified four new waterway crossings, replacing three crossings presented in the Technical Report 11 - Hydrology and Flood Impact Assessment. The specific modifications in the locations are illustrated in Figure 6-18 below.

Waterway crossing locations are referenced using chainages. Chainages for the amended project corridor footprint are presented in Figure 4-1. Chainage references are for the purposes of referencing the location of the waterway intersections discussed in this report only. Flood maps for all four watercourse intersections are provided in Attachment C. The regional flood assessment has identified that there are no waterway intersections with 'major' flood characteristic classification.

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

Table 6-7 Summary of regional flooding at key locations along the transmission line route

River intersection	Catchment	Gauge catchment	Stream Order Classification	Map ID
Adelong Creek	Murrumbidgee Catchment	Adelong Creek at Batlow Road (410061)	Minor Stream	Attachment D, Figure D-1, D-2
Yaven Creek	Murrumbidgee Catchment	Hillas Creek at Mount Adrah (410043)	Minor Stream	Attachment D, Figure D-3, D-4
Gilmore Creek	Murrumbidgee Catchment	Tumut River at upstream Nimbo offtake (410199)	Minor Stream	Attachment D, Figure D-5, D-6
Yellowin Creek	Murrumbidgee Catchment	Tumut River at upstream Nimbo offtake (410199)	Minor Stream	Attachment D, Figure D-7, D-8



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

1:125,000

0 2.5 5km

Projection: GDA 1994 MGA Zone 55

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FIGURE 6-18: New waterway crossings along the Green Hills corridor amendment

6.3 Impact of climate change

The impact of climate change has been assessed for the proposed Gugaa 500 kV substation. The assessment, undertaken by Lyall & Associates (2023), adopted the 0.5% AEP flood event as a proxy for the 1% AEP change scenario. This flood event is in the order of a 15 per cent increase in rainfall compared to the 1% AEP event.

The impact of climate change on flooding (flood risk to the substation) and the change in the impact on flooding resulting from the substation are presented in Table 6-8.

Table 6-8 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 due to climate change (mm)
Gugaa 500 kV	226 - 231	5-10	15-20

Note:

- Gugaa 500 kV substation results are extracted from *Gugaa 500 kV Substation Addendum Flooding Report* (Lyall & Associates, 2023) and reflect the results for the 0.5% 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 around five to 10 millimetres under future climate conditions. This increase has no discernible impact at the substation site.

The proposed Gugaa 500 kV substation bench is above the PMF level with the exception of the north-western corner of the site (refer to Attachment F), and therefore would not be impacted by the future climate risk, given the PMF is a far greater event. Nonetheless, all electrical equipment is elevated above ground level, providing freeboard to the critical components. With respect to flooding impacting access, as previously mentioned, Transgrid sites will be operated remotely therefore access to the sites under future climate flood conditions is not considered a risk.

Considering the influence of the substation on flood conditions, the proposed Gugaa 500 kV substation proposes filling across two benches. Despite these changes, the overall effect of the development on flooding remains comparable to the current situation under existing climate conditions.

6.4 Cumulative impacts

Since the public exhibition of the EIS, an updated cumulative impact search has been undertaken. This updated search has identified the following two proposed projects that had not been considered in Chapter 25 (Cumulative impacts) of the EIS:

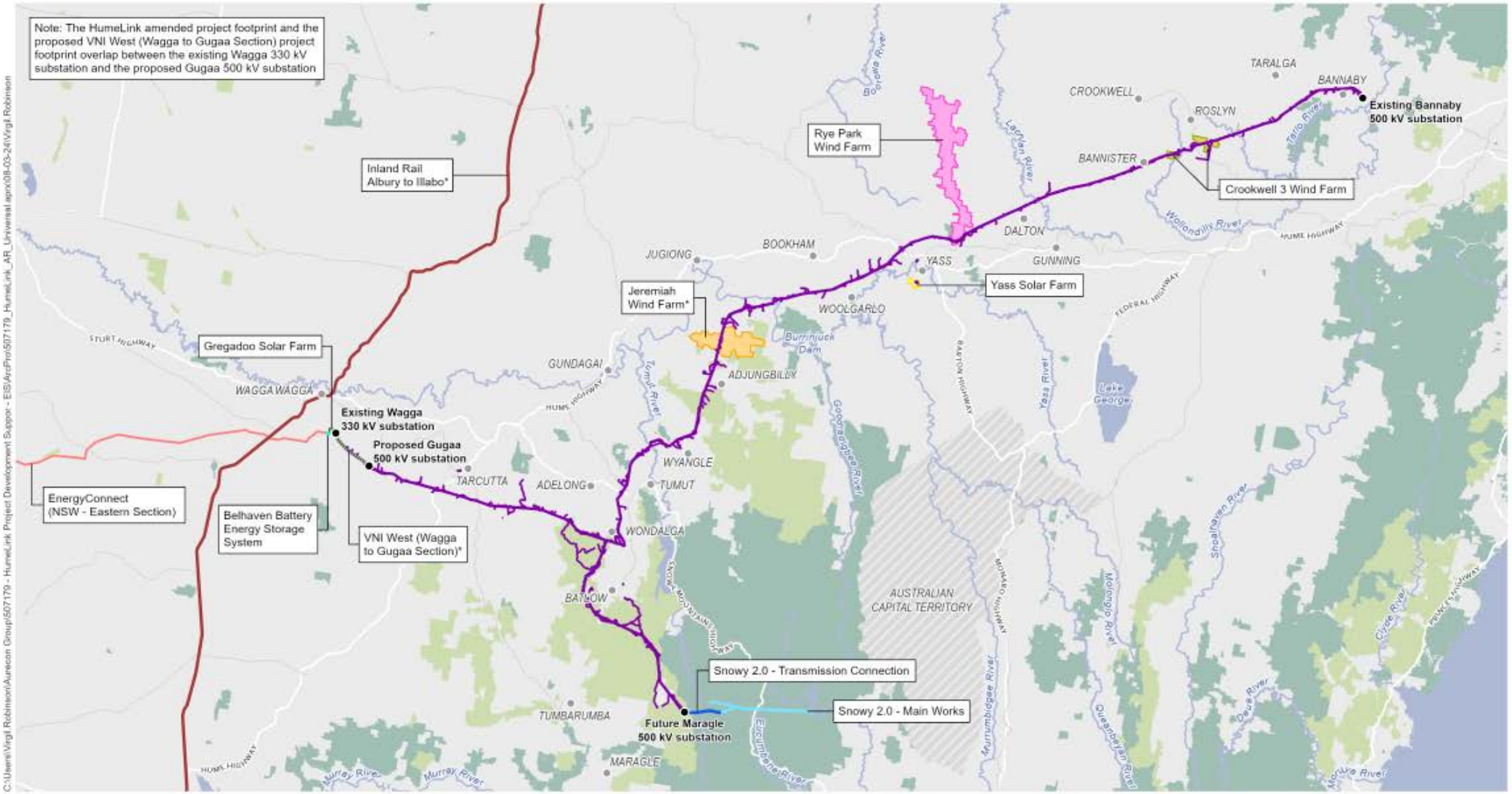
- Belhaven Battery Energy Storage System
- Yass Solar Farm.

Table 6-9 presents the cumulative impacts of the amended project for these two newly identified proposed project.

A qualitative desktop approach was adopted to carry out the assessment for cumulative impacts mentioned above. The location of projects for which cumulative impacts were considered relative to the amended project is set out in Figure 6-18.

Table 6-9 Summary of cumulative impacts identified

Project	Details	Status	Distance and Interface	Cumulative Impacts
Belhaven Battery Energy Storage System	Construction and operation of a 400 MW / 800 MWh Battery Energy Storage System including transmission connection and associated infrastructure.	EIS being prepared SEARs issued on 18/05/2023	The main site is located about 1.5 km west of the existing Wagga 330 KV substation, but a connection from BESS to the substation (most likely underground) is proposed. Based on publicly available information there are likely to be overlapping construction programs.	The proposed Belhaven Battery Energy Storage System is situated near the Wagga 330kV substation compound (C01). The Wagga 330kV substation and compound (C01) was evaluated in the EIS and does not form part of the amended project assessed in this report. No offsite adverse impacts are predicted from the Wagga 330kV substation and compound (C01) (refer to *Technical Report 11 – Hydrology and Flooding Impact Assessment* prepared for the EIS). Offsite adverse flood impacts from Belhaven Battery Energy Storage System would be unlikely as offsite impacts are expected to be mitigated through specific management measures. Therefore, it is not anticipated that there would be any cumulative impacts as a result of the proposed works.
Yass Solar Farm	The construction, operation and decommissioning of a 100 MW solar photovoltaic energy generating facility with an associated battery energy storage system	EIS being prepared SEARs issued on 22/12/2023	The site surrounds the Yass substation, and based on publicly available information, there are likely to be overlapping construction programs. However, given the proximity and likely impacts, cumulative impacts are likely limited to the establishment and use of HumeLink's combined worker accommodation facility and construction compound proposed at Yass during construction only.	The proposed Yass Solar Farm is situated near the Yass substation compound (C10). The Yass substation compound (C10) was evaluated in the EIS and does not form part of the amended project assessed in this report. No offsite adverse impacts are predicted from the Yass substation compound (C10) (refer to *Technical Report 11 – Hydrology and Flooding Impact Assessment* prepared for the EIS). Offsite adverse flood impacts from Yass solar farm would be unlikely as offsite impacts are expected to be mitigated through specific management measures. Therefore, it is not anticipated that there would be any cumulative impacts as a result of the proposed works.



Amended project footprint
National park and reserve
State forest
Waterbody
Waterway
Major road
Railway
Substation

Relevant future projects

- Belhaven Battery Energy Storage System
- Crookwell 3 Wind Farm
- EnergyConnect (NSW - Eastern Section)
- Gregadoo Solar Farm
- Inland Rail Albury to Illabo*
- Jeremiah Wind Farm*
- Rye Park Wind Farm
- Snowy 2.0 - Main Works
- Snowy 2.0 - Transmission Connection
- VNI West (Wagga to Gugga Section)*
- Yass Solar Farm

*Note: Subject to approval

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

1:925,000
0 20 40km

Projection: GDA 1994 MGA Zone 55

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FIGURE 6-19: Relevant future projects

7 Management of impacts

Table 7-1 provides a summary of any new or revised mitigation measures required for the project based on the impact assessment. Any new or revised mitigation measures are marked in bold and any mitigation measures that are no longer relevant are ~~struck out~~.

Table 7-1 Revised 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 **and combined worker accommodation facilities and construction compounds**
HF3	Impact on flooding at **all construction compounds and combined worker accommodation facilities and construction compounds** ~~the Snowy Mountains Highway construction compound (C02)~~	**Where possible,** overland flow **paths** up to the 5% AEP event **for construction compounds and 2% AEP for combined worker accommodation facilities and construction compounds** ~~across the southern extent of the Snowy Mountains Highway compound (C02) is~~ **are** 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. **Where bulk filling of flood prone land is required, a flood impact assessment is required to demonstrate the impact of proposed works with consideration of mitigation measures to minimise any downstream impacts.**	Detailed design	**All construction compounds and combined worker accommodation facilities and construction compounds** ~~Snowy Mountains Highway compound (C02)~~

Ref	Impact	Mitigation measures	Timing	Relevant location
HF4	Impact on flooding and drainage at construction compounds**, combined worker accommodation facilities and construction compounds** and Bannaby 500 kV substation	**Where possible,** existing drainage and overland flowpaths will be maintained at ~~the Maragle substation compound (C05)~~, ~~Gregadoo Road compound (C06)~~ **construction compounds, combined worker accommodation facilities and construction compounds** 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~~ ***Managing Urban Stormwater - Soils and Construction, Volume 1*** (Landcom, 2004)**, and *Volumes 2A* (DECC, 2008b) and *2C* (DECC, 2008a), commonly referred to as the 'Blue Book'.**	Detailed design and construction	Maragle substation compound (C05), ~~and~~ **Amended** Gregadoo Road compound (C06)**,** ~~and~~ Bannaby 500 kV substation**, Amended Bannaby 500 kV substation compound (C12), Gadara Road compound (C19), Adjungbilly accommodation facility and compound (AC04), Yass accommodation facility and compound (AC05), Crookwell accommodation facility and compound (AC06), Ardrossan Headquarters Road compound (C17), Ellerslie Road compound (C21).**
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 **proposed Gugaa 500 kV** substation footprint**, unless otherwise approved by NSW Department of Planning, Housing and Infrastructure.**	Detailed design and construction	Proposed Gugaa 500 kV substation

Note:

* Refer to the limitations in Section 4.5.

8 Conclusion

This report documents the hydrology and flood impact assessment carried out for the amended project. The assessment was undertaken using the same methodology and approach as per the EIS. The revised and new construction compounds, new combined worker accommodation facilities and construction compounds and changes to the transmission line corridor were assessed for flood risk from both a regional and local flooding context.

A combination of assessment methodologies was used to assess the flood risk to the amended project. Sites were initially assessed via a desktop approach to understand the proximity to waterways and general topographical location. Where the risk of flooding was identified, more detailed assessment was undertaken, being either flood modelling or hydraulic calculations to assess the risk of flooding.

The Amended Honeysuckle Road compound (C07), Snubba Road compound (C18), and Green Hills accommodation facility and compound (AC07) were identified as being unlikely to be at risk from local flooding. All other sites were all identified for further investigation due to their proximity to waterways. Local flood modelling of these sites was undertaken to quantify the flood risk.

Of the sites investigated further, the modelling identified that the Amended Gregadoo Road compound (C06), Gadara Road compound (C19), Adjungbilly accommodation facility and compound (AC04), Yass accommodation facility and compound (AC05) and Crookwell accommodation facility and compound (AC06) would be impacted by local flooding. These sites either have overland flow paths through or along the boundary of the site that will require consideration or management when designing the site layout, placing infrastructure and considering earthworks.

The Amended Bannaby 500 kV substation compound (C12), Ardrossan Headquarters Road compound (C17), Ellerslie Road compound (C21) and Tarcutta accommodation facility and compound (AC03) were not identified to be at risk of local flooding but require local drainage considerations to manage onsite stormwater in the respective design events.

The assessment identified new waterway crossings within the amended project footprint. The flood risks at these new waterway crossings were assessed as being minor, with flooding mostly confined to the waterway valley. The influence of the newly proposed access tracks on flooding was also qualitatively examined. Most of these tracks intersect with smaller waterways (Strahler stream order 4 or below), where flood risks are relatively low. Given the absence of specific flood immunity requirements for the access tracks, they can be constructed at existing ground levels. This approach, along with the implementation of appropriate cross drainage, is expected to minimise their impact on flood behaviour by reducing their obstruction to flow. Regular maintenance is advised to monitor and manage potential scour risks and ensure the integrity of the drainage infrastructure, even though the tracks are not intended for use during heavy rain or flood events. This report identified relevant flood mitigation and management measures for construction and operation of the amended project. The resulting impacts from and on flooding is considered to generally be minor or low risk and can be managed through proper implementation of the recommended management measures. The overall outcome of the impact assessment conducted for amended project aligns with the conclusions presented in the *Technical Report 11 – Hydrology and Flooding Impact Assessment* prepared for the EIS.

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Attachments

Attachment A
Local modelling methodology

Ancillary Infrastructure models (Local flood models)

Multiple local hydraulic models were created to assess the impact on flooding and construction activities for the relevant construction compounds and combined worker accommodation facilities and construction compounds included in the amended project. An initial desktop assessment of the flood risk was undertaken using the results of the regional scale and a review of the local topography. This process informed the risk of flooding and whether a local flood model was required or not to assess the flood risk and impact of the amended project. Outcome of this process is presented in Table A-1.

Table A-1 Summary of local catchment analysis methodology

Name	ID	Catchment Area	Assessment	Local Model Developed?
Construction compounds				
Amended Gregadoo Road compound	C06	Murrumbidgee Catchment	Located near O'Brian's Creek. Potential local flood risk	Yes
Amended Honeysuckle Road compound	C07	Murrumbidgee Catchment	Located on high ground. No regional flood risk. Unlikely at risk of flooding.	No
Amended Bannaby 500 kV substation compound	C12	Wollondilly Catchment	Evident overland flow paths through the compound. Potential local flood risk	Yes
Ardrossan Headquarters Road compound	C17	Murrumbidgee Catchment	Located near Germans Creek. Potential local flood risk.	Yes
Snubba Road compound	C18	Murrumbidgee Catchment	Located on high ground. No regional flood risk. Unlikely at risk of flooding.	No
Gadara Road compound	C19	Murrumbidgee Catchment	Evident overland flow paths through the compound. Potential local flood risk	Yes
Ellerslie Road compound	C21	Murrumbidgee Catchment	Located near Yaven Yaven Creek. Potential local flood risk.	Yes
Combined worker accommodation facilities and construction compounds				
Tarcutta accommodation facility and compound	AC03	Murrumbidgee Catchment	Located on high ground. No regional flood risk. Unlikely at risk of flooding.	No
Adjungbilly Road accommodation facility and compound	AC04	Murrumbidgee Catchment	Evident overland flow paths through the compound. Potential local flood risk.	Yes
Yass accommodation facility and compound	AC05	Murrumbidgee Catchment	Local near Bango Creek. Potential local flood risk.	Yes
Crookwell accommodation facility and compound	AC06	Murrumbidgee Catchment	Evident overland flow paths through the compound. Potential local flood risk.	Yes
Green Hills accommodation facility and compound	AC07	Murrumbidgee Catchment	Located on high ground. No regional flood risk. Unlikely at risk of flooding.	No

Local Model Resolution

The local models used a finer LiDAR data for model topography with grid sizes of five (5) metres and two (2) metres. No finer sub grid (TUFLOW quadtree) modelling was considered for the local models assessed. The summary of local model grid resolution is provided in Table A-2.

Table A-2 Summary of local model grid size

Local Model	Grid Size
Amended Gregadoo Road compound (C06)	N/A Modelling undertaken by Lyall & Associates
Amended Honeysuckle Road compound (C07)	No modelling undertaken. Desktop assessment only
Amended Bannaby 500 kV substation compound (C12)	2m
Ardrossan Headquarters Road compound (C17)	2m
Snubba Road compound (C18)	No modelling undertaken. Desktop assessment only
Gadara Road compound (C19)	2m
Ellerslie Road compound (C21)	5m
Tarcutta accommodation facility and compound (AC03)	No modelling undertaken. Desktop assessment only
Adjungbilly Road accommodation facility and compound (AC04)	2m
Yass accommodation facility and compound (AC05)	5m
Crookwell accommodation facility and compound (AC06)	5m
Green Hills accommodation facility and compound (AC07)	No modelling undertaken. Desktop assessment only

Local model critical duration analysis

For each of the models undertaken, the total gridded rainfall data obtained from the Bureau of Meteorology was pre-processed based on relevant rainfall region temporal pattern increments, which were then considered as inputs into the hydraulic model. The model was then simulated for multiple durations for all 10 ensemble temporal patterns. The critical temporal pattern was based on the upper median peak flow rather than peak flood level near the site of interest. Further to this, the critical duration (for the selected temporal pattern) was selected based on the maximum peak flow. Peak flow rather than flood level was used to maintain consistency with the peak flow calibration approach used for the regional catchment modelling. The critical duration analysis is summarised in Table A-3.

Table A-3 Summary of local model critical duration analysis

Local Model	ID	Event Modelled	Max flow (m^3/s)	Min flow (m^3/s)	Critical flow (m^3/s) (upper median)	Critical Duration (min)	Critical temporal pattern ID
Amended Bannaby 500 kV substation compound	C12	5% AEP	33.8	23.1	30.9	60	4,568
Ardrossan Headquarters Road compound	C17	5% AEP	15.4	2.4	8.1	540	4,060
Gadara Road compound	C19	5% AEP	3.2	2.5	3.0	20	3,762
Ellerslie Road compound	C21	5% AEP	404.3	290.1	364.5	360	4,039
Adjungbilly Road accommodation facility and compound	AC04	5% AEP	14.1	10.8	12.7	30	3,828
		2% AEP	18.8	14.0	16.5	30	3,830
Yass accommodation facility and compound	AC05	5% AEP	280.2	227.4	264.8	120	3,944
		2% AEP	351.2	283.5	330.6	120	3,944
Crookwell accommodation facility and compound	AC06	2% AEP	9.1	7.4	8.5	30	4,509

Local model critical durations, loss parameters flow summary

The loss parameters (initial and continuing losses) for the local models below are estimated based on the ratio of probability neutral loss value and adopted calibrated value for the 1% AEP regional model for each sub-catchment. This process adheres to the methodology used in *Technical Report 11 – Hydrology and Flooding Impact Assessment* prepared for the EIS.

The local models enveloped within these sub-catchments adopted the respective ratio of probability neutral loss value and adopted calibrated value for the 1% AEP regional model to estimate its adopted initial and continuous loss value for the 5% and 2% AEP respectively. The probability neutral loss values were extracted for 5% AEP and 2% AEP events and modified as per the same calibrated scale ratio with the final adopted values shown in Table A-4.

Table A-4 Construction compound and combined accommodation facility and construction compound critical duration

Local Model	ID	Event Modelled	Critical Duration	Loss Type	Probability neutral loss value	Adopted loss value
Amended Bannaby 500 kV substation compound	C12	5% AEP	60 min	Initial Loss	9.7	0.4
				Continuous Loss	1.2	0.5
Ardrossan Headquarters Road compound	C17	5% AEP	540min	Initial Loss	13.1	49.6
				Continuous Loss	2.1	5.0
Gadara Road compound	C19	5% AEP	20min	Initial Loss	3.7	12.8
				Continuous Loss	1.6	5
Ellerslie Road compound	C21	5% AEP	360min	Initial Loss	14.5	1.0
				Continuous Loss	1.7	0.5
Adjungbilly Road accommodation facility and compound	AC04	5% AEP	30min	Initial Loss	6.1	6.1
				Continuous Loss	1.7	1.9
		2% AEP	30min	Initial Loss	6.0	6.0
				Continuous Loss	1.7	1.9
Yass accommodation facility and compound	AC05	5% AEP	120min	Initial Loss	11.1	0.4
				Continuous Loss	1.5	0.5
		2% AEP	120min	Initial Loss	10.5	*0.4
				Continuous Loss	1.5	*0.5
The Crookwell accommodation facility and compound	AC06	2% AEP	30min	Initial Loss	4.6	0.3
				Continuous Loss	1.2	0.5

Note:

* Initial and Continuous loss values were adopted based on the interpolation of loss values adopted for the 1% AEP and 5% AEP

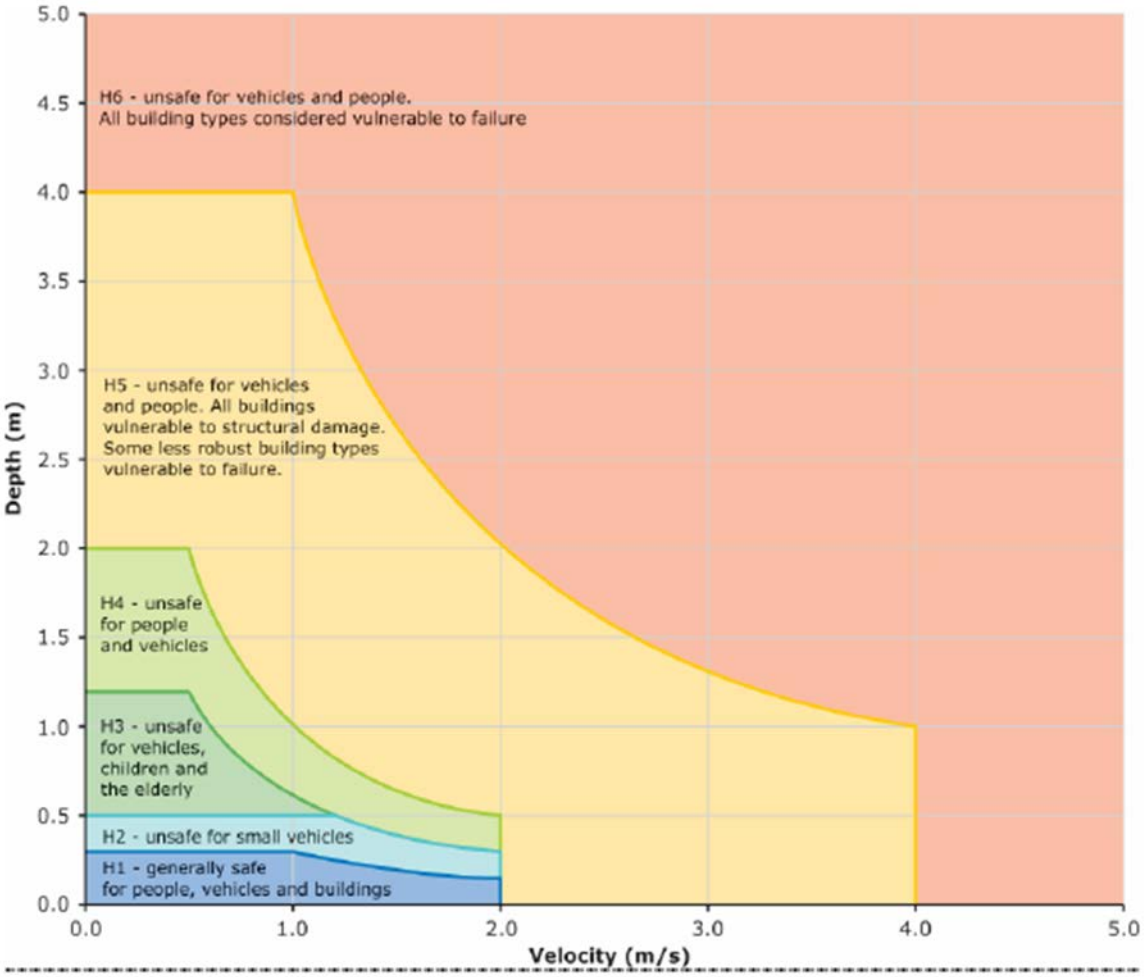
The local model flow values were checked with the online Regional Flood Frequency Estimation (RFFE) model (Australian Rainfall & Runoff, 2022). As a part of this analysis, the critical flow estimated from the TUFLOW local model was compared with the 'Discharge', 'Lower confidence limit', and 'upper confidence limit' of the RFFE model. While the critical flow estimated by the TUFLOW model demonstrates some variance from the RFFE discharge, the flows are within the lower and upper confidence limits for the respective sites.

The TUFLOW critical flow at the Ellerslie Road compound (C21) is considerably higher as compared to the respective RFFE upper confidence limit. Upon further investigation, it was understood that this reflects the methodology adopted to estimate the initial and continuous losses for the local model summarised in Table A-4. The TUFLOW model reflects lower flow (closer to the RFFE upper confidence limit) if the probability neutral losses values from ARR Data Hub are directly used (refer to Table A-4). However, to maintain a consistent approach for all local catchments, no change to the loss values were adopted. In addition, it can be understood that a higher flow from the TUFLOW model in comparison to RFFE assessment provides for a more conservative approach. The summary of local model flow comparison is provided in Table A-5.

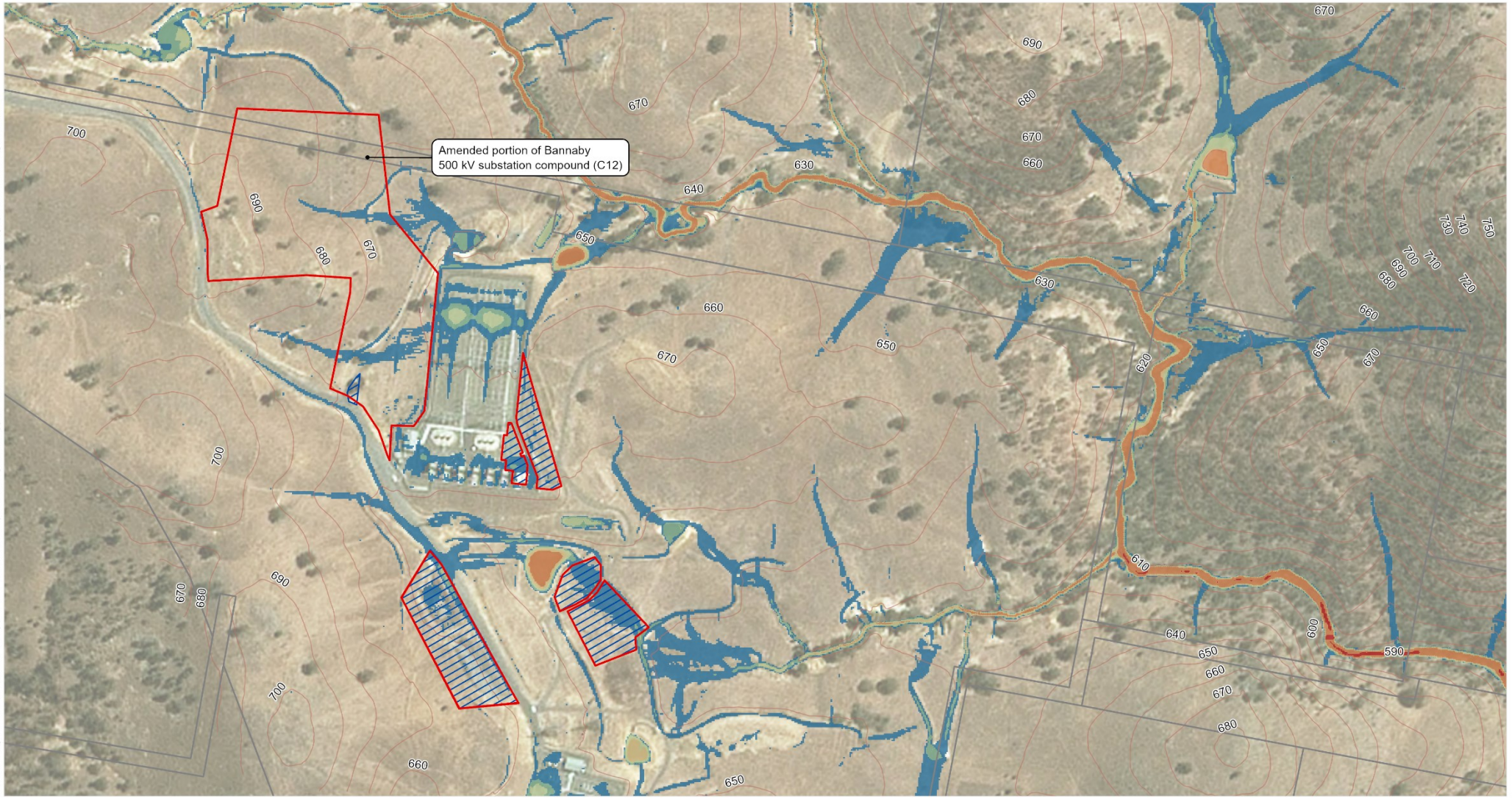
Table A-5 Local model flow comparison with RFFE flows

Local Model	ID	Catchment area (km^2)	Event	Critical Flow (m^3/s)	RFFE Value		
					Discharge (m^3/s)	Lower Confidence Limit (m^3/s)	Upper Confidence Limit (m^3/s)
Amended Bannaby 500 kV substation compound	C12	3.6	5% AEP	30.9	11.0	2.9	34.4
Ardrossan Headquarters Road compound	C17	5.0	5% AEP	8.1	16.8	3.7	66.9
Gadara Road compound	C19	0.2	5% AEP	3.00	4.7	0.9	20.4
Ellerslie Road compound	C21	154.8	5% AEP	364.5	100.6	64.8	185.0
Adjungbilly Road accommodation facility and compound	AC04	1.3	5% AEP	12.7	7.6	1.5	33.5
			2% AEP	16.5	10.9	1.9	50.0
Yass accommodation facility and compound	AC05	66.2	5% AEP	264.8	80.4	16.6	340.5
			2% AEP	330.6	131.0	24.0	585.9
Crookwell accommodation facility and compound	AC06	1.3	2% AEP	4.5	5.9	1.2	21.2

Attachment B
ARR 2019 Flood Hazard Classifications



Attachment C
Local Hazard Flood Maps



Construction compound

Construction compound (EIS)

Cadastre

Surface level contour (10m AHD interval)

ARR 2019 Flood Hazard Classification

H1

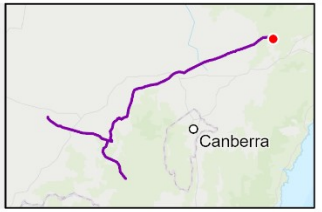
H2

H3

H4

H5

H6



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

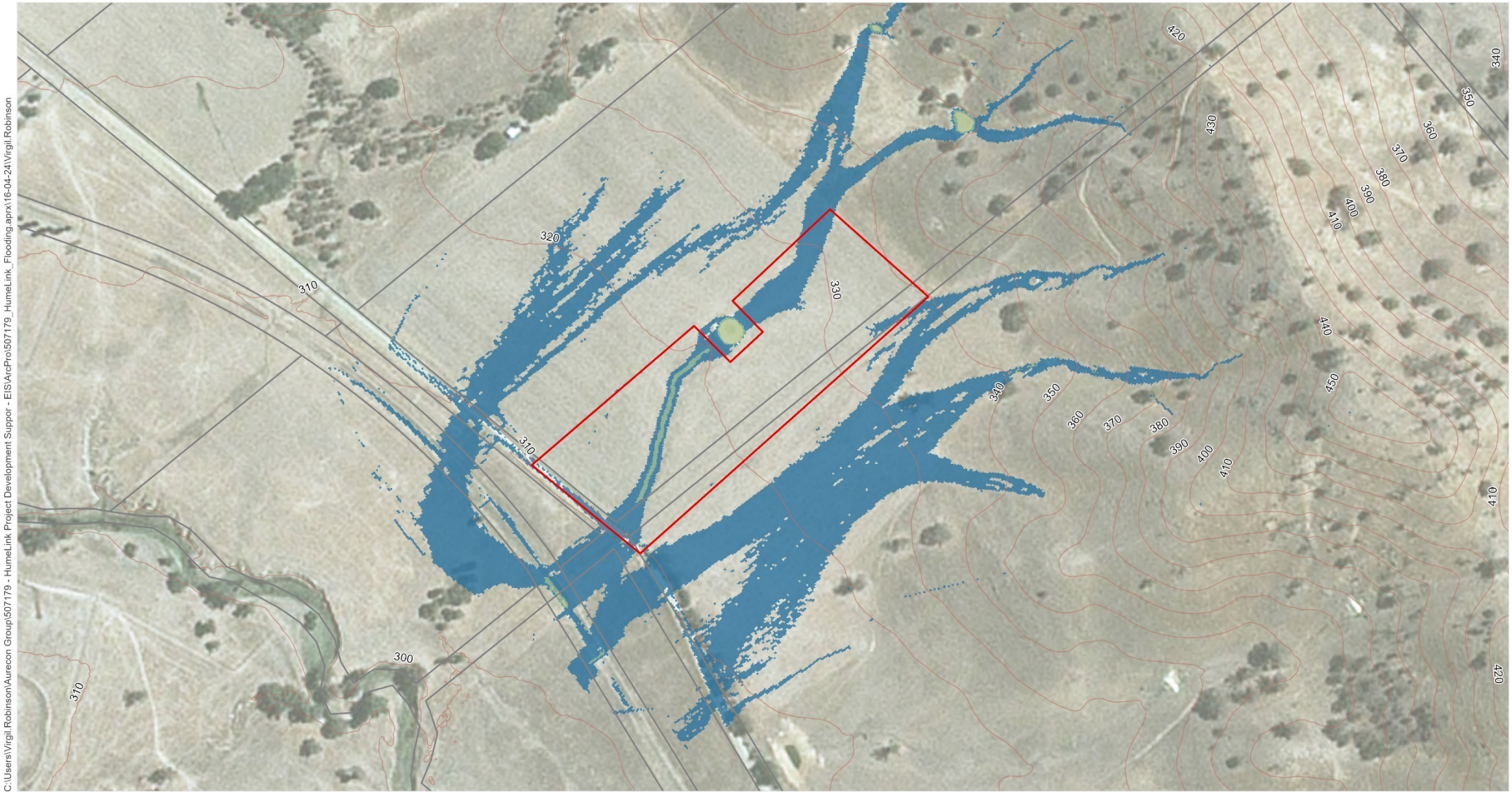
1:5,000

0 110 220m

Projection: GDA 1994 MGA Zone 55

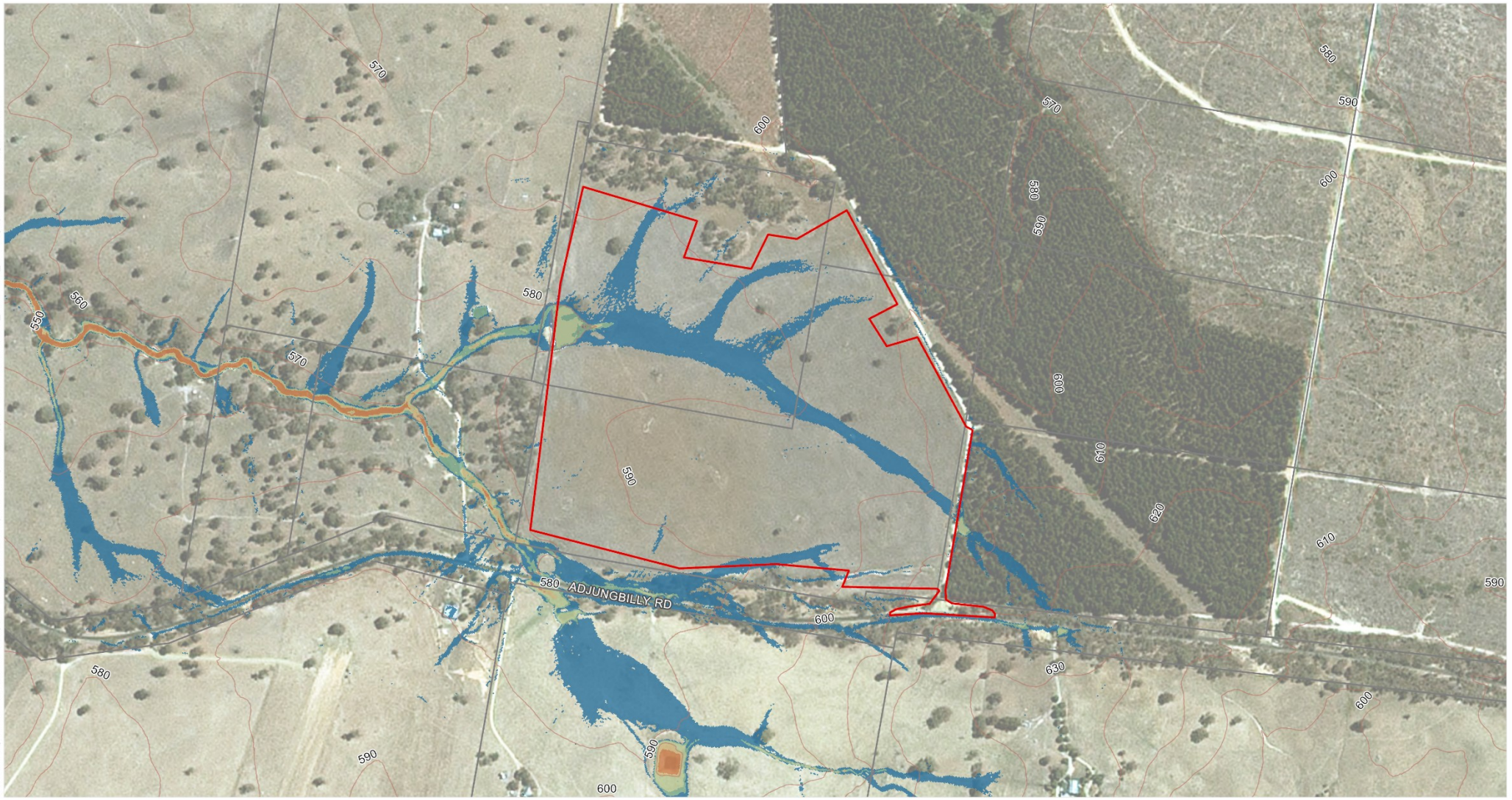
HumeLink **Hydrology and Flooding**

FIGURE C-1: ARR 2019 5% AEP Flood Hazard Classification for Amended Bannaby 500 kV substation compound (C12)



HumeLink **Hydrology and Flooding**

FIGURE C-2: ARR 2019 5% AEP Flood Hazard Classification for Gadara Road compound (C19)



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Construction compound

Cadastre

Surface level contour (10m AHD interval)

ARR 2019 Flood Hazard Classification

H1

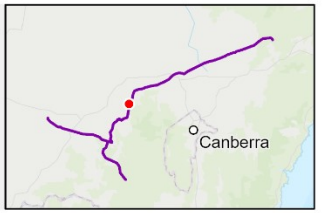
H2

H3

H4

H5

H6



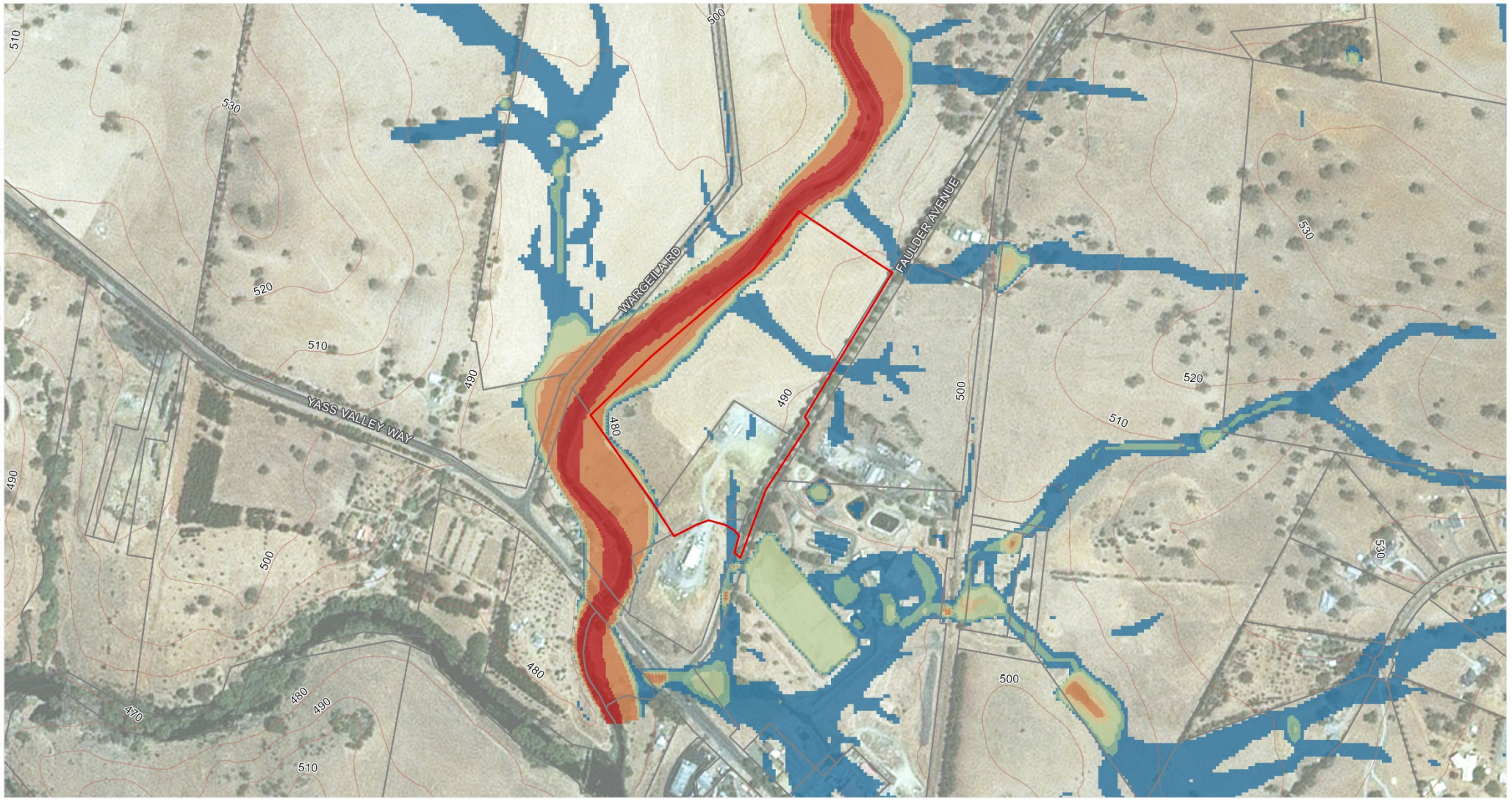
Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

1:6,250

0 140 280 m

Projection: GDA 1994 MGA Zone 55

FIGURE C-3: ARR 2019 2% AEP Flood Hazard Classification for Adjungbilly accommodation facility and compound (AC04)



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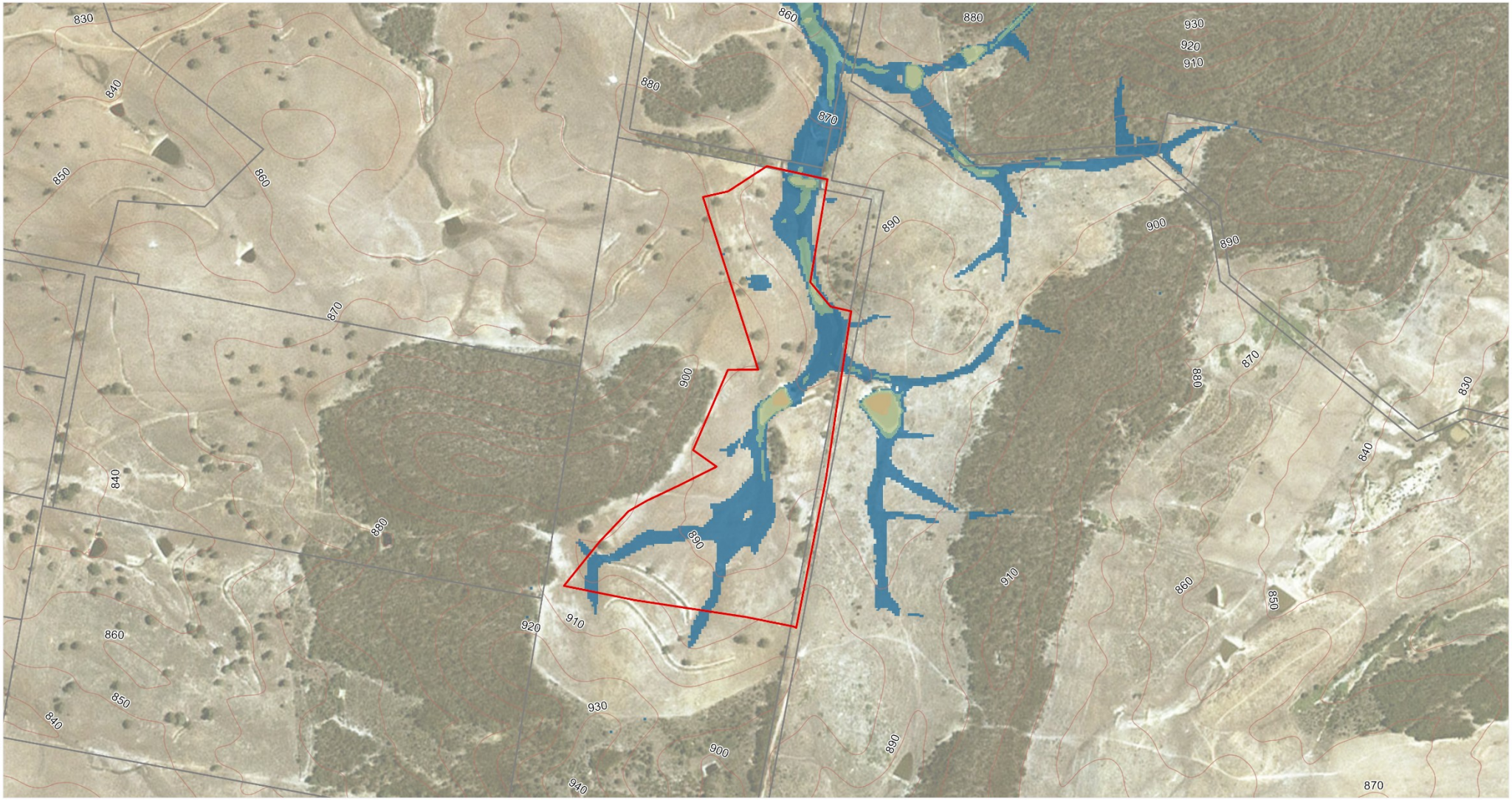
Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

1:6,000
0 140 280 m

Projection: GDA 1994 MGA Zone 55

FIGURE C-4: ARR 2019 2% AEP Flood Hazard Classification for Yass accommodation facility and compound (AC05)



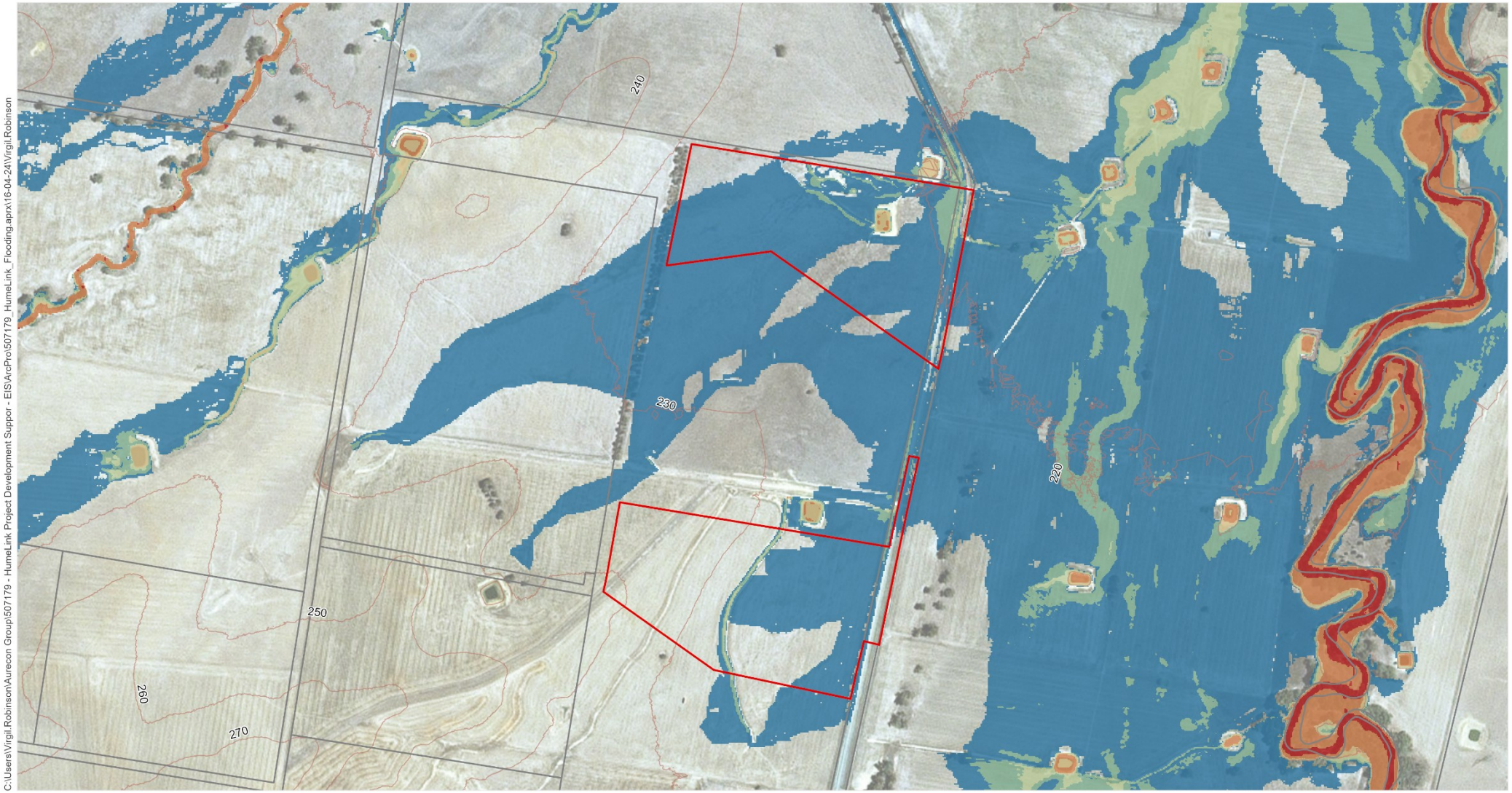
Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

1:7,500

0 175 350 m

Projection: GDA 1994 MGA Zone 55

FIGURE C-5: ARR 2019 2% AEP Flood Hazard Classification for Crookwell accommodation facility and compound (AC06)



Construction compound

Cadastre

Surface level contour (10m AHD interval)

ARR 2019 Flood Hazard Classification

H1

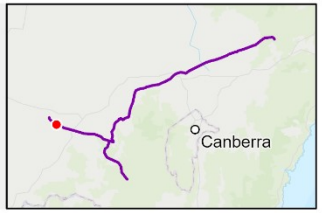
H2

H3

H4

H5

H6



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

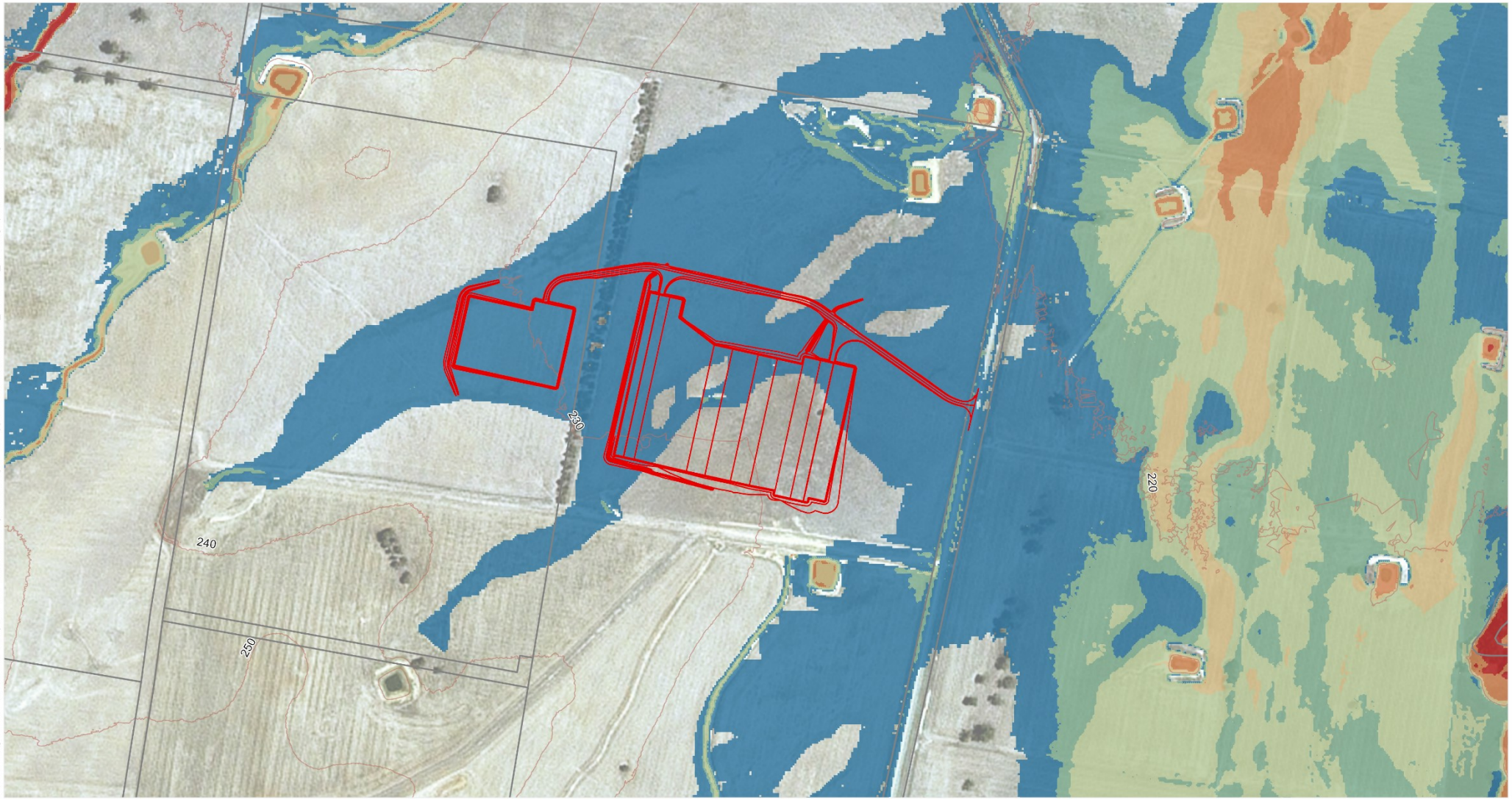
1:8,000

0 180 360m

Projection: GDA 1994 MGA Zone 55

HumeLink **Hydrology and Flooding**

FIGURE C-6: ARR 2019 5% AEP Flood Hazard Classification for Amended Gregadoo Road compound (C06)



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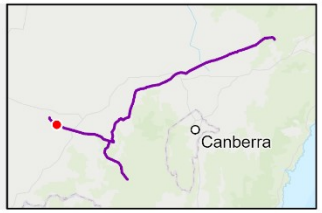
Substation extent
Cadastre
Surface level contour (10m AHD interval)

ARR 2019 Flood Hazard Classification

H1
H2
H3
H4
H5
H6



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

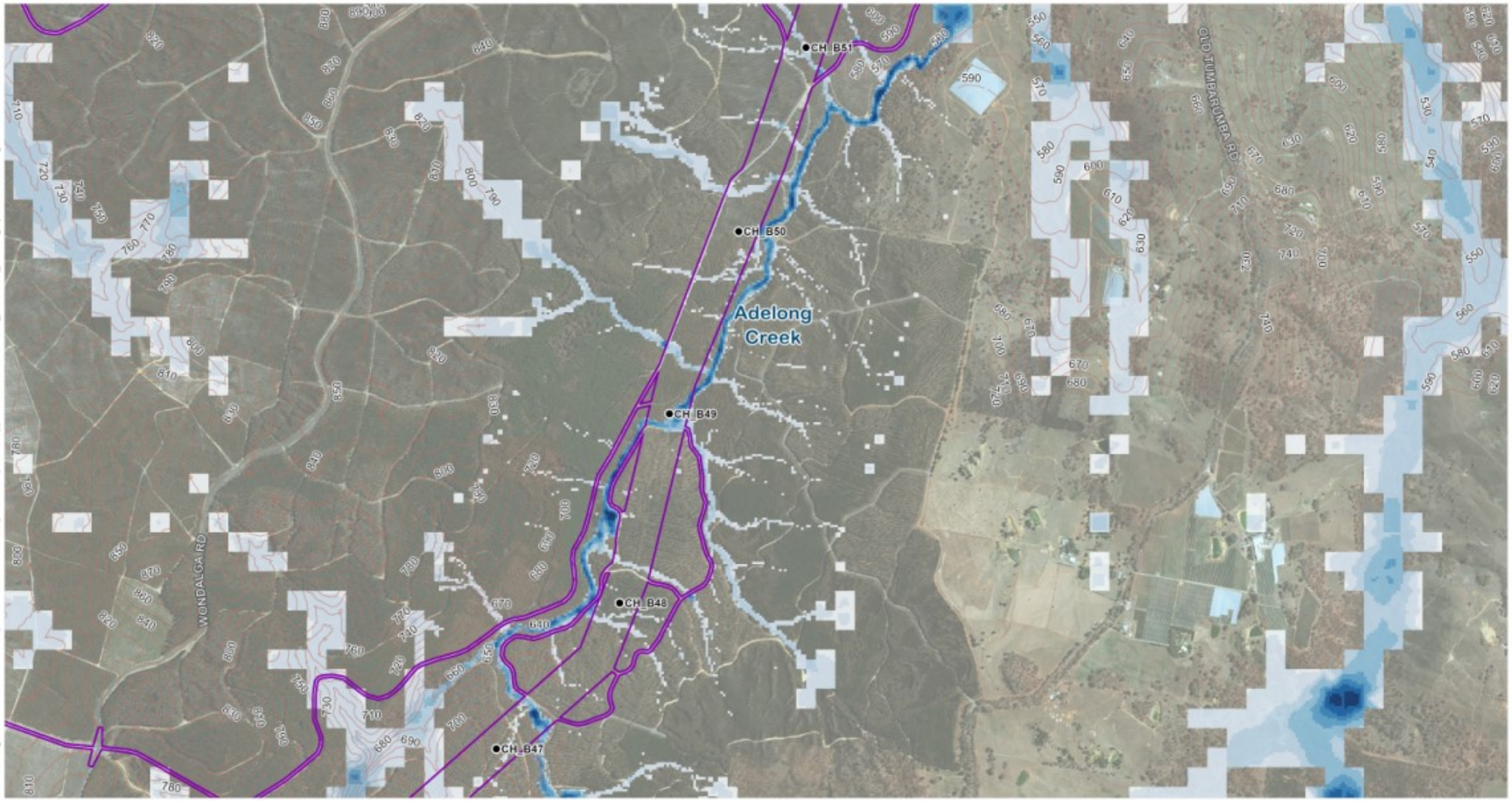
1:6,000
0 140 280 m

Projection: GDA 1994 MGA Zone 55

HumeLink **Hydrology and Flooding**

FIGURE C-7: ARR 2019 1% AEP Flood Hazard Classification for Gugaa 500kV Substation

Attachment D
Regional Flood Mapping



Amended project footprint

Surface level contour (10m AHD interval)

Chainage

Flood Depth (m)

<= 0.03

0.03 - 0.1

0.1 - 0.25

0.25 - 0.5

0.5 - 0.75

0.75 - 1

1 - 1.5

> 1.5

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

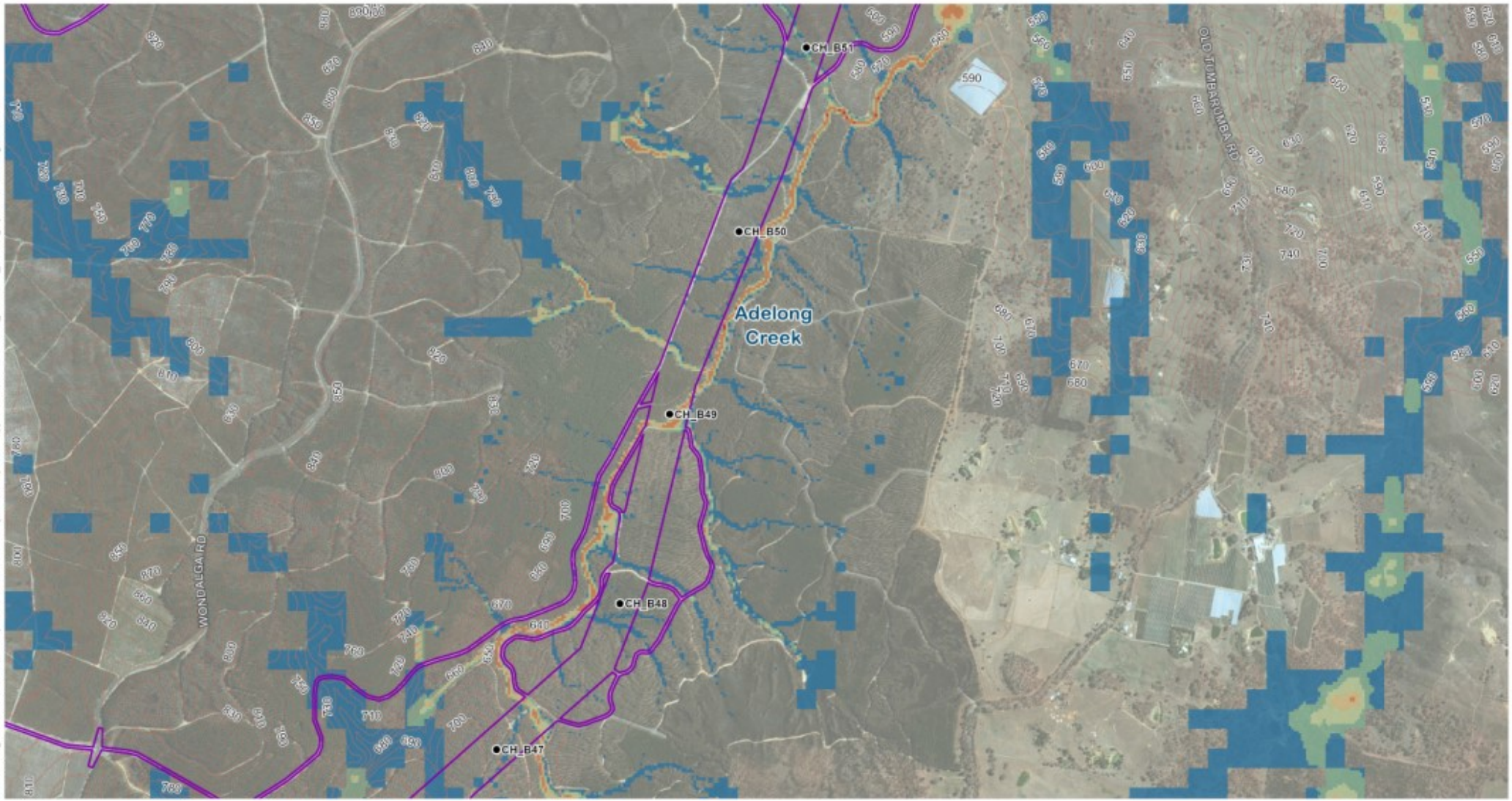
1:20,000

0 470 940m

Projection: GDA 1994 MGA Zone 55

HumeLink **Hydrology and Flooding**

FIGURE D-1: 1% AEP flood depth at Adelong Creek Intersection

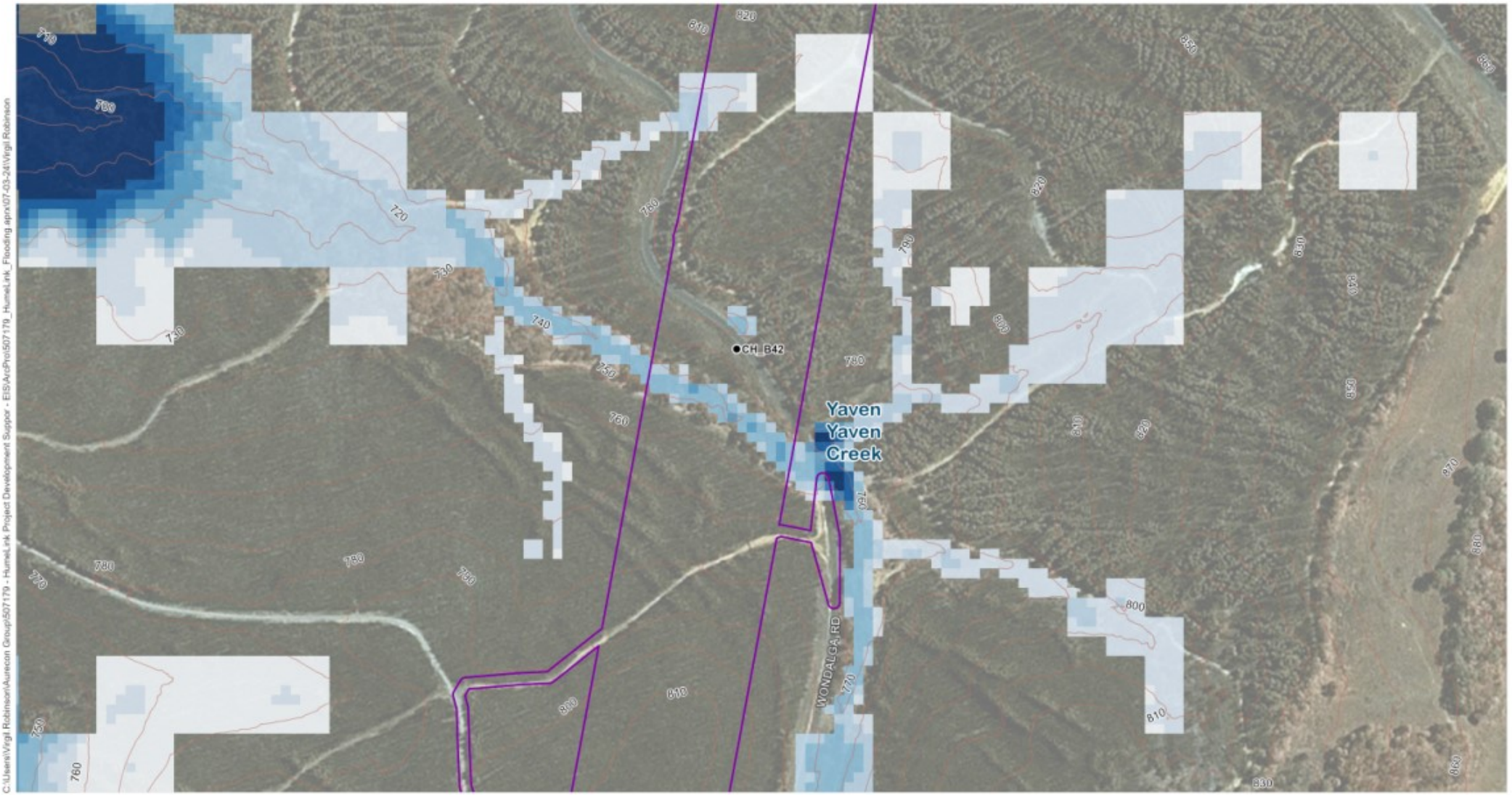


Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

Projection: GDA 1994 MGA Zone 55

HumeLink **Hydrology and Flooding**

FIGURE D-2: ARR 2019 1% AEP Flood Hazard Classification for Adelong Creek Intersection



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Amended project footprint

Surface level contour (10m AHD interval)

Chainage

Flood Depth (m)

<= 0.03

0.03 - 0.1

0.1 - 0.25

0.25 - 0.5

0.5 - 0.75

0.75 - 1

1 - 1.5

> 1.5

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

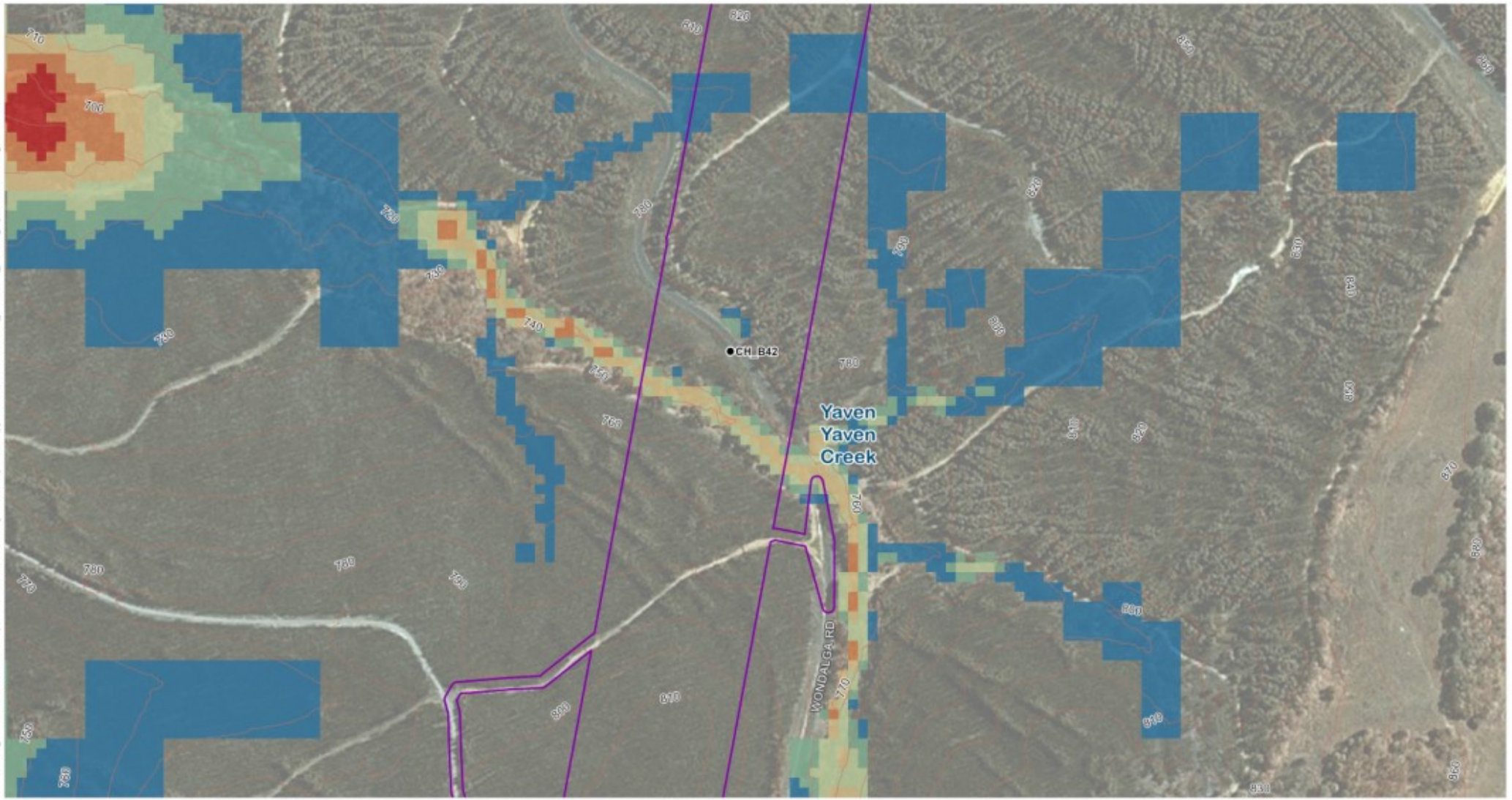
1:5,000

0 110 220m

Projection: GDA 1994 MGA Zone 55

HumeLink **Hydrology and Flooding**

FIGURE D-3: 1% AEP flood depth at Yaven Yaven Creek Intersection



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Amended project footprint

Surface level contour (10m AHD interval)

Chainage

ARR 2019 Flood Hazard Classification

H1

H2

H3

H4

H5

H6

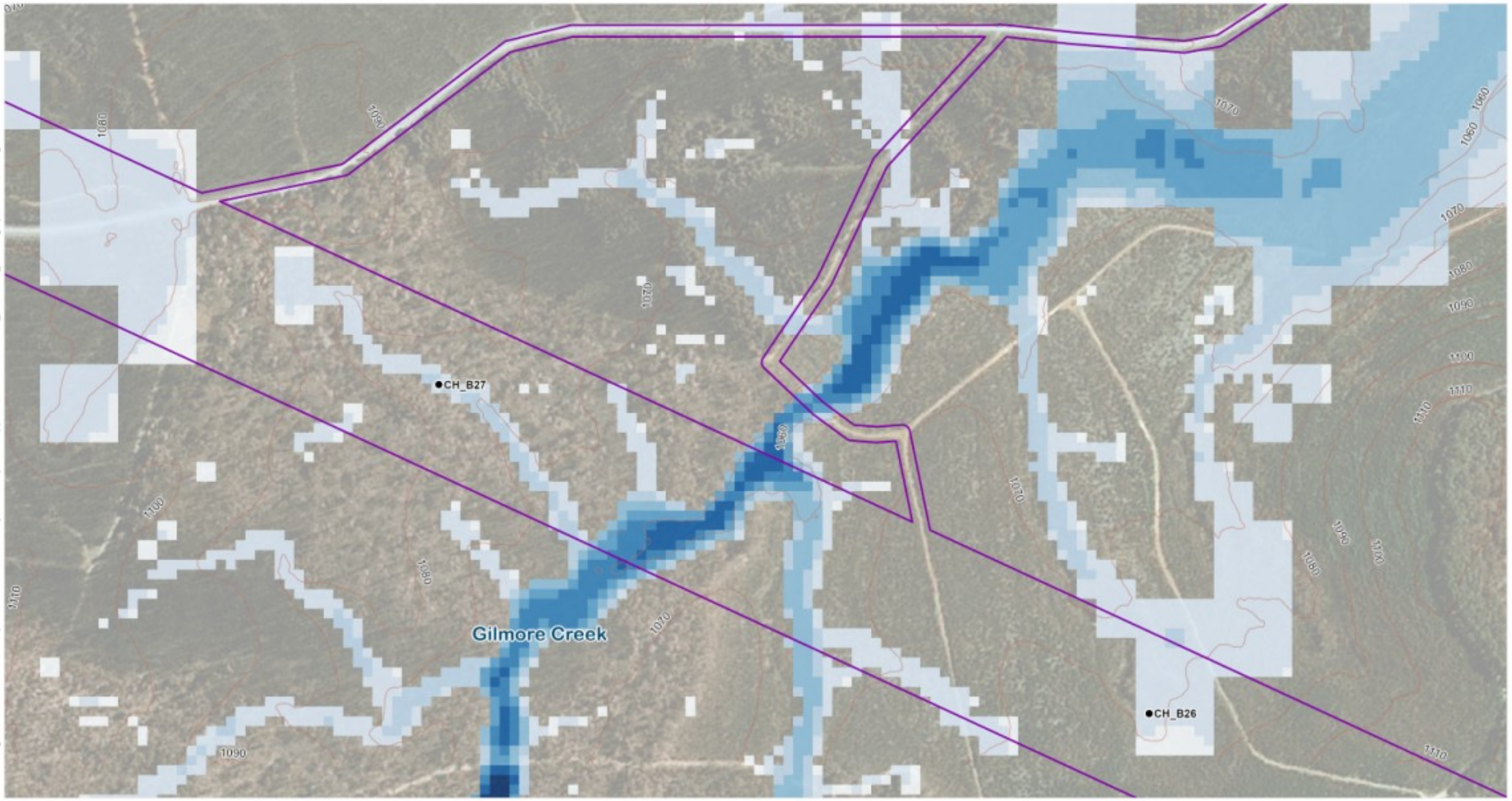
Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

1:5,000

0 110 220m

Projection: GDA 1994 MGA Zone 55

FIGURE D-4: ARR 2019 1% AEP Flood Hazard Classification for Yaven Yaven Creek Intersection



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Amended project footprint

Surface level contour (10m AHD interval)

Chainage

Flood Depth (m)

- <= 0.03
- 0.03 - 0.1
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.5
- > 1.5

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

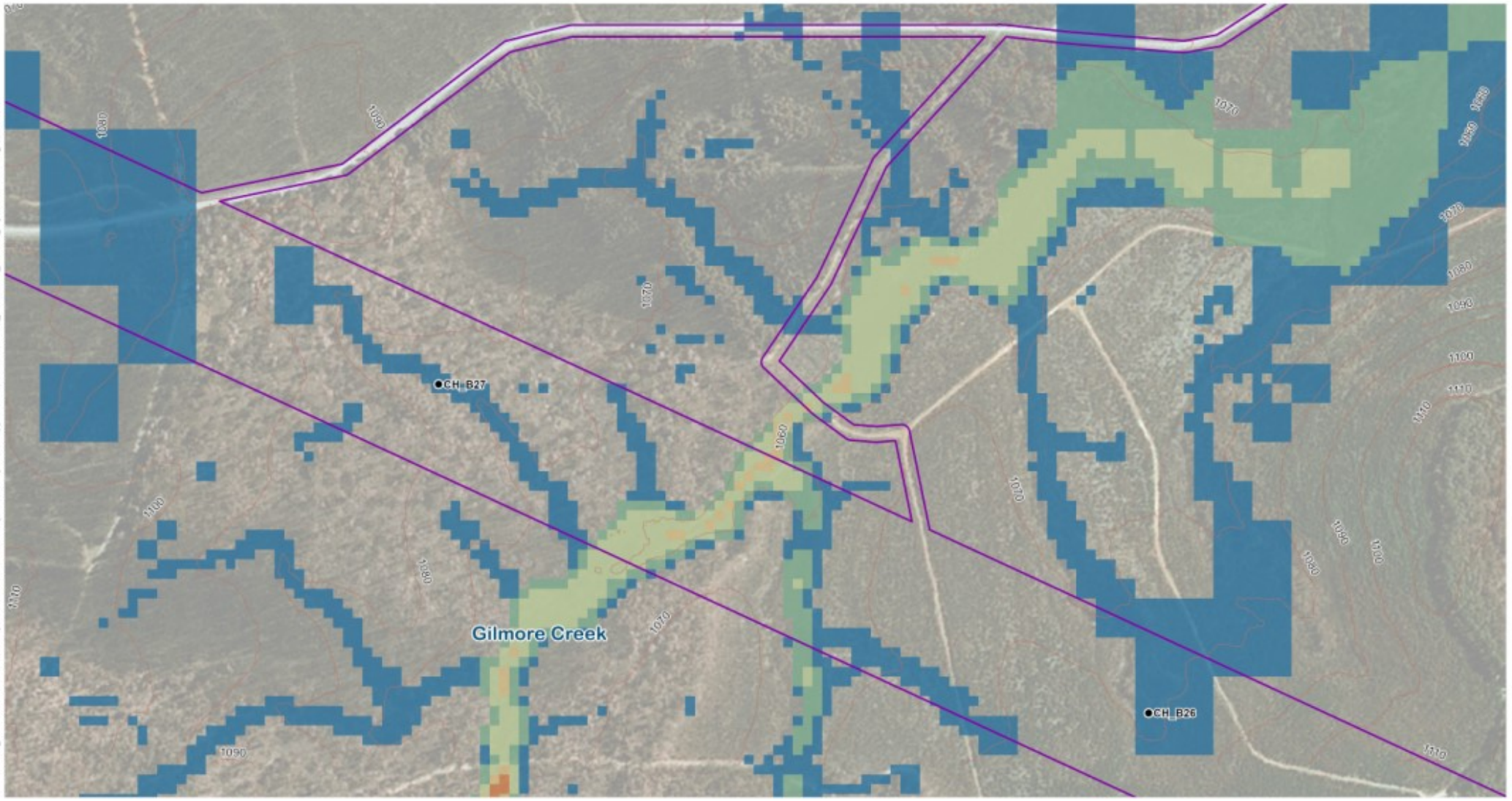
1:5,000

0 110 220m

Projection: GDA 1994 MGA Zone 55

HumeLink **Hydrology and Flooding**

FIGURE D-5: 1% AEP flood depth at Gilmore Creek Intersection



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Amended project footprint

Surface level contour (10m AHD interval)

Chainage

ARR 2019 Flood Hazard Classification

H1

H2

H3

H4

H5

H6

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

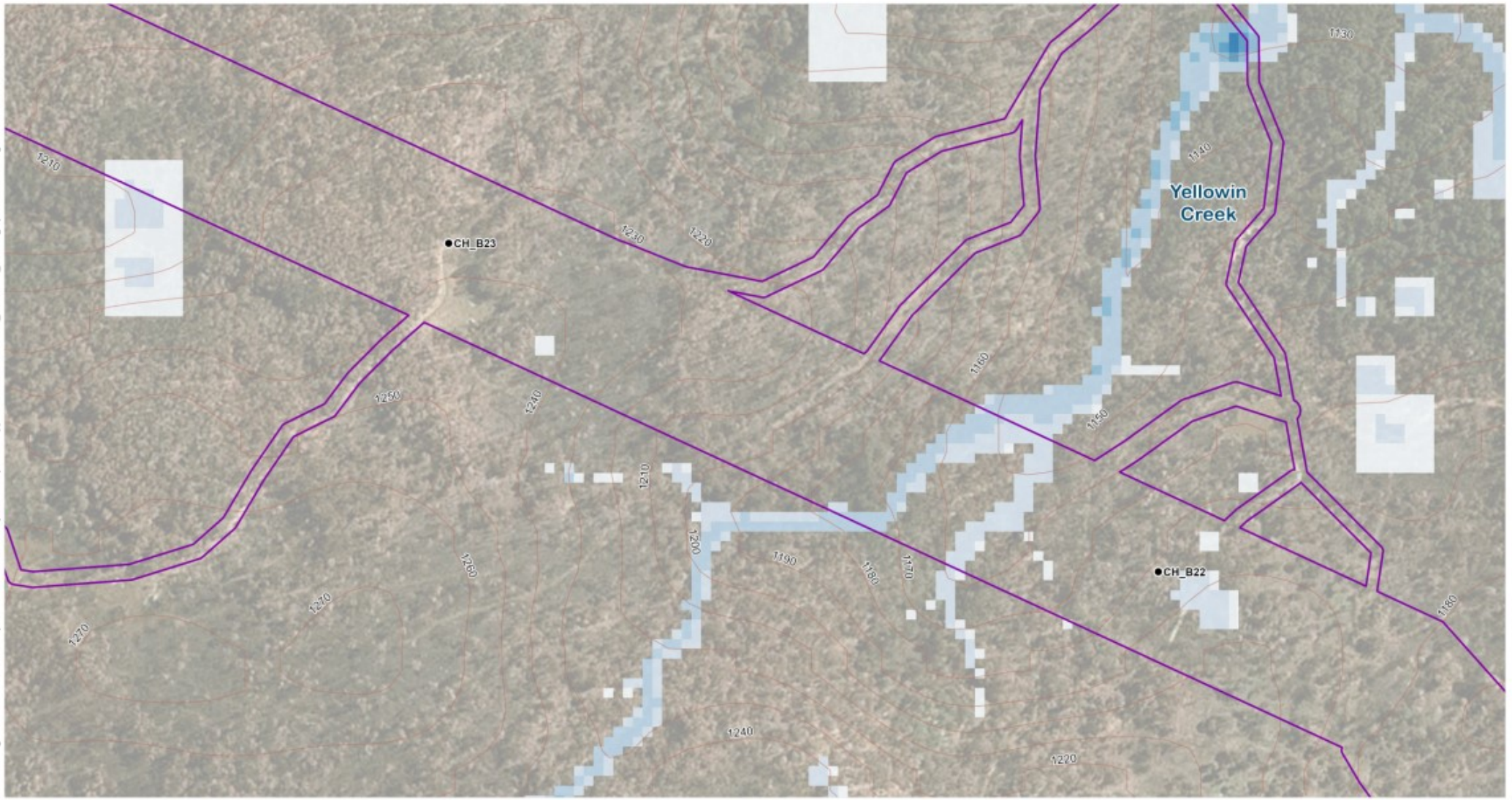
1:5,000

0 110 220m

Projection: GDA 1994 MGA Zone 55

HumeLink **Hydrology and Flooding**

FIGURE D-6: ARR 2019 1% AEP Flood Hazard Classification for Gilmore Creek Intersection



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Amended project footprint

Surface level contour (10m AHD interval)

Chainage

Flood Depth (m)

<= 0.03

0.03 - 0.1

0.1 - 0.25

0.25 - 0.5

0.5 - 0.75

0.75 - 1

1 - 1.5

> 1.5

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

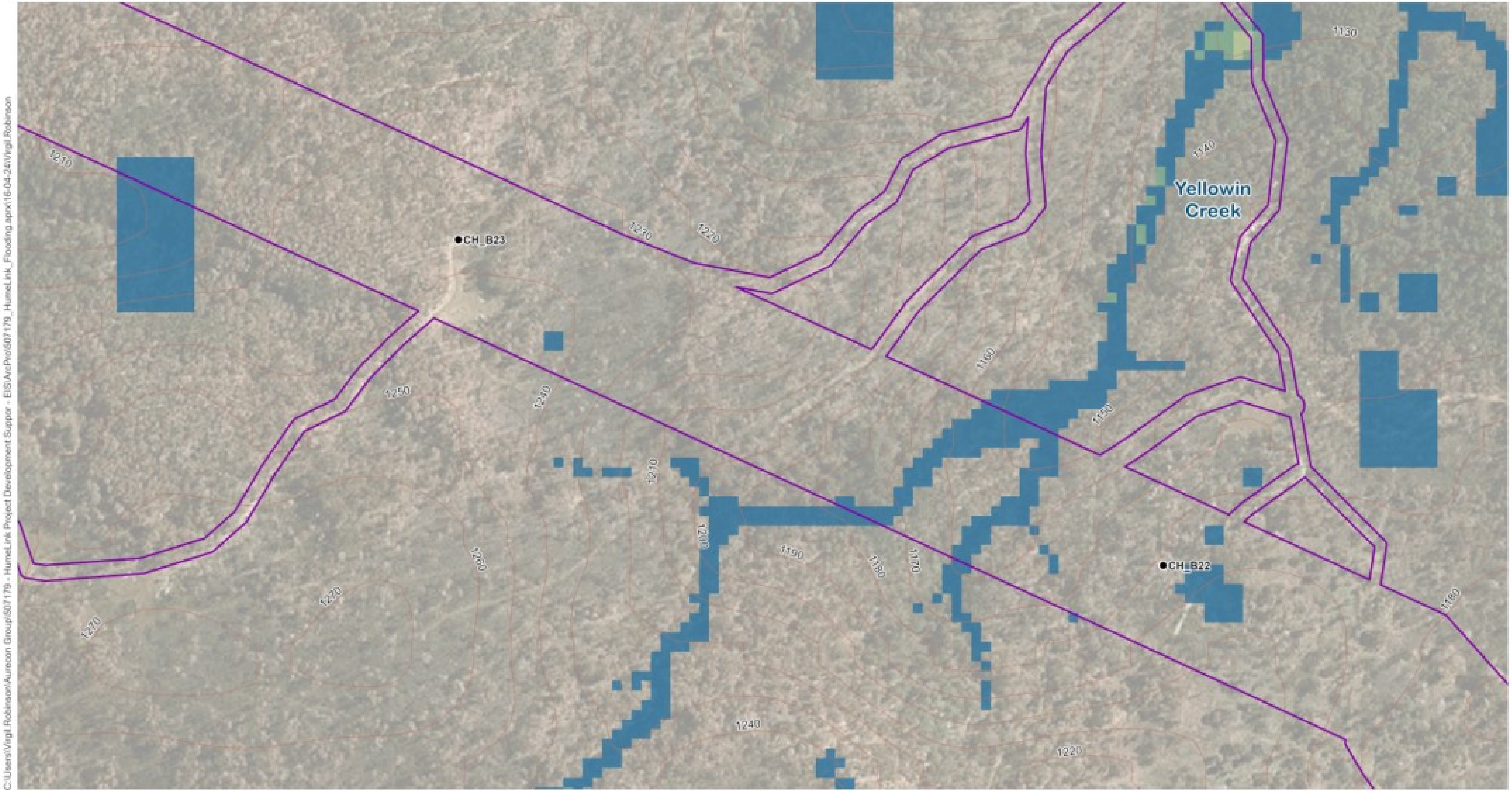
1:5,000

0 110 220m

Projection: GDA 1994 MGA Zone 55

HumeLink **Hydrology and Flooding**

FIGURE D-7: 1% AEP flood depth at Yellowin Creek Intersection



Amended project footprint

Surface level contour (10m AHD interval)

Chainage

ARR 2019 Flood Hazard Classification

H1

H2

H3

H4

H5

H6

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 D-8: ARR 2019 1% AEP Flood Hazard Classification for Yellowin Creek Intersection

Attachment E

Tarcutta accommodation facility and compound (AC03) – detailed methodology

The detailed methodology used to carry out an assessment of flood risk at Tarcutta accommodation facility and compound (AC03) is provided below. Lumped catchment hydrological assessment was undertaken using Watercom's DRAINS software. The model was developed to calculate the catchments to the site for a 1 in 50 (2% AEP) event design flood immunity for a range of storm durations and temporal patterns in accordance with ARR2019.

The catchment was also evaluated against the ARR2019 Regional Flood Frequency Estimation (RFFE) tool to validate the outcome. The tabulated results indicate the DRAINS analysis is towards the upper confidence limit of the RFFE outcome. The comparable peak flowrates are presented in Table E-1.

Table E-1 Tarcutta accommodation facility and compound (AC03) Tarcutta Creek tributary flowrate comparison

Methodology	2%AEP Flowrate (m^3/s)		
	Lower Confidence Limit	Discharge	Upper Confidence Limit
Watercom DRAINS		32.2	
RFFE	5.3	14.2	38.2

Based on the calculated 2%AEP flowrate from the Watercom DRAINS modelling, the Tarcutta Creek tributary was evaluated to establish if the creek banks would breach and impact upon the site. Using Bentley's *Flowmaster* software, an irregular cross section was analysed at the catchment boundary. It was concluded that the Tarcutta accommodation facility and compound (AC03) is not impacted by the Tarcutta Creek tributary in a 2%AEP event. Results indicate that the site is in excess of 4.5 metres higher than the predicted peak flood level, as illustrated in Figure E-1.

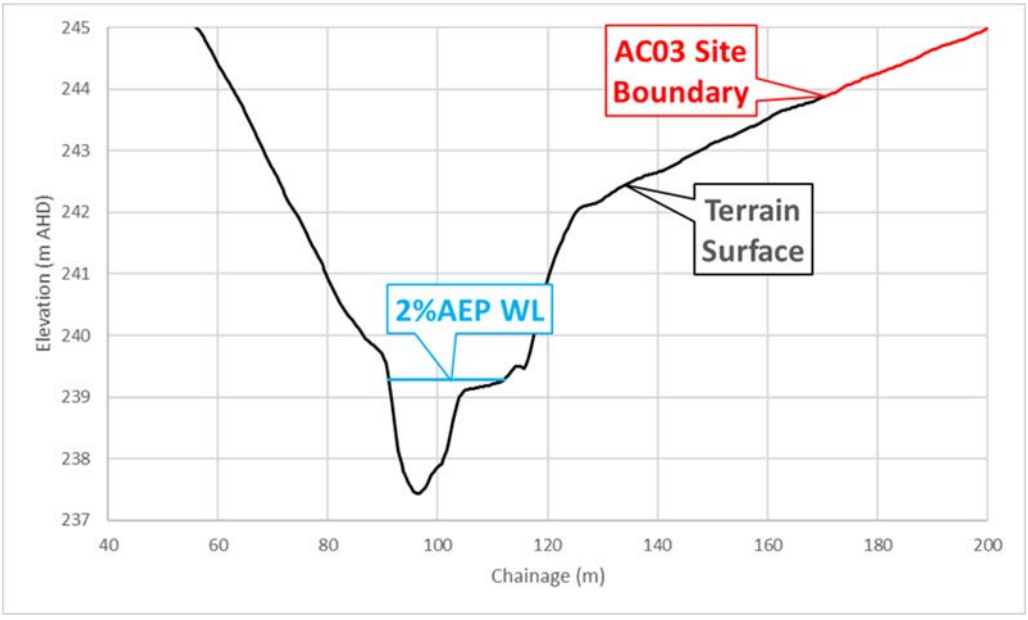
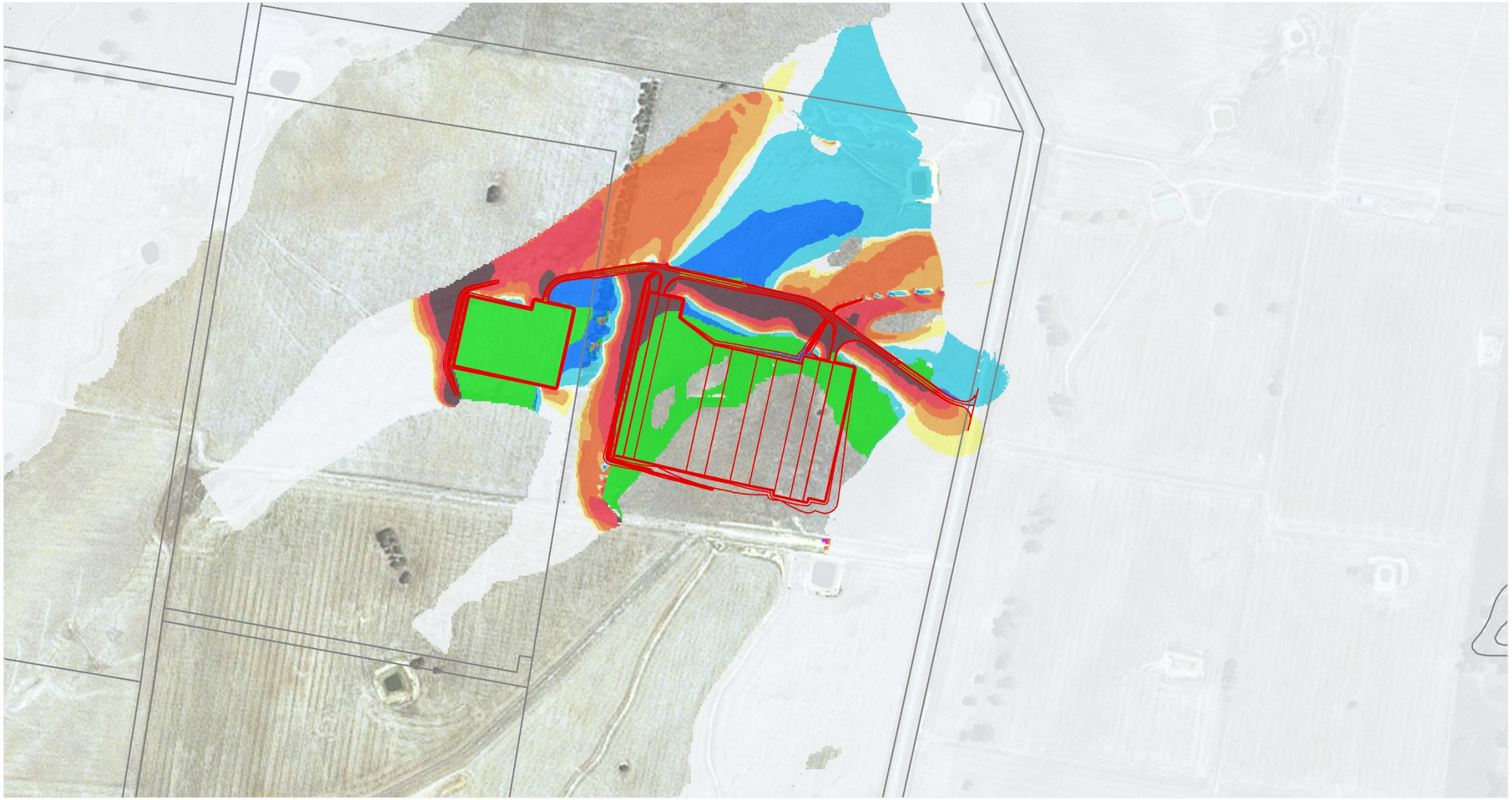


Figure E-1 Flowmaster 2% AEP immunity for Tarcutta accommodation facility and compound (AC03) at Tarcutta Creek tributary

Local catchments to the south of Mates Gully Road were also investigated. The catchments vary in size but are generally between 3.4 to 5.5 hectares. The catchment location relevant to the site has been illustrated in Figure 5-9. The largest of the four catchments was analysed within a Watercom DRAINS model and the 2% AEP peak flowrate was determined to be in the order of 1.1 m^3/s which can be managed using drainage pipes, indicating that the site is unlikely to be at risk from local flooding with the appropriate local drainage management.

Attachment F

Proposed Gugaa 500 kV Substation (Lyall & Associates)



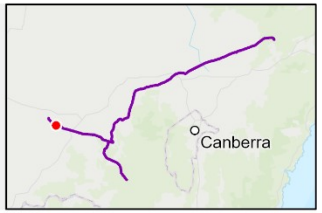
C:\Users\Virgil.Robinson\Aurecon Group\507179 - HumeLink Project Development Suppor - EIS\ArcPro\507179_HumeLink_Flooding.aprx\16-04-24\Virgil.Robinson

Substation extent

Cadastre

Was Dry Now Wet

Was Wet Now Dry



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

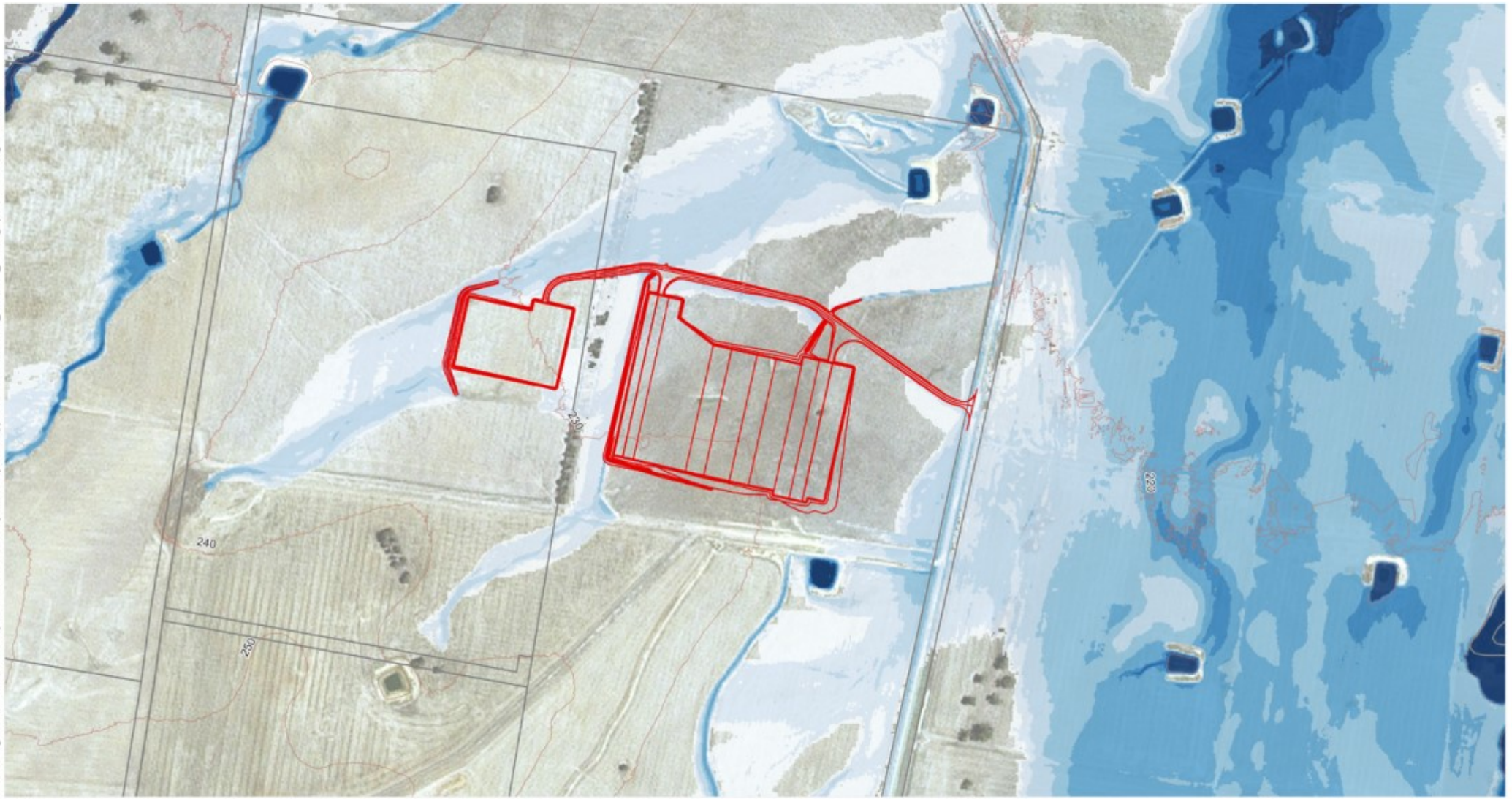
1:6,000

0 140 280m

Projection: GDA 1994 MGA Zone 55

HumeLink **Hydrology and Flooding**

FIGURE F-1: Gugaa 500kV Substation PMF peak flood afflux



C:\Users\Virgil Robinson\Aurecon Group\507179 - HumeLink Project Development Suppor - EIS\ArcPro\507179_HumeLink_Flooding.aprx\09-02-24\Virgil Robinson

Substation extent

Cadastre

Surface level contour (10m AHD interval)

Flood Depth (m)

- <= 0.03
- 0.03 - 0.1
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 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 F-2: Gugaa 500kV Substation 1% AEP peak flood depth – Design Scenario

Substation extent

Cadastre

Surface level contour (10m AHD interval)

Flood Depth (m)

- <= 0.03
- 0.03 - 0.1
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 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 F-3: Gugaa 500kV Substation PMF peak flood depth – Design Scenario

Attachment G

Lyall & Associates Gugaa 500 kV Substation Addendum Flooding Investigation

Transgrid
180 Thomas Street
SYDNEY NSW 2000

Job No. FP614

21 December 2023

Re: Gugaa 500 kV Substation Addendum Flooding Report

The letter sets out the findings of an investigation that has been undertaken to assess the impact that a revised design for the Gugaa 500 kilovolt (kV) substation that Transgrid proposes to construct as part of the HumeLink project would have on flood behaviour. The revised design forms part of the amended project.

1. Background

Transgrid has identified a preferred site for the Gugaa 500 kV substation at Lot A in DP 376288 and Lot 56 in DP 757261 (1.4 kilometres south of the intersection of Gregadoo East Road and Livingston Gully Road) on Livingston Gully Road, Gregadoo (**Gugaa 500 kV substation preferred location site**). The Gugaa 500 kV substation preferred location site is located to the west of O'Briens Creek which discharges to Kyeamba Creek approximately two kilometres to the north of Gregadoo East Road.

Lyall & Associates previously prepared a flood assessment for the Gugaa 500 kV substation based on the early concept design. The findings of the investigation, which are set out in a letter style report entitled "Gugaa 500 kV Substation Flooding Investigation" and dated 6 October 2022, formed part of the Environmental Impact Statement (**EIS**) for the HumeLink project.

On 4 December 2023, Transgrid awarded the HumeLink West project to the UGL Engineering Pty Ltd and CPB Contractors Pty Ltd joint venture (**UGL-CPB JV**). To assist in the assessment process, the UGL-CPB JV provided an alternative bench and access road design to that previously assessed as part of the EIS. Following a review of the alternative bench and access road design, it was determined that it would be necessary to modify the structure of the hydrologic and hydraulic models that were relied upon for undertaking the previous assessment (collectively referred to herein as "the flood models"). This required an update of the flood models representing both pre-and post-substation conditions.

The following sections of this letter provide a brief description of the updates that were made to the structure of the flood models representing both pre-and post-substation conditions, as well as the key findings of the updated flooding investigation.

It is noted that this Addendum Report addresses the requirement of the Secretary's Environmental Assessment Requirements (**SEARS**) to undertake an assessment of the potential flooding impacts and risks of the project. It has also been undertaken in accordance with the *NSW Flood Risk Management Manual 2023*, with specific reference to Flood Risk Management Guideline LU01 titled "Flood Impact and Risk Assessment".

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Lyall & Associates Consulting Water Engineers ABN 93 257 653 251 trading as Lyall & Associates

2. Flood Model Updates – Pre-Gugaa 500 kVSubstation Conditions

2.1 Refined Kyeamba Creek Hydrologic Model

To assess the impact that the Gugaa 500 kV substation would have on flood behaviour, it was necessary to further sub-divide the sub-catchments comprising the Refined Kyeamba Creek Hydrologic Model in its immediate vicinity, noting that design rainfall losses and intensities remained unchanged. **Figure 1** attached to this letter shows the extent to which the sub-catchments were modified as part of the present investigation.

2.2 Kyeamba Creek TUFLOW Model

Similar to catchment hydrology, it was necessary to modify the structure of the Kyeamba Creek TUFLOW Model in the immediate vicinity of the Gugaa 500 kV substation. This involved the assigning of inflow hydrograph locations based on the updated Refined Kyeamba Creek Hydrologic Model, as well as the addition of a series of ridge lines to more accurately define the crest level of existing diversion banks that are located to the north of the Gugaa 500 kV substation. **Figure 2** shows the key features comprising the Kyeamba Creek TUFLOW Model in the immediate vicinity of the Gugaa 500 kV substation.

2.3 Updated Kyeamba Creek TUFLOW Model Results

Figures 3 to **16** show the indicative extent and depth of inundation, as well as maximum flow velocities under pre-Gugaa 500 kV substation conditions for design floods with Annual Exceedance Probabilities (**AEPs**) of 20%, 10%, 5%, 2%,1% and 0.5%, as well as the Probable Maximum Flood (**PMF**). Note that the figures only show the nature of flooding in the immediate vicinity of the Gugaa 500 kV substation, as flooding conditions on the wider O'Briens Creek floodplain remain unchanged from those presented in our letter dated 6 October 2022.

The key finding of the updated assessment is that flooding patterns under pre-Gugaa 500 kV substation conditions are generally consistent with those presented in our 6 October 2022 letter.

3. Flood Model Updates – Post-Gugaa 500kV Substation Conditions

3.1 Key Features of Gugaa 500 kV Substation

Figure 17 shows the following key features of the Gugaa 500 kV substation and its associated external drainage system:

- A large, elevated bench area that is located adjacent to Livingstone Gully Road and is about 350 metres in length and about 200 metres in width.
- A separate smaller elevated bench area that is located to the west of the aforementioned large elevated bench area and measures about 170 metres in length and about 120 metres in width.
- A series of diversion banks (or filled areas) that divert overland flow which approaches the two elevated bench areas around their western sides.
- A series of transverse drainage structures under the proposed access road.
- A series of tail-out drains downstream of the aforementioned transverse drainage structures.
- A modified (raised) section of diversion bund that is located to the north of the Gugaa 500 kV substation which is aimed at diverting overland flow to the existing farm dam that is located to its east.

3.2 Refined Kyeamba Creek Hydrologic Model

In order to assess the impact that the Gugaa 500 kV substation has on the receiving drainage lines, the fraction impervious,[1] slope and rainfall loss model associated with the sub-catchments which span the footprint of the two elevated bench areas were modified in the Refined Kyeamba Creek Hydrologic Model. **Figure 18** shows the sub-catchments which were modified so as to represent the increased runoff potential of the two elevated bench areas.

3.3 Kyeamba Creek TUFLOW Model

The structure of the Kyeamba Creek TUFLOW Model representing pre- Gugaa 500 kV substation conditions was updated to incorporate all of the features set out in **Section 3.1** of this letter. **Figure 19** shows the key features of the Kyeamba Creek TUFLOW Model representing post-Gugaa 500 kV substation conditions.

3.4 Updated Kyeamba Creek TUFLOW Model Results

Figures 20 to **47** show the indicative extent and depth of inundation, as well as maximum flow velocities under post-Gugaa 500 kV substation conditions for design floods with AEPs of 20%, 10%, 5%, 2%,1% and 0.5%, as well as the PMF. The figures also show the impact that the Gugaa 500 kV substation would have on flood behaviour.

The key findings of the updated flooding investigation are as follows:

- The raising of natural surface levels associated with the smaller elevated bench area will reduce the width of flow at its north-west corner, resulting in an increase in both the depth and velocity of flow.
- The concentration of flow in the north-west corner of the large, elevated bench area would result in an increase in the depth and velocity of flow downstream of the adjacent transverse drainage structure.
- The project would result in a minor increase in both the depth and velocity of flow in privately owned land that is located to the north of the site during storms up to 1% AEP in intensity. For example, during storms with AEPs of 20% and 1%, depths of inundation would be increased by a maximum of about 0.011 m and 0.03 m, respectively, while flow velocities would be increased by a maximum of about 0.04 m/s and 0.13 m/s, respectively.
- The project would result in a minor increase in both the depth and velocity of flow surcharging Livingstone Gully Road adjacent to the north-east corner of the site during storms up to 1% AEP in intensity. For example, during storms with AEPs of 20% and 1%, the depth of overtopping would be increased by less than 0.01 m and 0.04 m, respectively, while flow velocities over the road would be increased by a maximum of about 0.08 m/s and 0.4 m/s, respectively.
- The PMF event would inundate the north-west corner of the larger, elevated bench area to a maximum depth of about 0.5 m.

[1] For the purpose of the present assessment, it has been assumed that the surface of the two bench areas is 100% impervious. This approach provides in a conservative assessment of the impact that the Gugaa 500 kV substation would have on the receiving drainage lines given it is understood that a large portion of the two bench areas will likely comprise a semi-permeable pavement.

4. Consideration of Permissible Flood Related Impact

It is understood that no permissible flood related impacts have presently been set for the HumeLink project. As a result, the flood related impacts set out in **Section 3.4** of this letter have been assessed against the Quantitative Design Limits (**QDLs**) that are set out in the NSW Department of Planning and Environment's (**DPEs**) *State Significant Infrastructure Template Conditions of Approval* (Linear Infrastructure), noting that the document is water marked "INDICATIVE" (DPE, 2022). Clauses E2 and E3 of DPE, 2022 deal with the permissible impacts of linear type infrastructure on flood behaviour:

E2 Measures identified in the documents listed in Condition A1 to not worsen flood characteristics or other measures that achieve the same outcomes, must be incorporated into the detailed design of the CSSI. The incorporation of these measures into the detailed design must be reviewed and endorsed by a suitably qualified flood consultant, who is independent of the project's design and construction, in consultation with directly affected landowners, DPE Water, DPI Fisheries, ESS Group, NSW State Emergency Service (SES) and relevant Councils.

E3 Unless otherwise agreed by the Planning Secretary, the CSSI must be designed and constructed to limit impacts on flooding characteristics in areas outside the project boundary during any flood event up to and including the 1% AEP flood event, to the following:

- *(a) a maximum increase in inundation time of one hour;*
- *(b) a maximum increase of 10 mm in above-floor inundation to habitable rooms where floor levels are currently exceeded;*
- *(c) no above-floor inundation of habitable rooms which are currently not inundated;*
- *(d) a maximum increase of 50 mm in inundation of land zoned as residential, industrial or commercial;*
- *(e) a maximum increase of 100 mm in inundation of land zoned as rural, primary production, environment zone or public recreation;*
- *(f) no significant increase in the flood hazard or risk to life; and*
- *(g) maximum relative increase in velocity of 10%, where the resulting velocity is greater than 1.0 m/s, unless adequate scour protection measures are implemented and/or the velocity increases do not exacerbate erosion as demonstrated through site-specific risk of scour or geomorphological assessments.*

Where the requirements set out in clauses (d), (e) and (g) cannot be met alternative flood levels or mitigation measures may be agreed to with the affected landowner.

In the event that the Proponent and the affected landowner cannot agree on the measures to mitigate the impact as described in clauses (d), (e) and (g), the Proponent must engage a suitably qualified and experienced independent person to advise and assist in determining the impact and relevant mitigation measures.

As the above template Conditions of Approval do not deal with the permissible impacts on existing road infrastructure, reference is made to two Instruments of Approval that were recently signed off by the Minister for Planning associated with the Inland Rail project (refer **Annexure A** of this letter for a copy). In regard to the impact that the Gugaa 500 kV substation would have on flooding conditions along Livingstone Gully Road, it is noted that the QDLs for the two Inland Rail projects permit up to a 0.1 m increase in peak flood levels, with provision that any variation must be negotiated with the roads authority.

By comparison of the increases in peak flood levels set out in **Section 3.4** of this letter with the relevant QDLs set out above and in **Annexure A** of this letter, the Gugaa 500 kV substation would not exceed the permitted values external to the site. It is also noted that while flow velocities would be increased external to the site, they generally do not exceed 1 m/s, and where they do, increases attributable to the Gugaa 500 kV substation are less than 10%.

Based on the above findings, if the same or similar QDLs to those set out above and in **Annexure A** of this letter are incorporated in the Conditions of Approval for the HumeLink project, then no additional flood mitigation measures would be required to manage the impacts of the Gugaa 500 kV substation external to the site.

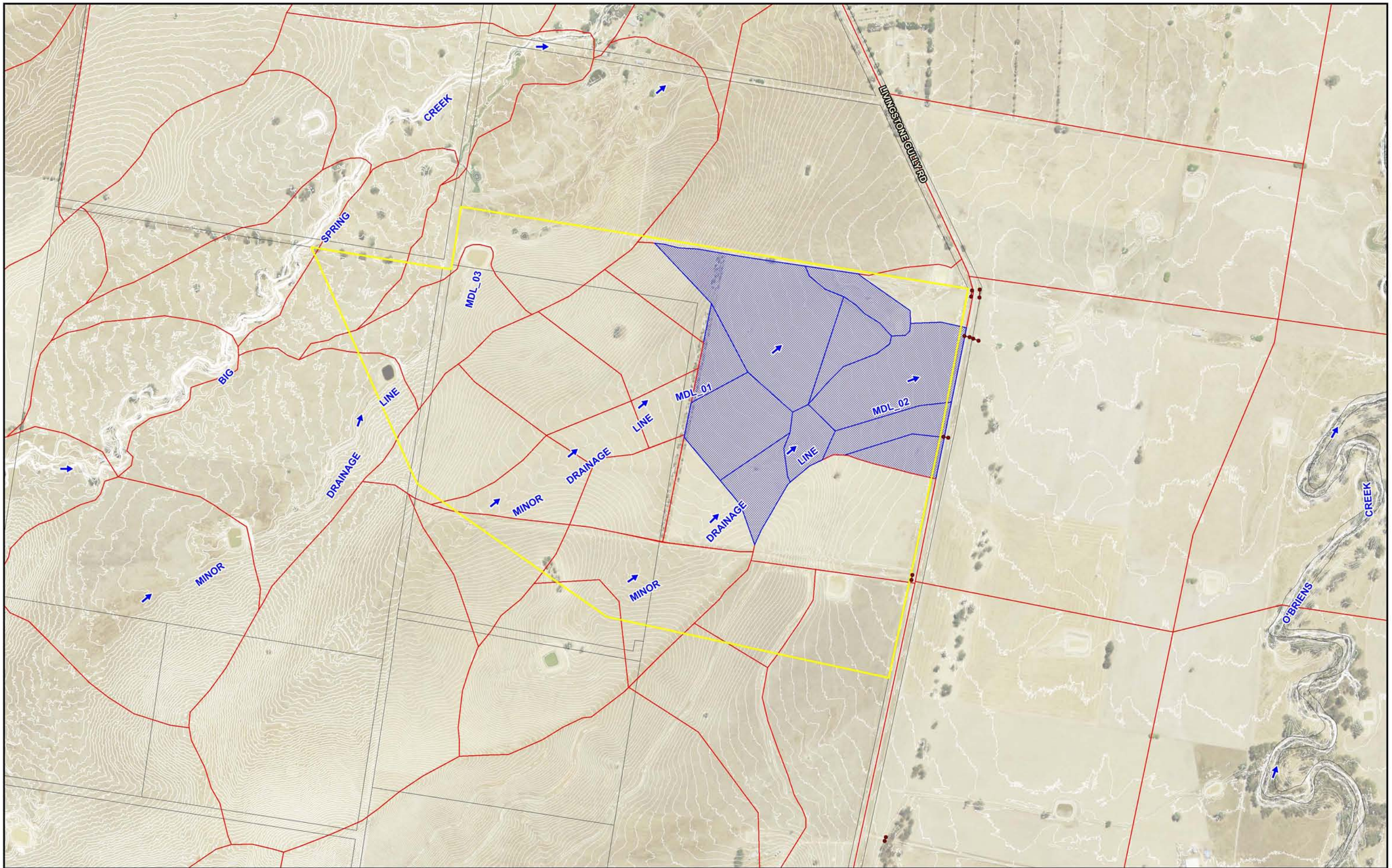
We trust that the findings of the present investigation will assist Transgrid in progressing its assessment of the flood immunity and drainage requirements for the Gugaa 500 kV substation. However, please do not hesitate to contact me should you have any queries or wish to discuss any aspect of our submission.

Yours faithfully
Lyall & Associates Consulting Water Engineers

Scott Button
Principal

FIGURES

LIST OF FIGURES



N

80 0 80 160 240 m

Scale: 1:8,000

Lyall & Associates

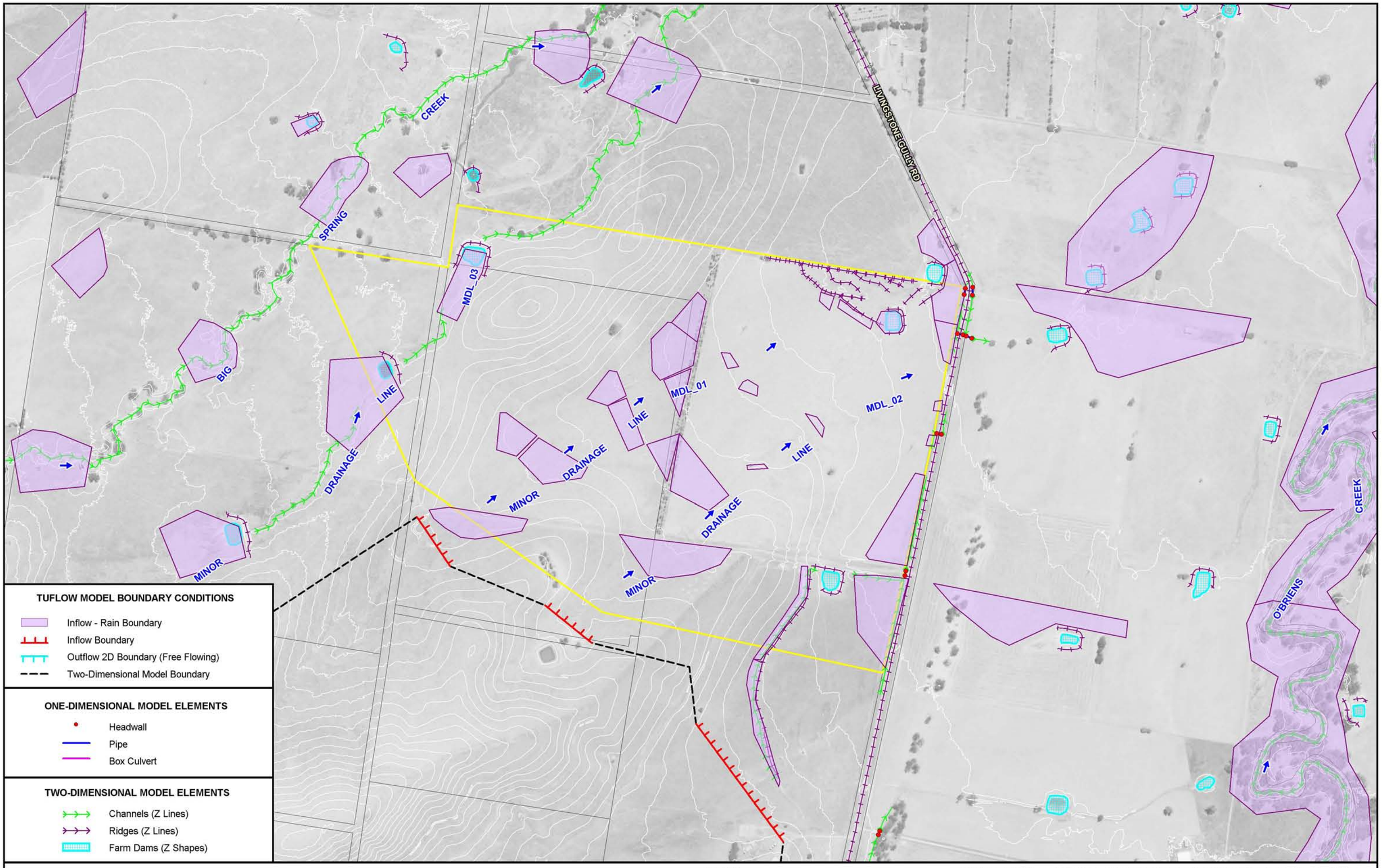
LEGEND

- Unmodified Sub-Catchment Boundary
- Site Boundary
- Revised Rural Sub-Catchment Extent
- Existing Piped Drainage System

GUGAA 500 kV SUBSTATION ADDENDUM FLOODING REPORT

Figure 1

REFINED KYEAMBA CREEK HYDROLOGIC MODEL
UPDATED SUB-CATCHMENT LAYOUT - PRE-GUGAA 500 kV SUBSTATION CONDITIONS



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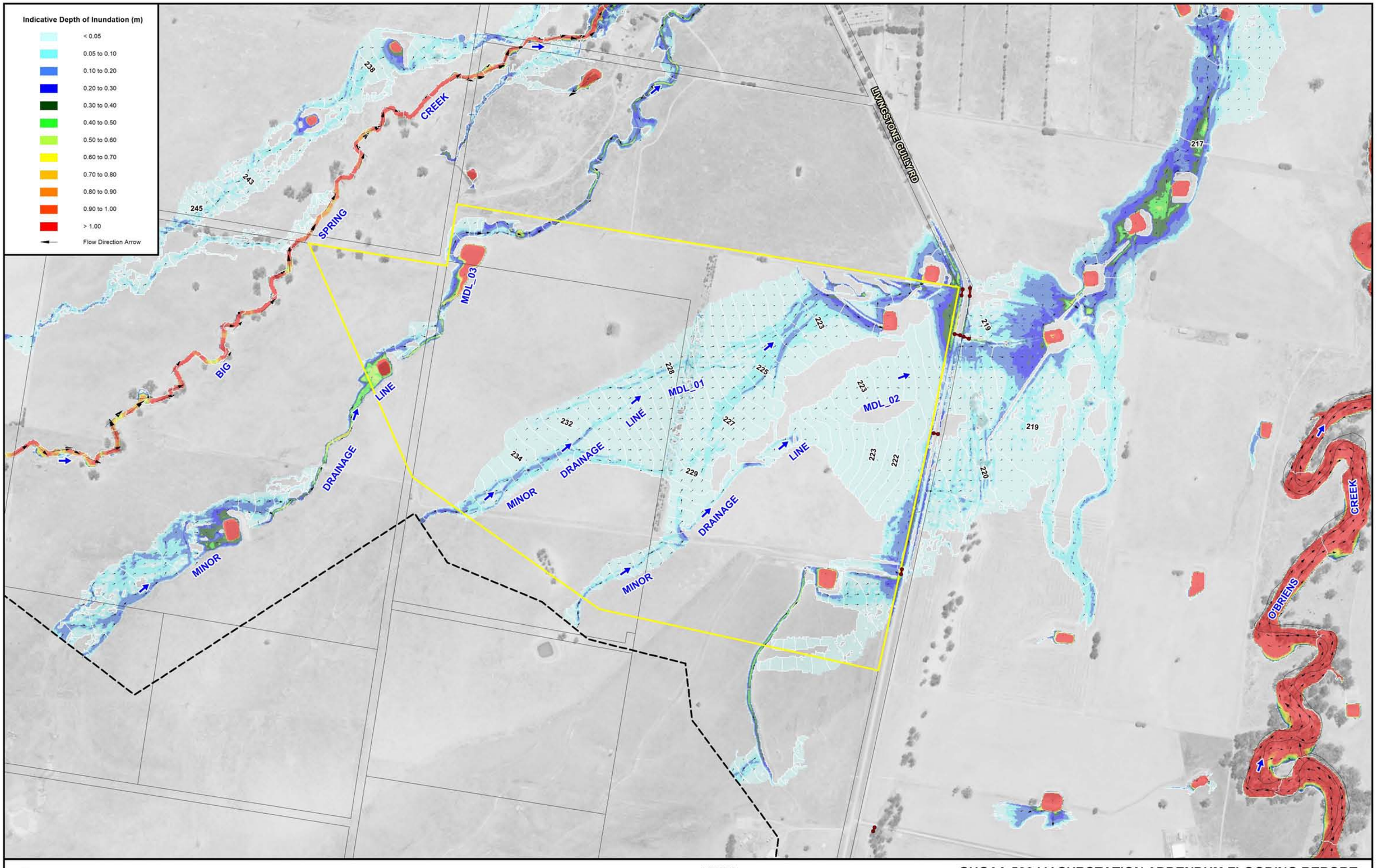
GUGAA 500 kV SUBSTATION ADDENDUM FLOODING REPORT

Figure 2

KYEAMBA CREEK TUFLOW MODEL
UPDATED MODEL LAYOUT - PRE-GUGAA 500 kV SUBSTATION CONDITIONS



N

80 0 80 160 240 m

Scale: 1:8,000

Lyall & Associates

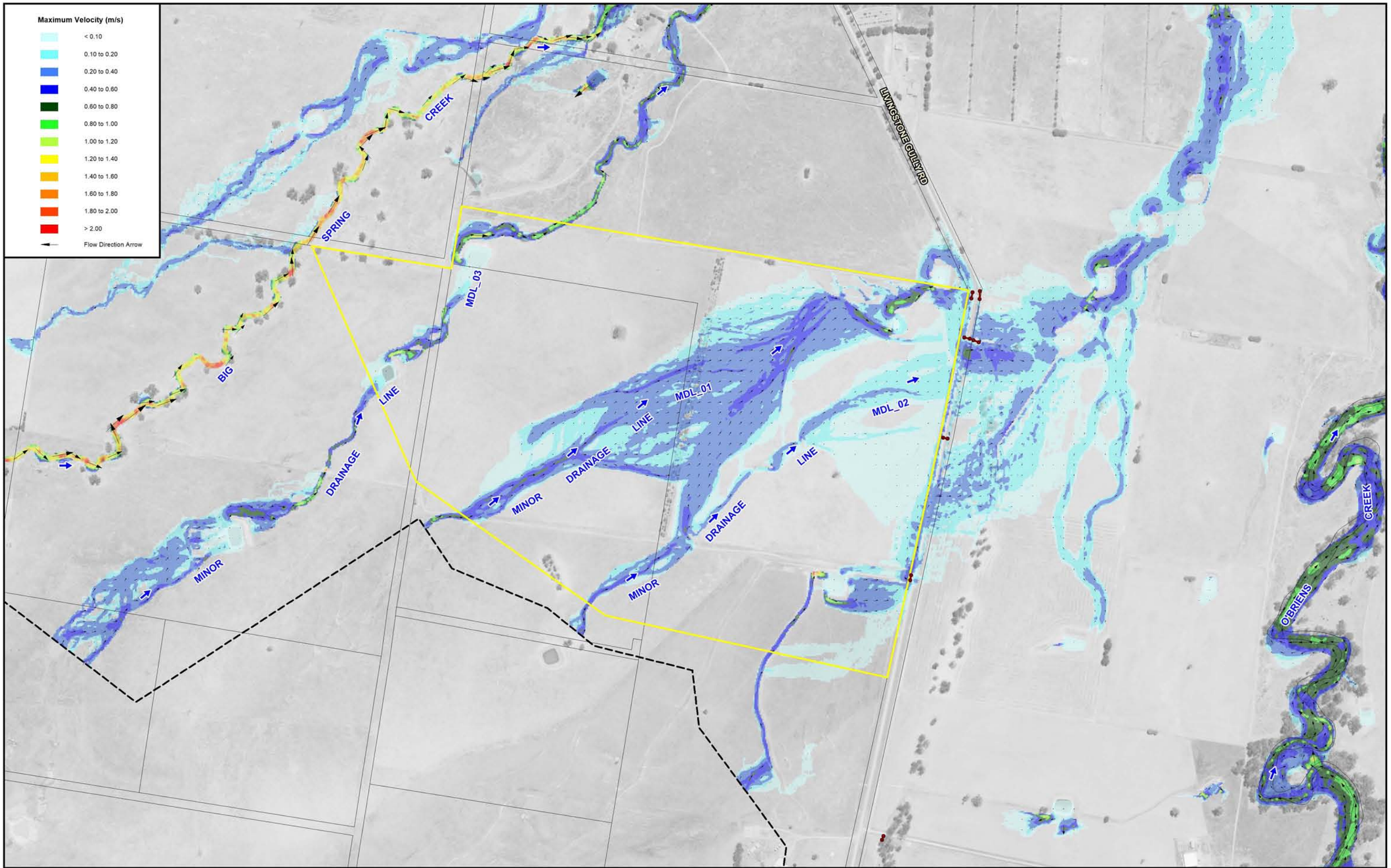
LEGEND

- Modelled Stormwater Drainage Network
- TUFLOW Model Extent
- Site Boundary
- 213 Water Surface Elevation Contours (m AHD)

GUGAA 500 kV SUBSTATION ADDENDUM FLOODING REPORT

Figure 3

INDICATIVE EXTENT AND DEPTH OF INUNDATION
PRE-GUGAA 500 kV SUBSTATION CONDITIONS - 20% AEP



N

80 0 80 160 240 m

Scale: 1:8,000

Lyall & Associates

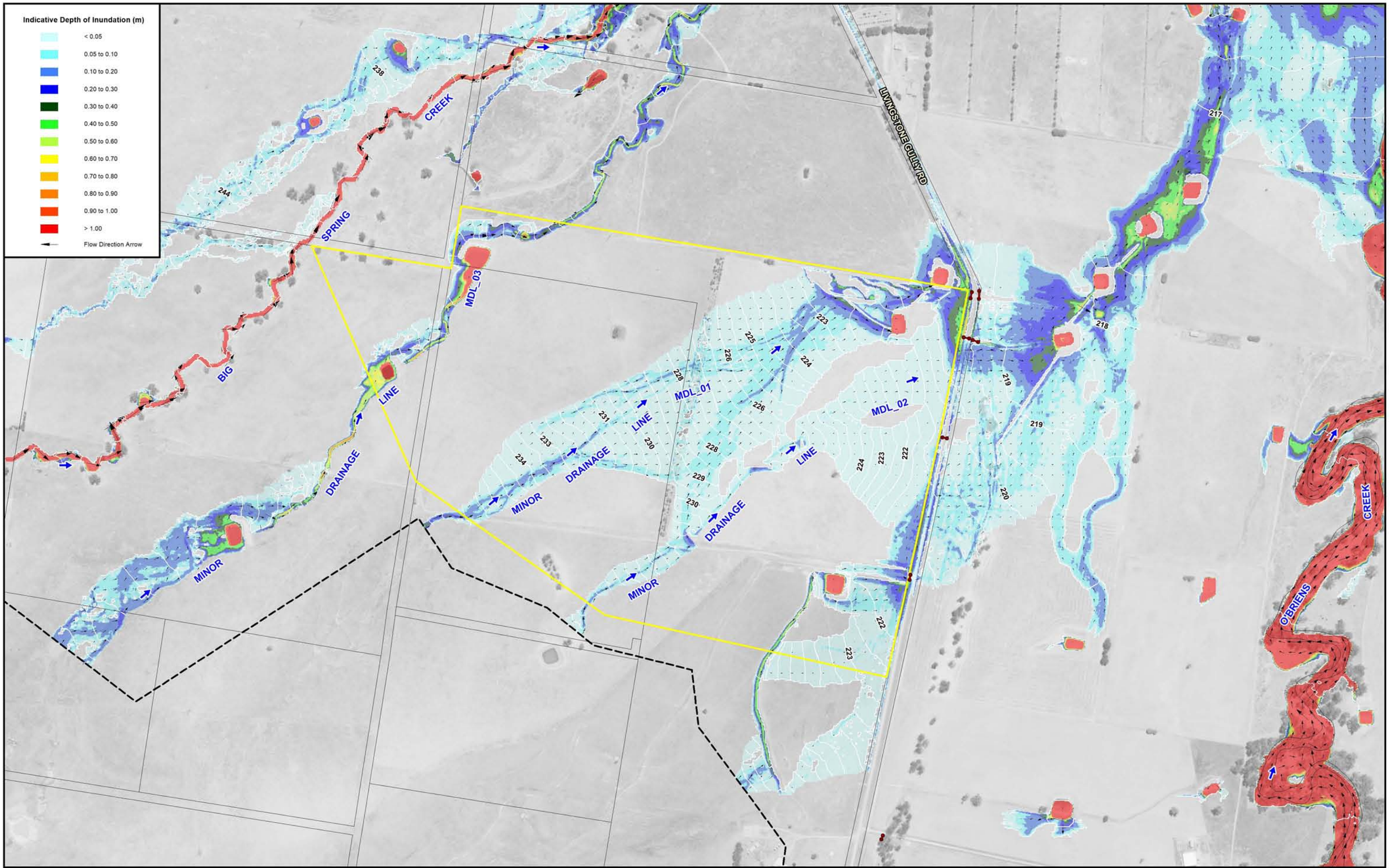
LEGEND

- Modelled Stormwater Drainage Network
- TUFLOW Model Extent
- Site Boundary

GUGAA 500 kV SUBSTATION ADDENDUM FLOODING REPORT

Figure 4

MAXIMUM FLOW VELOCITIES
PRE-GUGAA 500 kV SUBSTATION CONDITIONS - 20% AEP



N

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Scale: 1:8,000

Lyall & Associates

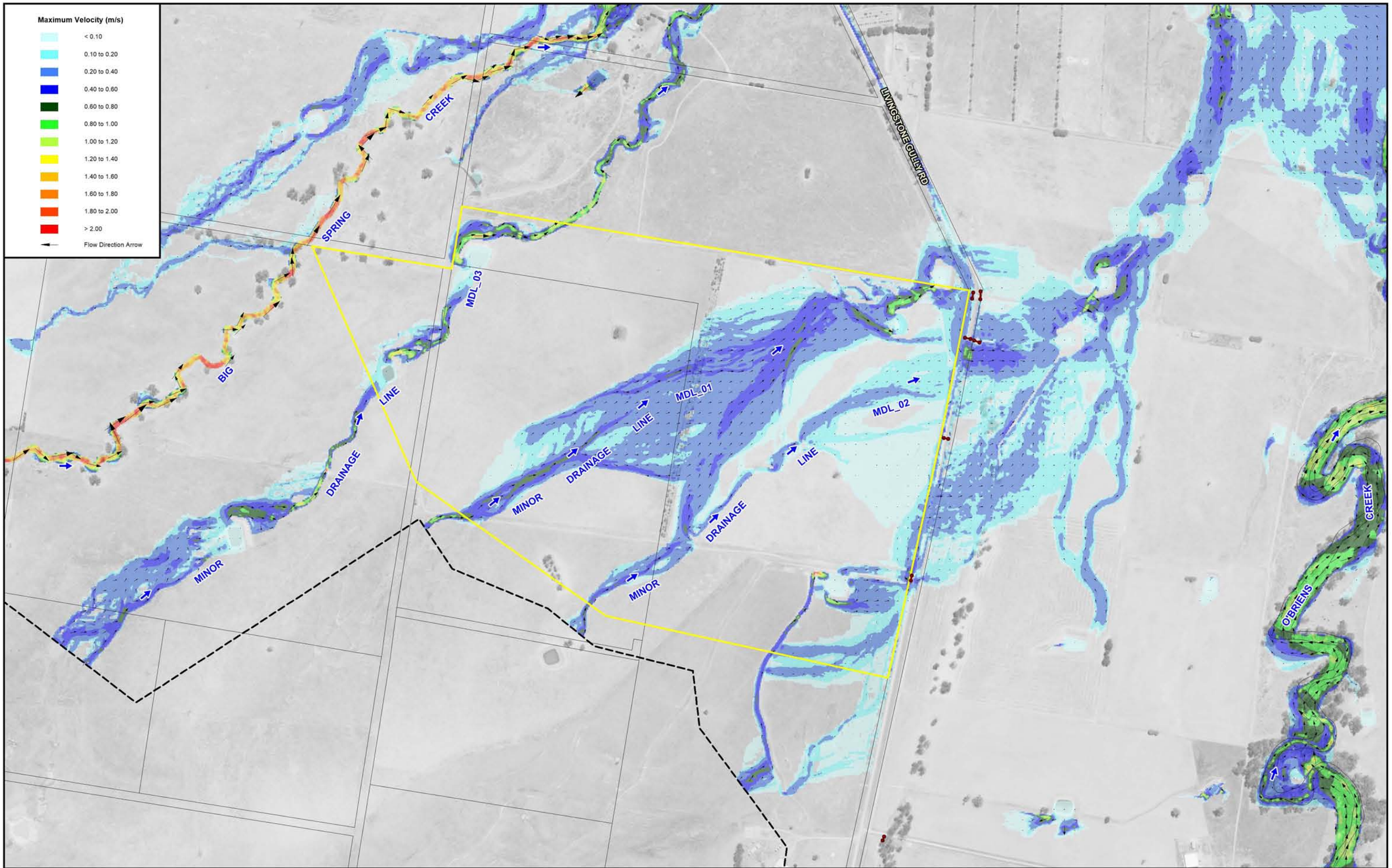
LEGEND

- Modelled Stormwater Drainage Network
- TUFLOW Model Extent
- Site Boundary
- 214 Water Surface Elevation Contours (m AHD)

GUGAA 500 kV SUBSTATION ADDENDUM FLOODING REPORT

Figure 5

INDICATIVE EXTENT AND DEPTH OF INUNDATION
PRE-GUGAA 500 kV SUBSTATION CONDITIONS - 10% AEP



N

80 0 80 160 240 m

Scale: 1:8,000

LEGEND

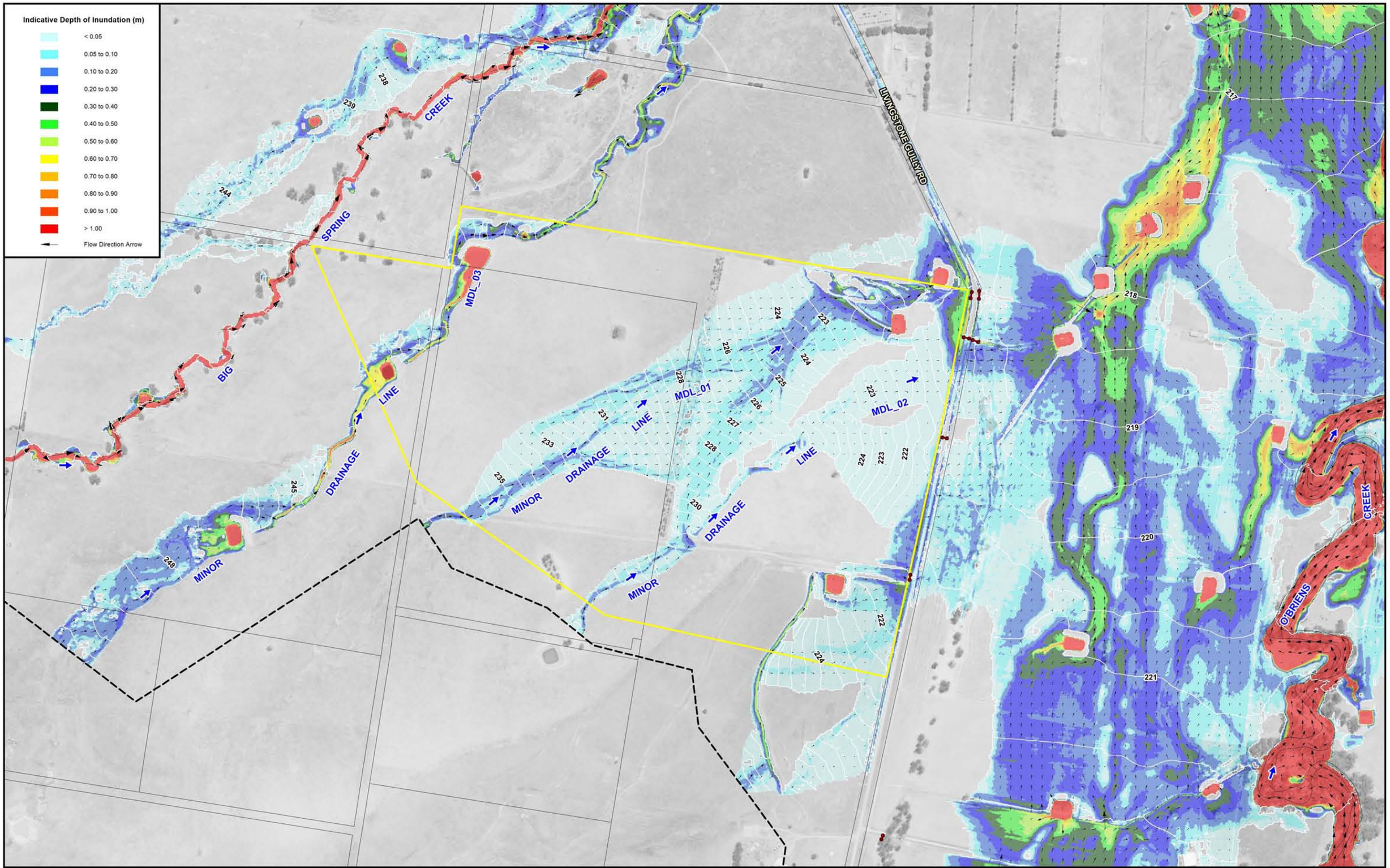
- Modelled Stormwater Drainage Network
- TUFLOW Model Extent
- Site Boundary

Lyall & Associates

GUGAA 500 kV SUBSTATION ADDENDUM FLOODING REPORT

Figure 6

MAXIMUM FLOW VELOCITIES
PRE-GUGAA 500 kV SUBSTATION CONDITIONS - 10% AEP



N

80 0 80 160 240 m

Scale: 1:8,000

LEGEND

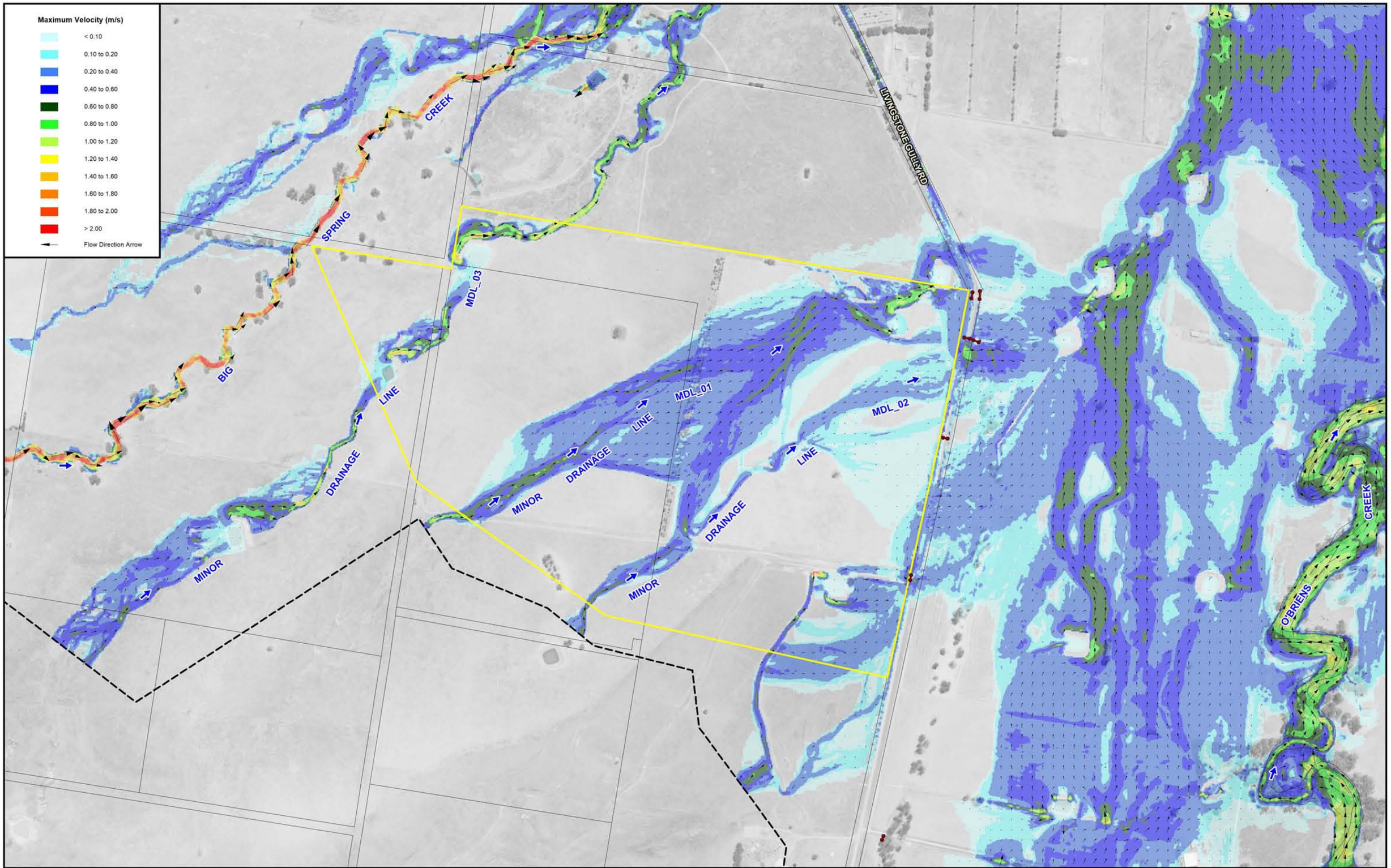
- Modelled Stormwater Drainage Network
- TUFLOW Model Extent
- Site Boundary
- 215.5 Water Surface Elevation Contours (m AHD)

Lyall & Associates

GUGAA 500 kV SUBSTATION ADDENDUM FLOODING REPORT

Figure 7

INDICATIVE EXTENT AND DEPTH OF INUNDATION
PRE-GUGAA 500 kV SUBSTATION CONDITIONS - 5% AEP



N

80 0 80 160 240 m

Scale: 1:8,000

LEGEND

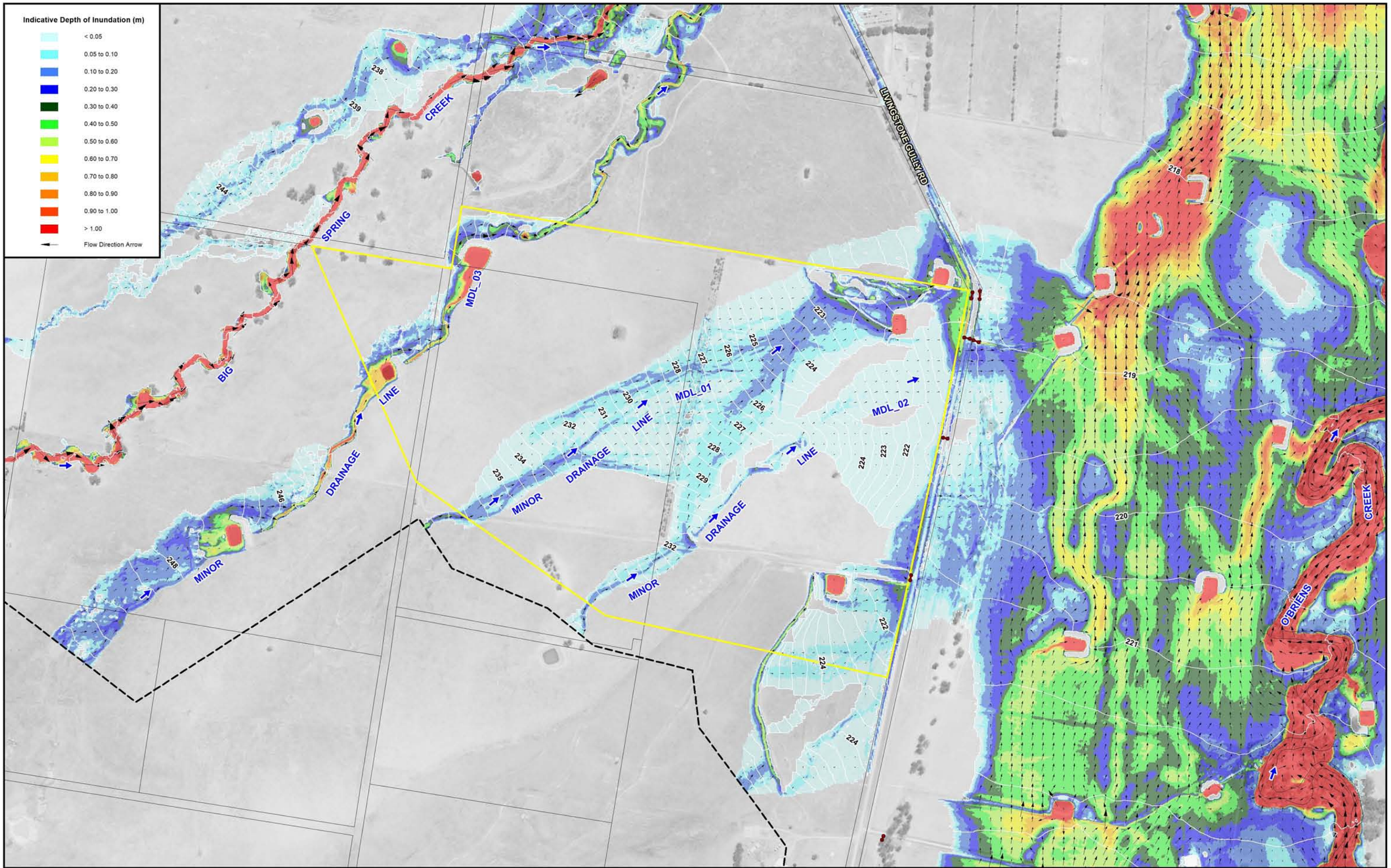
- Modelled Stormwater Drainage Network
- TUFLOW Model Extent
- Site Boundary

Lyall & Associates

GUGAA 500 kV SUBSTATION ADDENDUM FLOODING REPORT

Figure 8

MAXIMUM FLOW VELOCITIES
PRE-GUGAA 500 kV SUBSTATION CONDITIONS - 5% AEP



N

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Scale: 1:8,000

Lyall & Associates

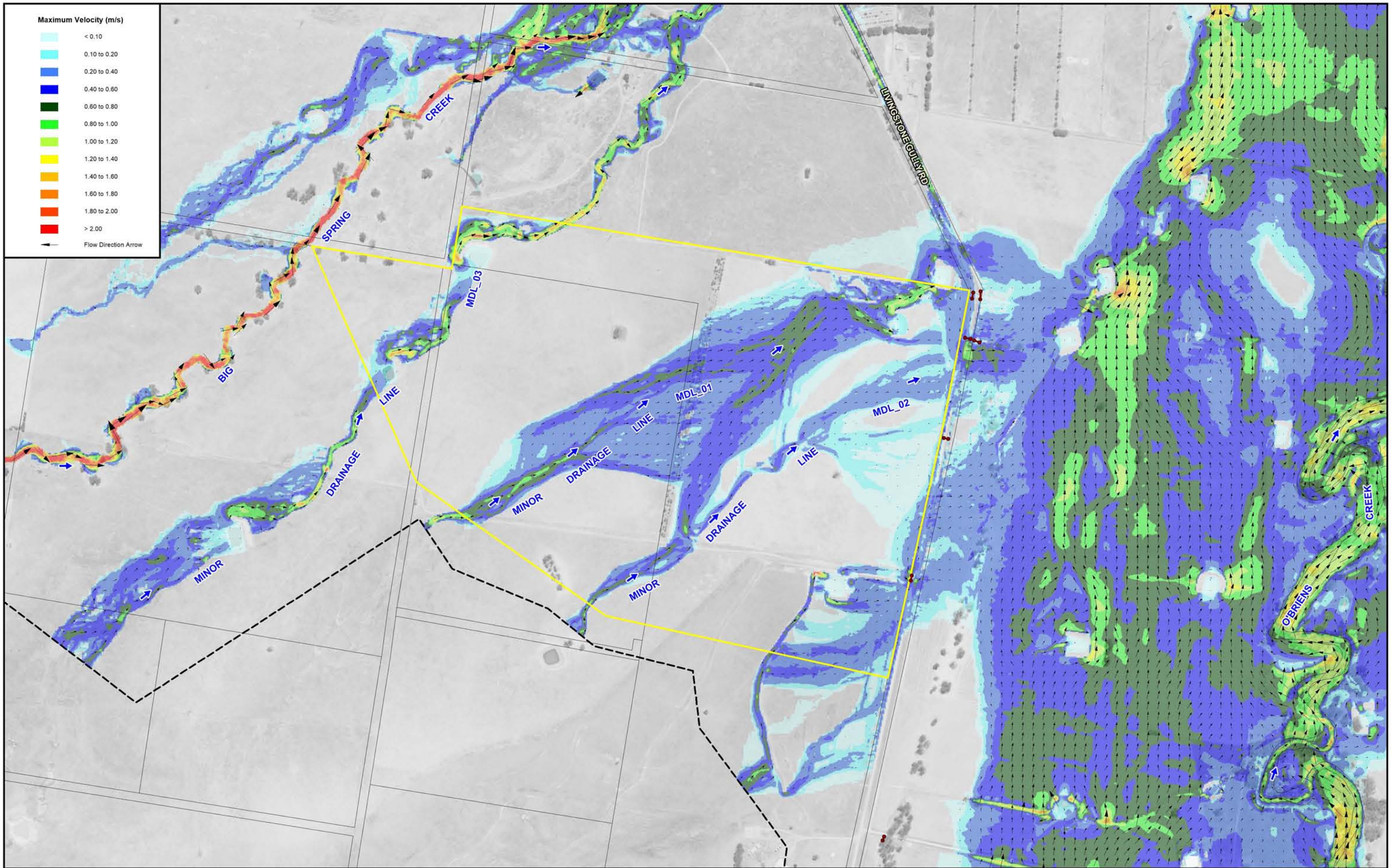
LEGEND

- Modelled Stormwater Drainage Network
- TUFLOW Model Extent
- Site Boundary
- 217 Water Surface Elevation Contours (m AHD)

GUGAA 500 kV SUBSTATION ADDENDUM FLOODING REPORT

Figure 9

INDICATIVE EXTENT AND DEPTH OF INUNDATION
PRE-GUGAA 500 kV SUBSTATION CONDITIONS - 2% AEP



N

80 0 80 160 240 m

Scale: 1:8,000

LEGEND

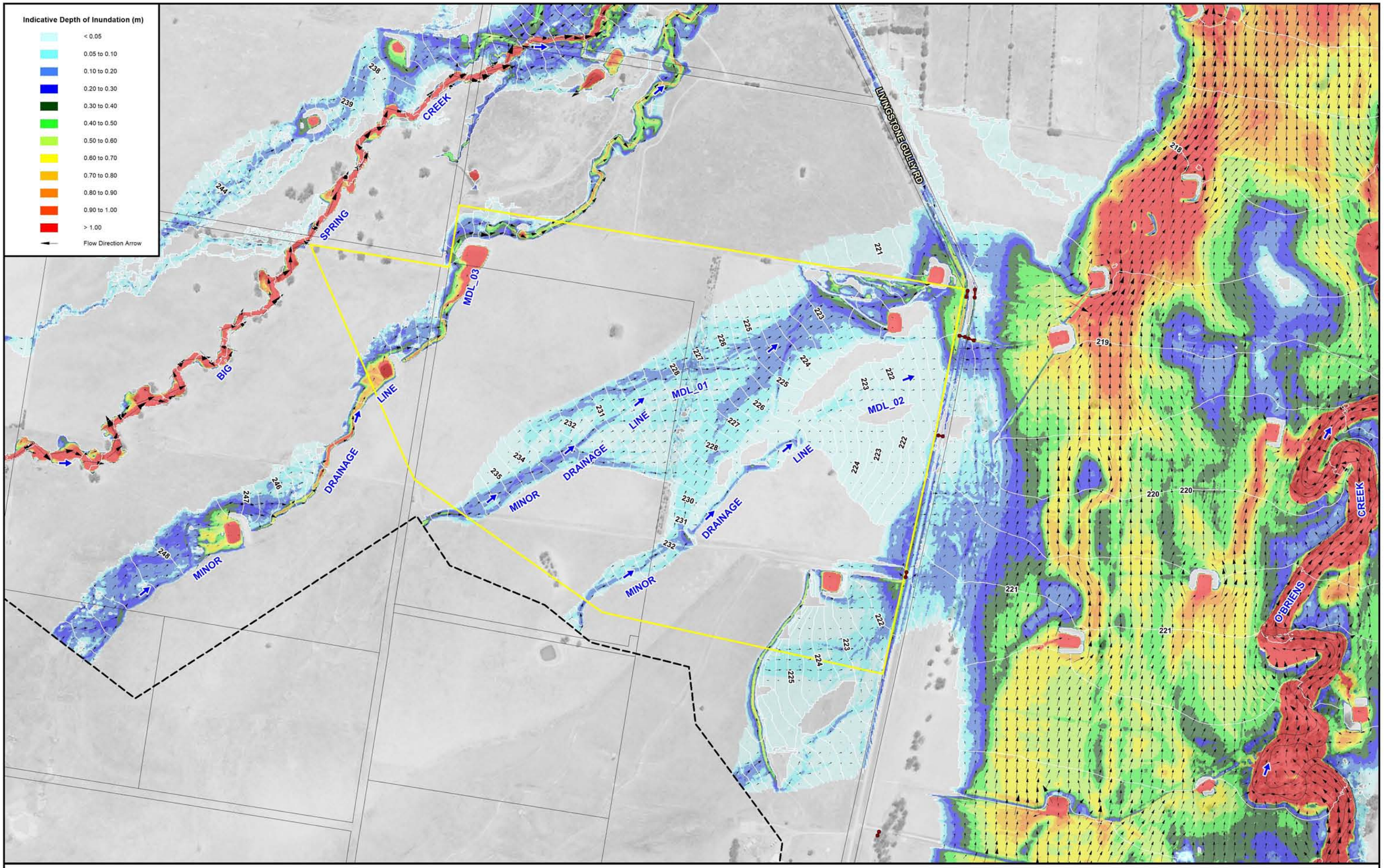
- Modelled Stormwater Drainage Network
- TUFLOW Model Extent
- Site Boundary

Lyall & Associates

GUGAA 500 kV SUBSTATION ADDENDUM FLOODING REPORT

Figure 10

MAXIMUM FLOW VELOCITIES
PRE-GUGAA 500 kV SUBSTATION CONDITIONS - 2% AEP



N

80 0 80 160 240 m

Scale: 1:8,000

Lyall & Associates

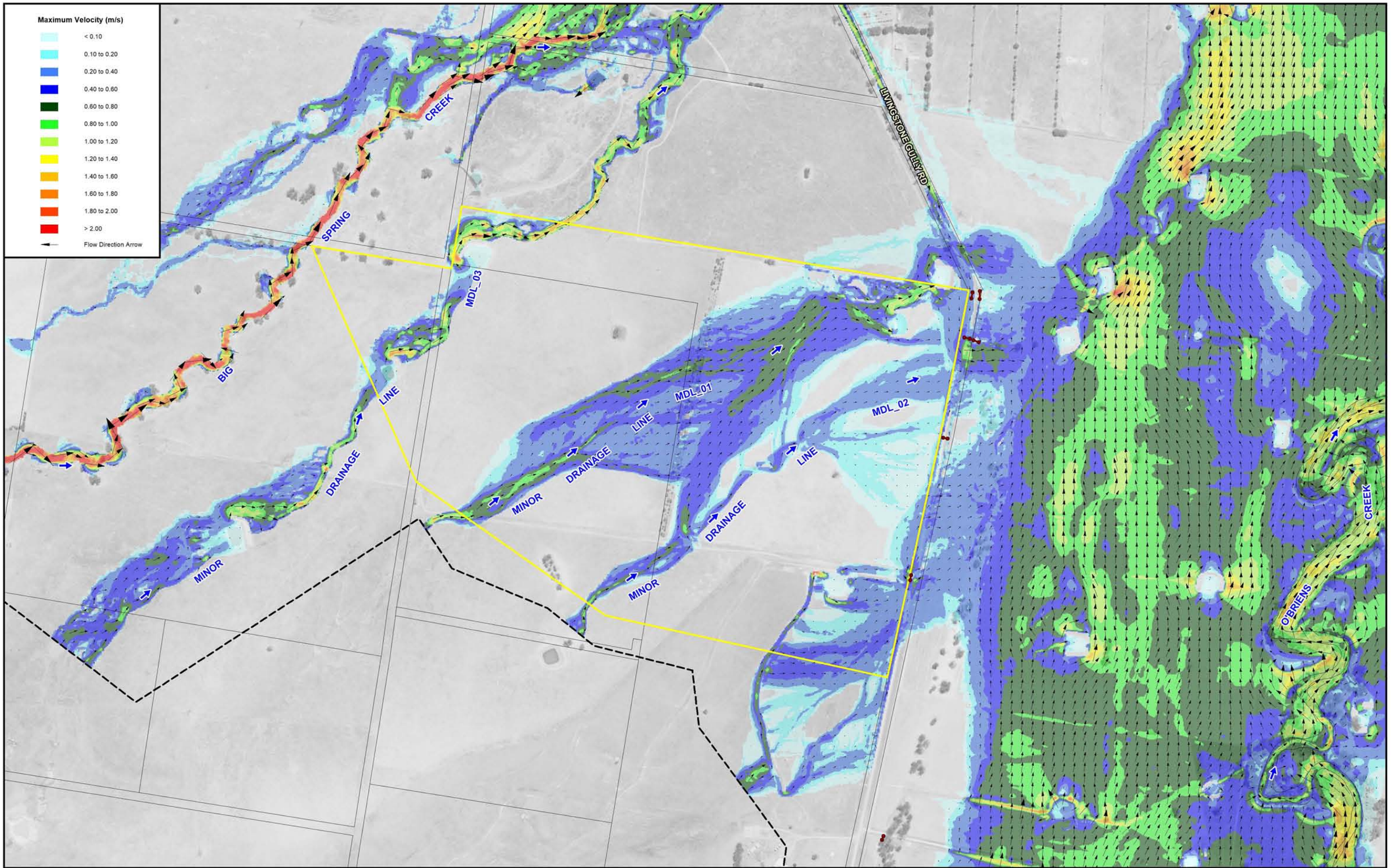
LEGEND

- Modelled Stormwater Drainage Network
- TUFLOW Model Extent
- Site Boundary
- 217 Water Surface Elevation Contours (m AHD)

GUGAA 500 kV SUBSTATION ADDENDUM FLOODING REPORT

Figure 11

INDICATIVE EXTENT AND DEPTH OF INUNDATION
PRE-GUGAA 500 kV SUBSTATION CONDITIONS - 1% AEP



N

80 0 80 160 240 m

Scale: 1:8,000

LEGEND

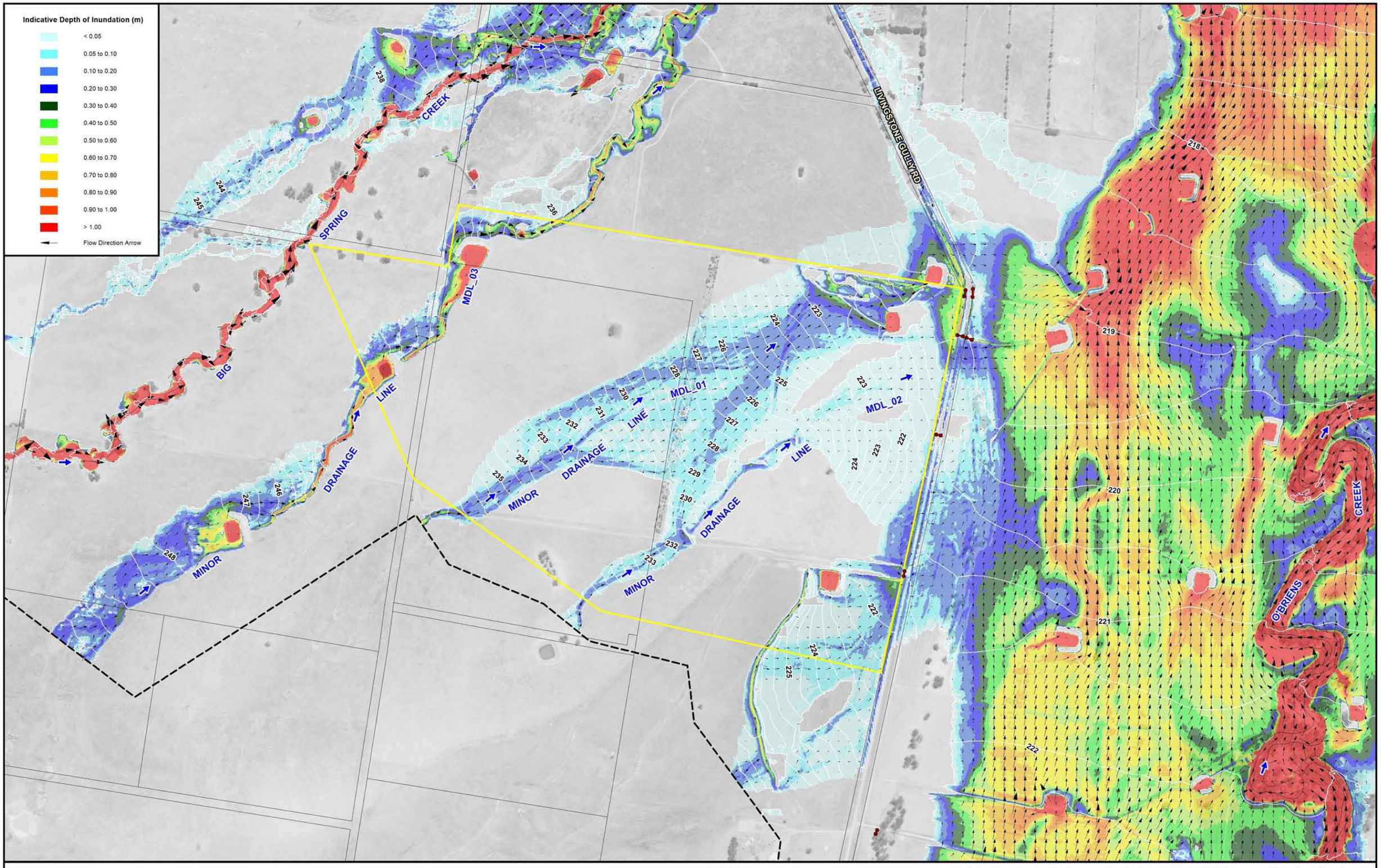
- Modelled Stormwater Drainage Network
- TUFLOW Model Extent
- Site Boundary

Lyall & Associates

GUGAA 500 kV SUBSTATION ADDENDUM FLOODING REPORT

Figure 12

MAXIMUM FLOW VELOCITIES
PRE-GUGAA 500 kV SUBSTATION CONDITIONS - 1% AEP



N

80 0 80 160 240 m

Scale: 1:8,000

Lyall & Associates

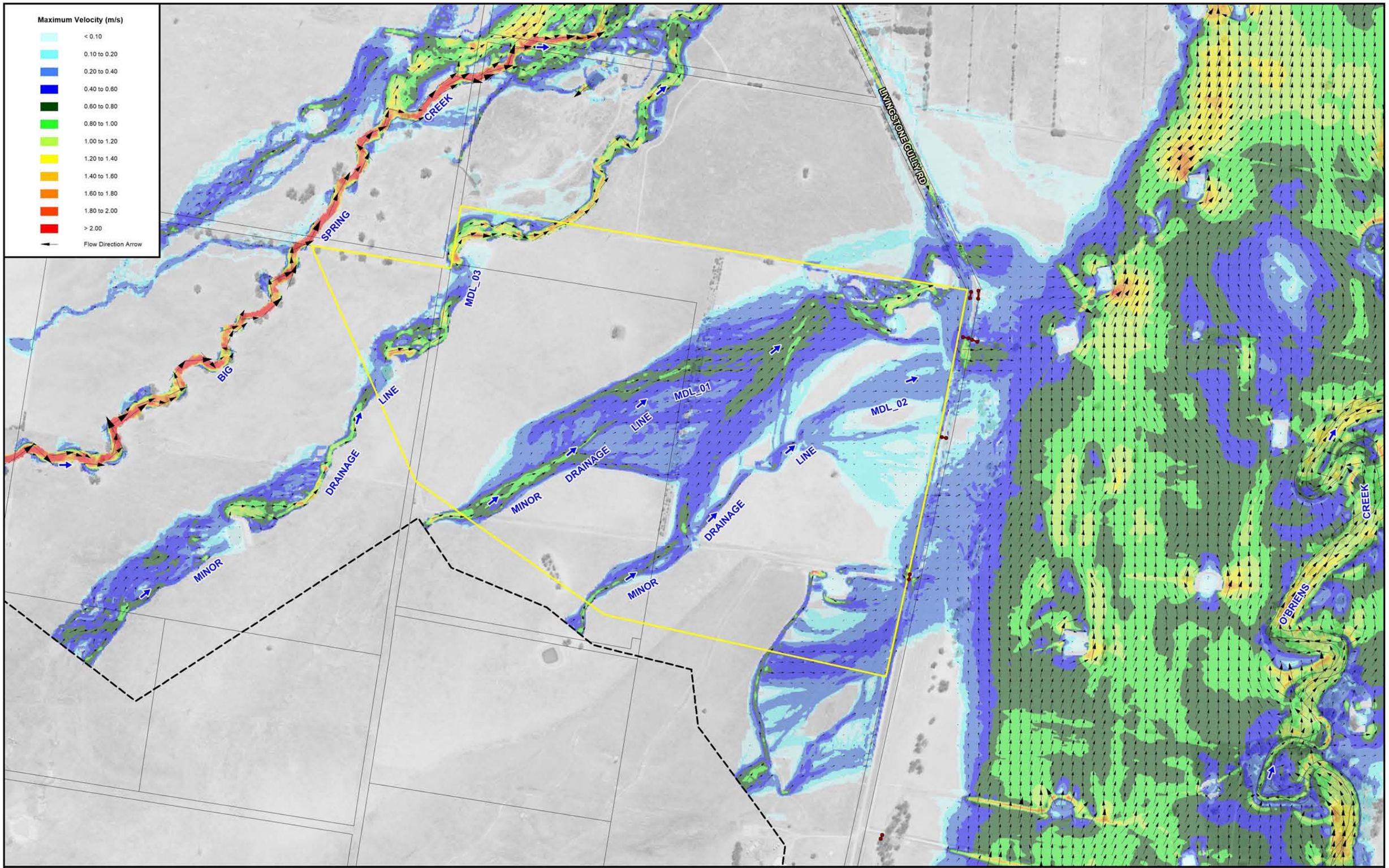
LEGEND

- Modelled Stormwater Drainage Network
- TUFLOW Model Extent
- Site Boundary
- 217 Water Surface Elevation Contours (m AHD)

GUGAA 500 kV SUBSTATION ADDENDUM FLOODING REPORT

Figure 13

INDICATIVE EXTENT AND DEPTH OF INUNDATION
PRE-GUGAA 500 kV SUBSTATION CONDITIONS - 0.5% AEP



N

80 0 80 160 240 m

Scale: 1:8,000

LEGEND

Modelled Stormwater Drainage Network

TUFLOW Model Extent

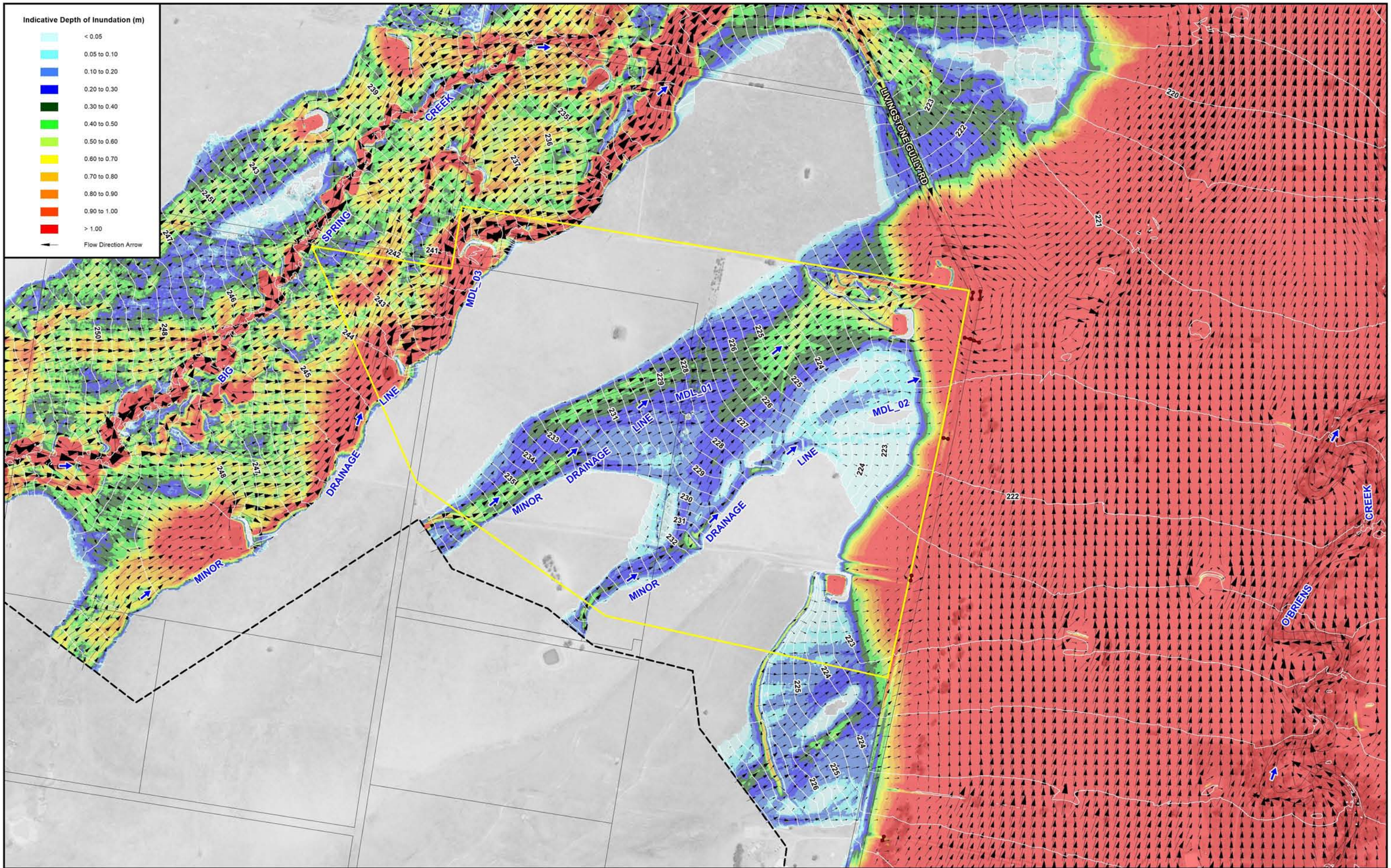
Site Boundary

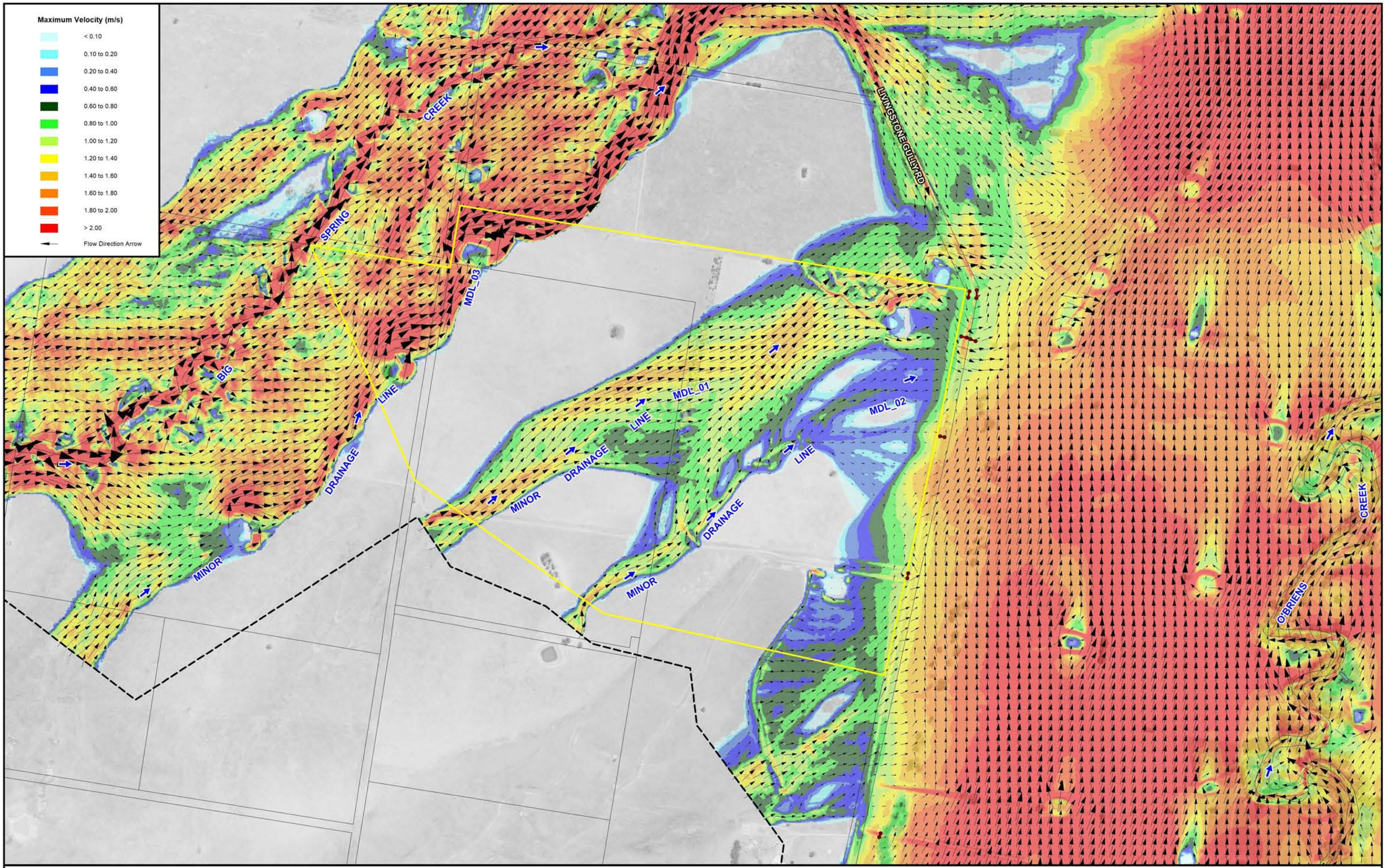
Lyall & Associates

GUGAA 500 kV SUBSTATION ADDENDUM FLOODING REPORT

Figure 14

MAXIMUM FLOW VELOCITIES
PRE-GUGAA 500 kV SUBSTATION CONDITIONS - 0.5% AEP


Indicative Depth of Inundation (m)
< 0.05
0.05 to 0.10
0.10 to 0.20
0.20 to 0.30
0.30 to 0.40
0.40 to 0.50
0.50 to 0.60
0.60 to 0.70
0.70 to 0.80
0.80 to 0.90
0.90 to 1.00
> 1.00
Flow Direction Arrow
SPRING CREEK
BIG LINE DRAINAGE
MINOR
MDL_03
MDL_01
MDL_02
LINE DRAINAGE
MINOR
LINE DRAINAGE
MINOR
LINE DRAINAGE
LIVINGSTONE GULLY RD
O'BRIENS CREEK
239
235
236
231
243
245
247
242
241
246
243
250
248
244
245
247
246
225
226
228
229
224
225
231
227
233
234
228
235
229
230
231
232
223
222
220
221
224
223
225
224
226
225
N
80 0 80 160 240 m
Scale: 1:8,000
Lyall & Associates
LEGEND
Modelled Stormwater Drainage Network
TUFLOW Model Extent
Site Boundary
219
Water Surface Elevation Contours (m AHD)
GUGAA 500 kV SUBSTATION ADDENDUM FLOODING REPORT
Figure 15
INDICATIVE EXTENT AND DEPTH OF INUNDATION
PRE-GUGAA 500 kV SUBSTATION CONDITIONS - PMF



N

80 0 80 160 240 m

Scale: 1:8,000

LEGEND

- Modelled Stormwater Drainage Network
- TUFLOW Model Extent
- Site Boundary

Lyall & Associates

GUGAA 500 kV SUBSTATION ADDENDUM FLOODING REPORT

Figure 16

MAXIMUM FLOW VELOCITIES
PRE-GUGAA 500 kV SUBSTATION CONDITIONS - PMF

N

80 0 80 160 240 m

Scale: 1:8,000

Lyall & Associates

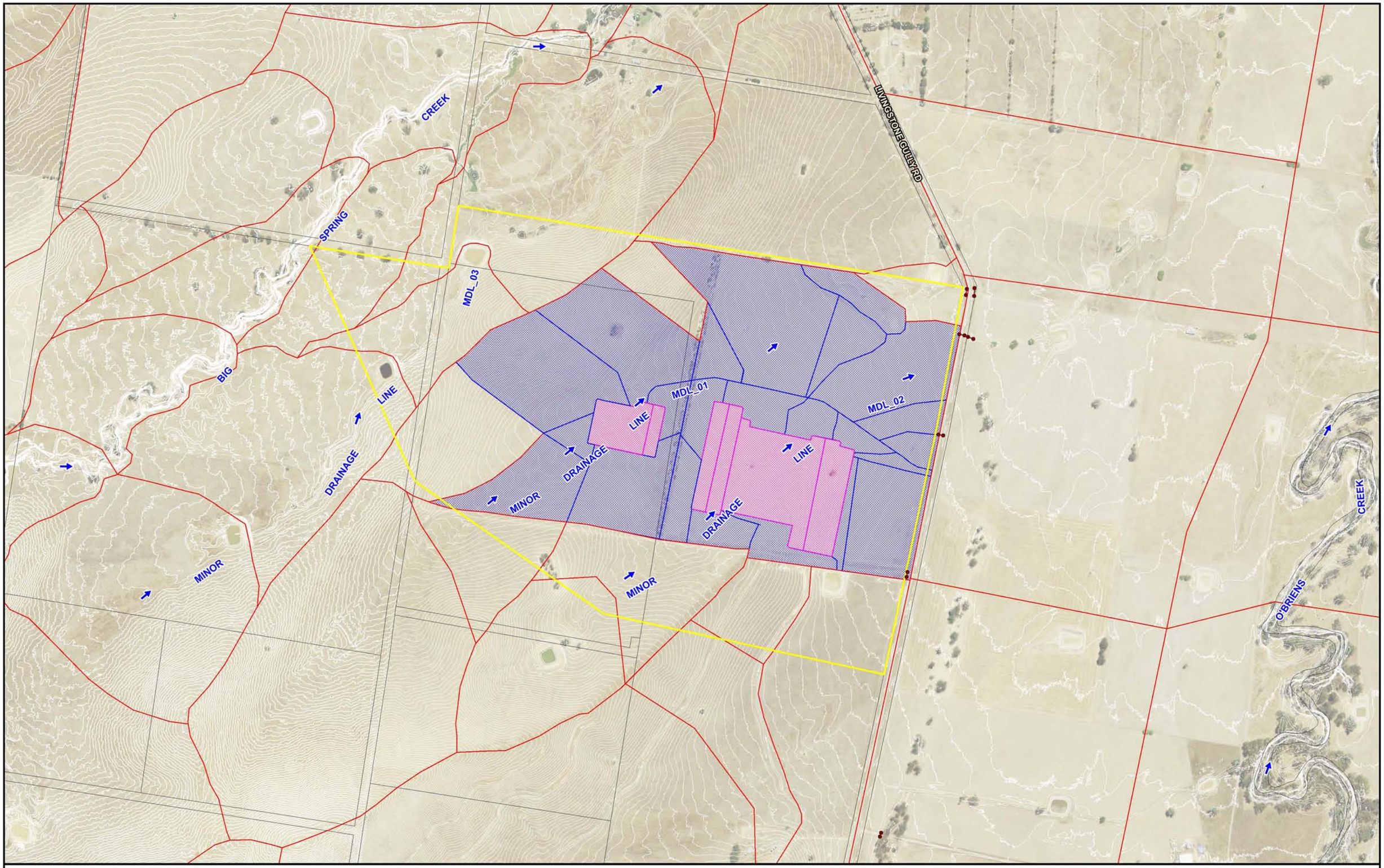
LEGEND

- Site Boundary
- Site Access Road (Indicative)
- Extent of Substation Bench (Indicative)
- Channel Works and Adopted Invert Level (m AHD) — 227.91
- Existing Stormwater Drainage Network
- TUFLOW Model Extent
- Proposed Stormwater Drainage System Network
- Upgraded Flow Diversion Bund
- Proposed Flow Diversion Bund
- Proposed Raised Area

GUGAA 500 kV SUBSTATION ADDENDUM FLOODING REPORT

Figure 17

LAYOUT OF GUGAA 500 kV GUGAA 500 kV SUBSTATION



N

80 0 80 160 240 m

Scale: 1:8,000

LEGEND

- Unmodified Sub-Catchment Boundary
- Site Boundary
- Revised Rural Sub-Catchment Extent
- Existing Piped Drainage System
- Revised Hardstand Sub-Catchment Extent

GUGAA 500 kV SUBSTATION ADDENDUM FLOODING REPORT

Figure 18

REFINED KYEAMBA CREEK HYDROLOGIC MODEL
UPDATED SUB-CATCHMENT LAYOUT - POST-GUGAA 500 kV SUBSTATION CONDITIONS

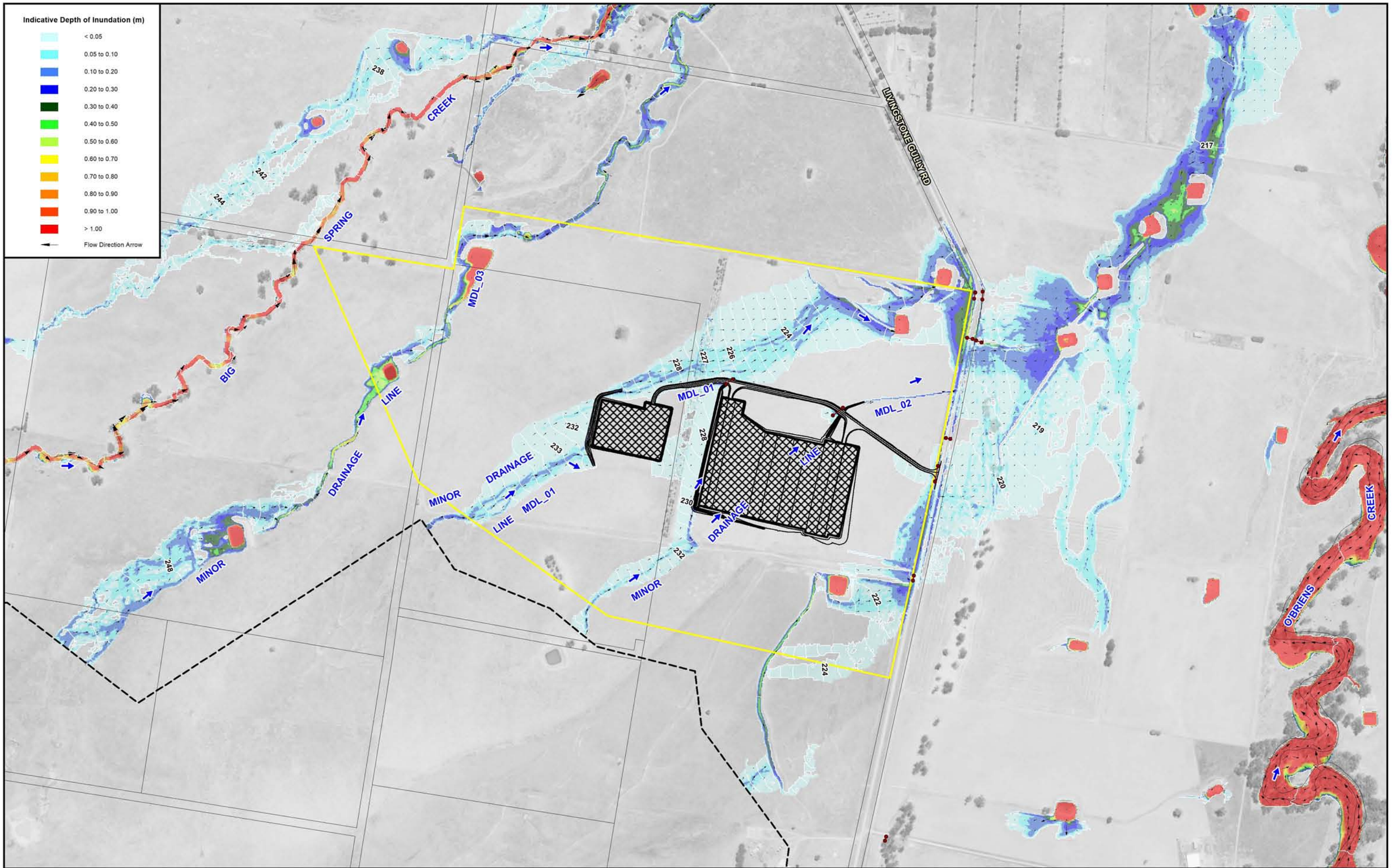
Lyall & Associates

Lyall & Associates

GUGAA 500 kV SUBSTATION ADDENDUM FLOODING REPORT

Figure 19

KYEAMBA CREEK TUFLOW MODEL
UPDATED MODEL LAYOUT - POST-GUGAA 500 kV SUBSTATION CONDITIONS



N

80 0 80 160 240 m

Scale: 1:8,000

Lyall & Associates

LEGEND

- Extent of Substation Bench (Indicative)
- Site Access Road (Indicative)
- Site Boundary
- Modelled Stormwater Drainage Network
- TUFLOW Model Extent
- 218 Water Surface Elevation Contours (m AHD)

GUGAA 500 kV SUBSTATION ADDENDUM FLOODING REPORT

Figure 20

INDICATIVE EXTENT AND DEPTH OF INUNDATION
POST-GUGAA 500 kV SUBSTATION CONDITIONS - 20% AEP

Afflux (m)

- < -0.2
- -0.20 to -0.10
- -0.10 to -0.01
- -0.01 to 0.01
- 0.01 to 0.02
- 0.02 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.30
- 0.30 to 0.50
- > 0.50
- Land Rendered Flood Free as a Result of Change
- Additional Area of Land Flooded as a Result of Change

LIVINGSTONE GULLY RD
CREEK
SPRING
MDL_03
BIG
LINE
DRAINAGE
MINOR
DRAINAGE
MDL_01
LINE
MINOR
MDL_01
MDL_02
LINE
DRAINAGE
CREEK
O'BRIENS

N

80 0 80 160 240 m

Scale: 1:8,000

Lyall & Associates

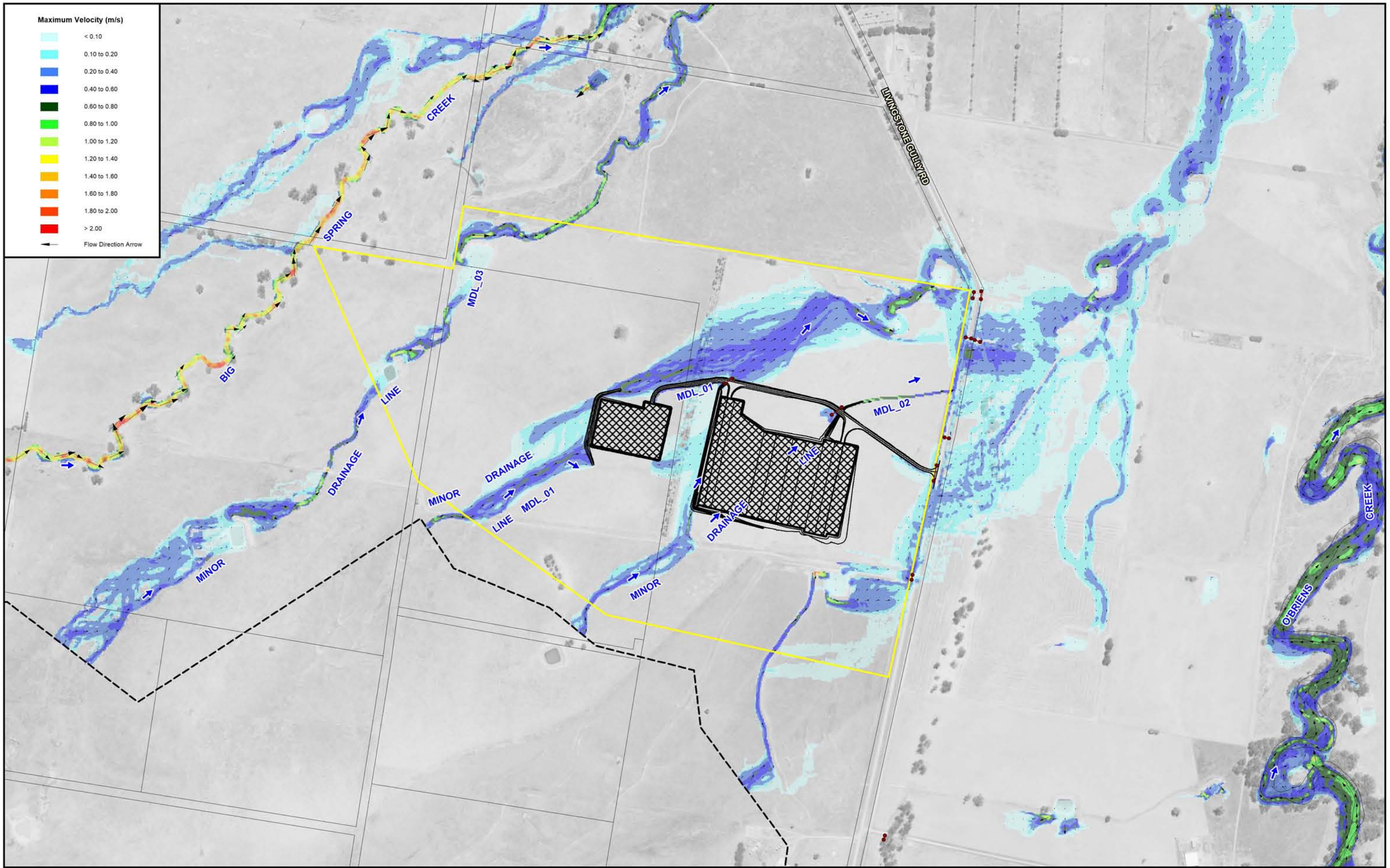
LEGEND

- Extent of Substation Bench (Indicative)
- Site Access Road (Indicative)
- Site Boundary
- Modelled Stormwater Drainage Network
- TUFLOW Model Extent

GUGAA 500 kV SUBSTATION ADDENDUM FLOODING REPORT

Figure 21

IMPACT OF GUGAA 500 kV SUBSTATION ON FLOOD BEHAVIOUR
20% AEP



N

80 0 80 160 240 m

Scale: 1:8,000

Lyall & Associates

LEGEND

- Extent of Substation Bench (Indicative)
- Site Access Road (Indicative)
- Site Boundary
- Modelled Stormwater Drainage Network
- TUFLOW Model Extent

GUGAA 500 kV SUBSTATION ADDENDUM FLOODING REPORT

Figure 22

MAXIMUM FLOW VELOCITIES
POST-GUGAA 500 kV SUBSTATION CONDITIONS - 20% AEP

Velocity Afflux (m/s)

- < -0.2
- -0.20 to -0.10
- -0.10 to -0.01
- -0.01 to 0.01
- 0.01 to 0.02
- 0.02 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.30
- 0.30 to 0.50
- > 0.50
- Land Rendered Flood Free as a Result of Project
- Additional Area of Land Flooded as a Result of Project

LIVINGSTONE GULLY RD
CREEK
SPRING
MDL_03
BIG
LINE
DRAINAGE
MINOR
DRAINAGE
MDL_01
LINE
MDL_01
MDL_02
LINE
DRAINAGE
MINOR
CREEK
O'BRIENS

N

80 0 80 160 240 m

Scale: 1:8,000

LEGEND

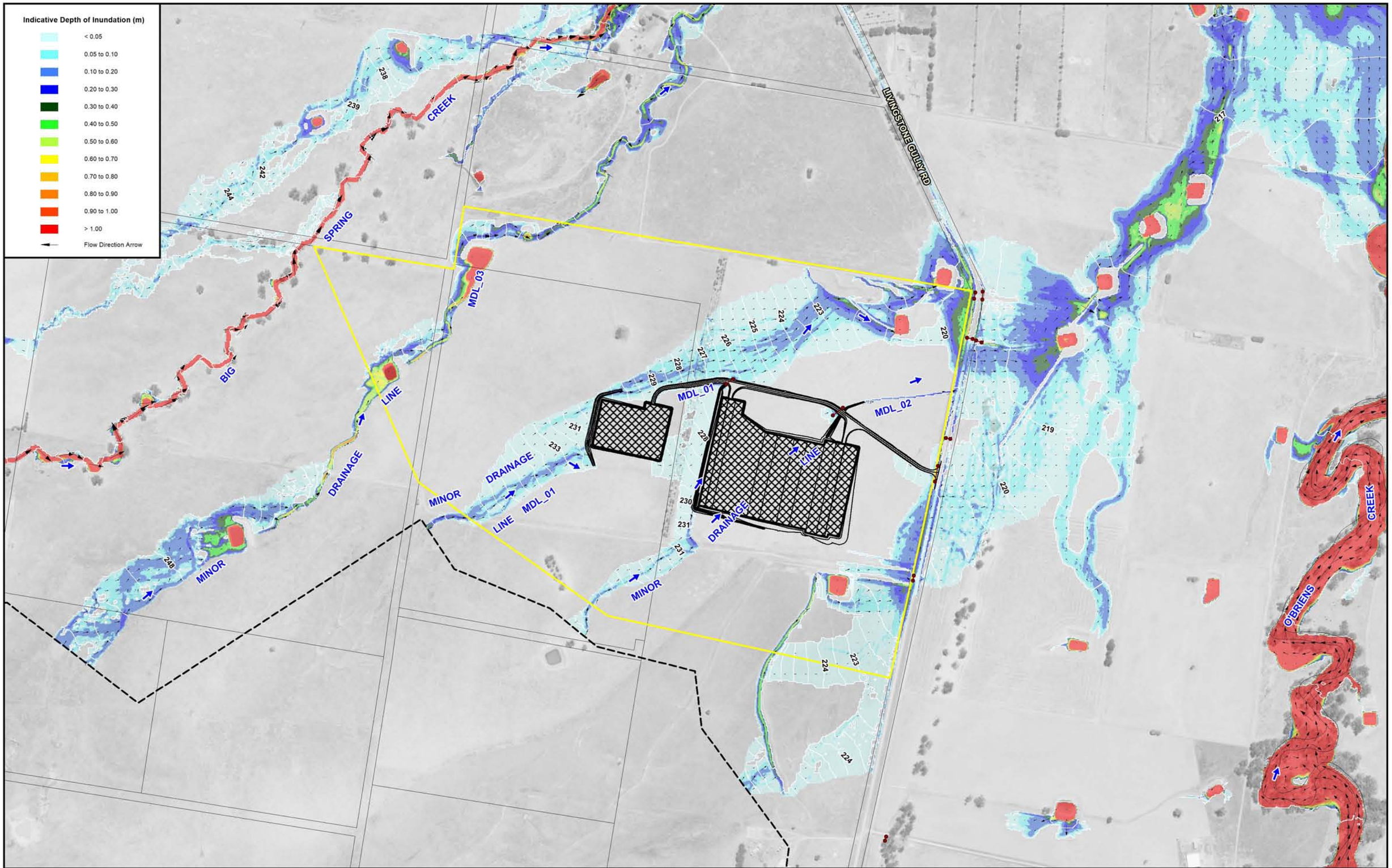
- Extent of Substation Bench (Indicative)
- Site Access Road (Indicative)
- Site Boundary
- Modelled Stormwater Drainage Network
- TUFLOW Model Extent

Lyall & Associates

GUGAA 500 kV SUBSTATION ADDENDUM FLOODING REPORT

Figure 23

IMPACT OF GUGAA 500 kV SUBSTATION ON MAXIMUM FLOW VELOCITIES
20% AEP



N

80 0 80 160 240 m

Scale: 1:8,000

Lyall & Associates

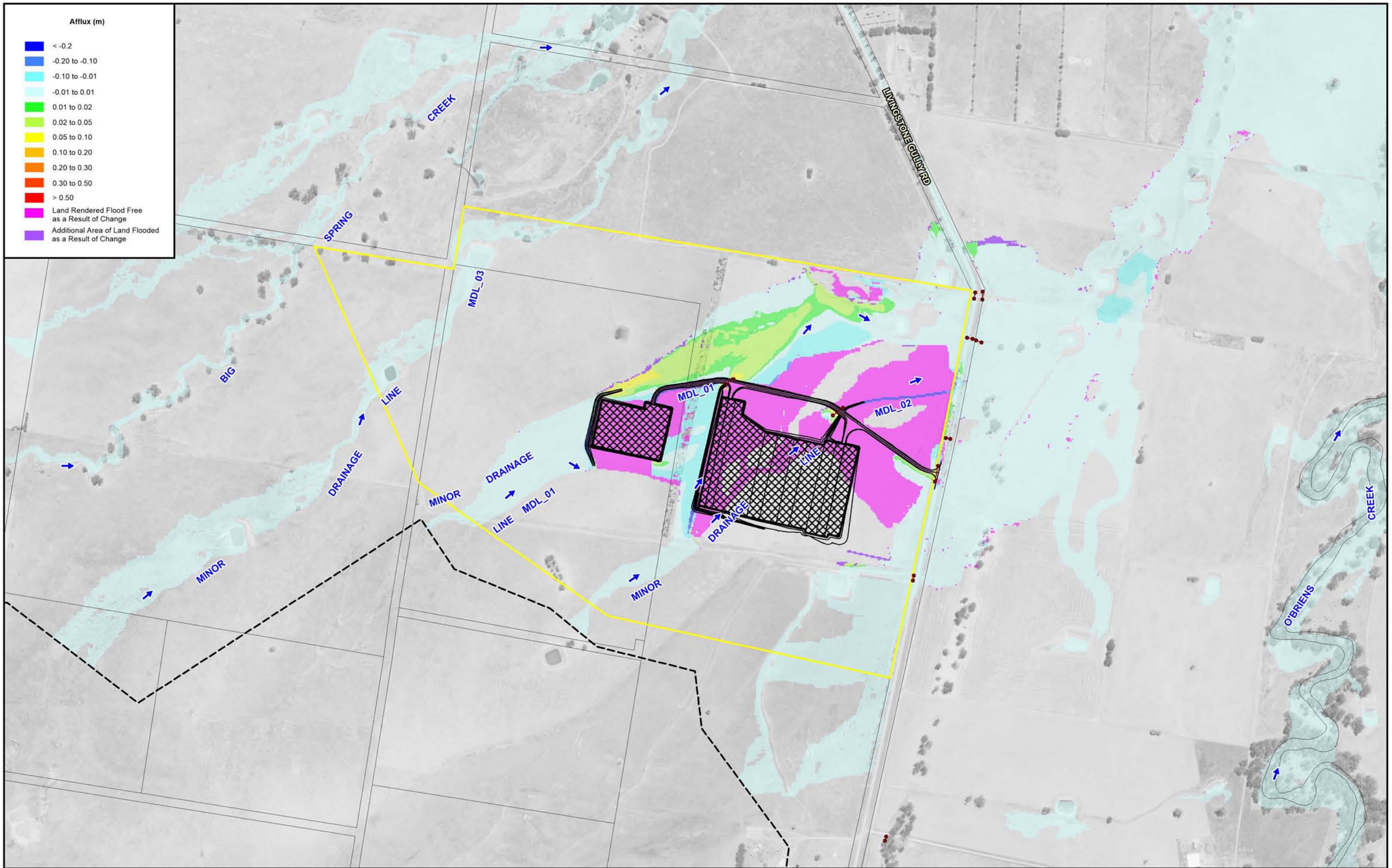
LEGEND

- Extent of Substation Bench (Indicative)
- Site Access Road (Indicative)
- Site Boundary
- Modelled Stormwater Drainage Network
- TUFLOW Model Extent
- 219 Water Surface Elevation Contours (m AHD)

GUGAA 500 kV SUBSTATION ADDENDUM FLOODING REPORT

Figure 24

INDICATIVE EXTENT AND DEPTH OF INUNDATION
POST-GUGAA 500 kV SUBSTATION CONDITIONS - 10% AEP



N

80 0 80 160 240 m

Scale: 1:8,000

Lyall & Associates

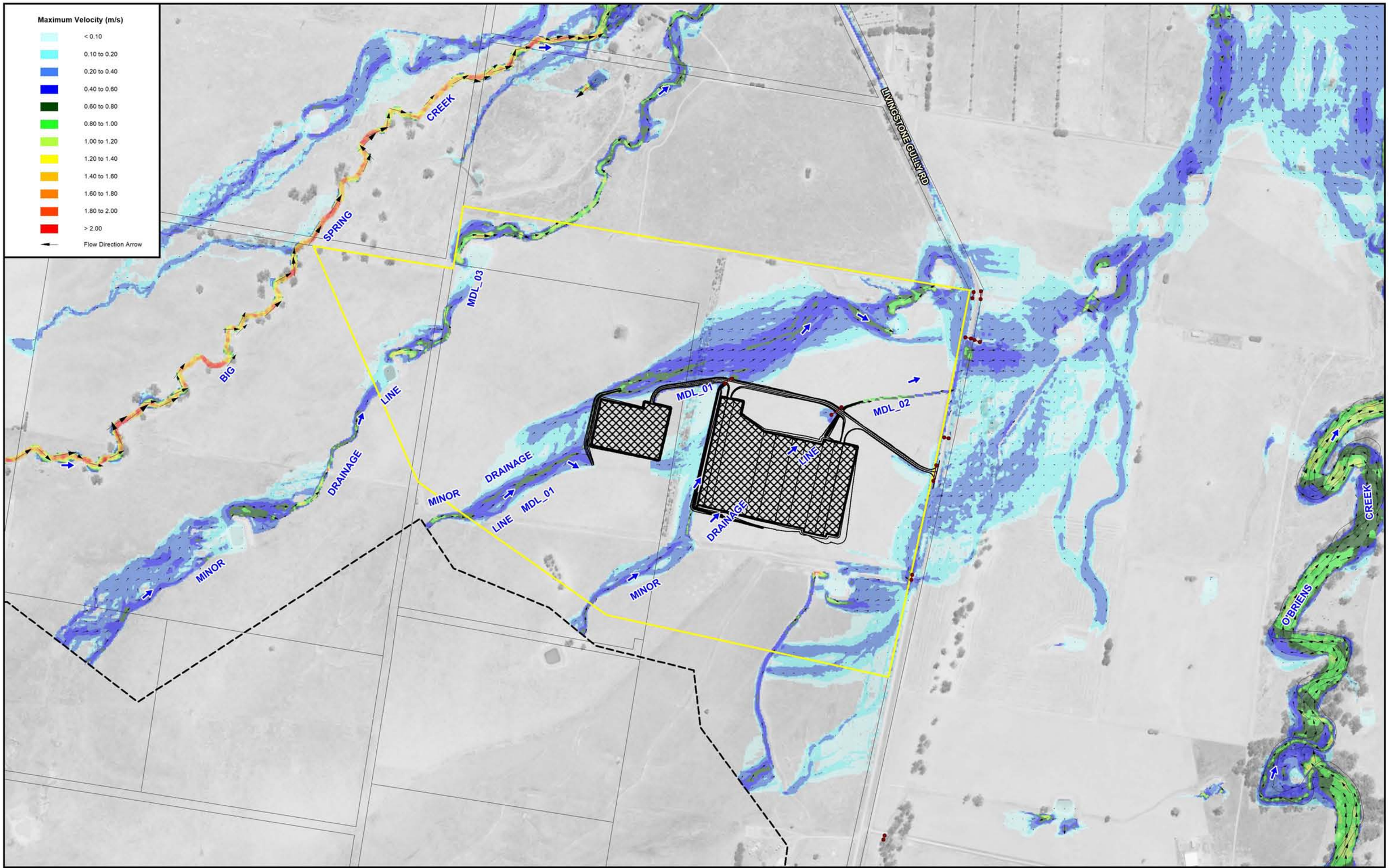
LEGEND

- Extent of Substation Bench (Indicative)
- Site Access Road (Indicative)
- Site Boundary
- Modelled Stormwater Drainage Network
- TUFLOW Model Extent

GUGAA 500 kV SUBSTATION ADDENDUM FLOODING REPORT

Figure 25

IMPACT OF GUGAA 500 kV SUBSTATION ON FLOOD BEHAVIOUR
10% AEP



N

80 0 80 160 240 m

Scale: 1:8,000

LEGEND

- Extent of Substation Bench (Indicative)
- Site Access Road (Indicative)
- Site Boundary
- Modelled Stormwater Drainage Network
- TUFLOW Model Extent

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GUGAA 500 kV SUBSTATION ADDENDUM FLOODING REPORT

Figure 26

MAXIMUM FLOW VELOCITIES
POST-GUGAA 500 kV SUBSTATION CONDITIONS - 10% AEP

Velocity Afflux (m/s)

- < -0.2
- -0.20 to -0.10
- -0.10 to -0.01
- -0.01 to 0.01
- 0.01 to 0.02
- 0.02 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.30
- 0.30 to 0.50
- > 0.50
- Land Rendered Flood Free as a Result of Project
- Additional Area of Land Flooded as a Result of Project

N

80 0 80 160 240 m

Scale: 1:8,000

Lyall & Associates

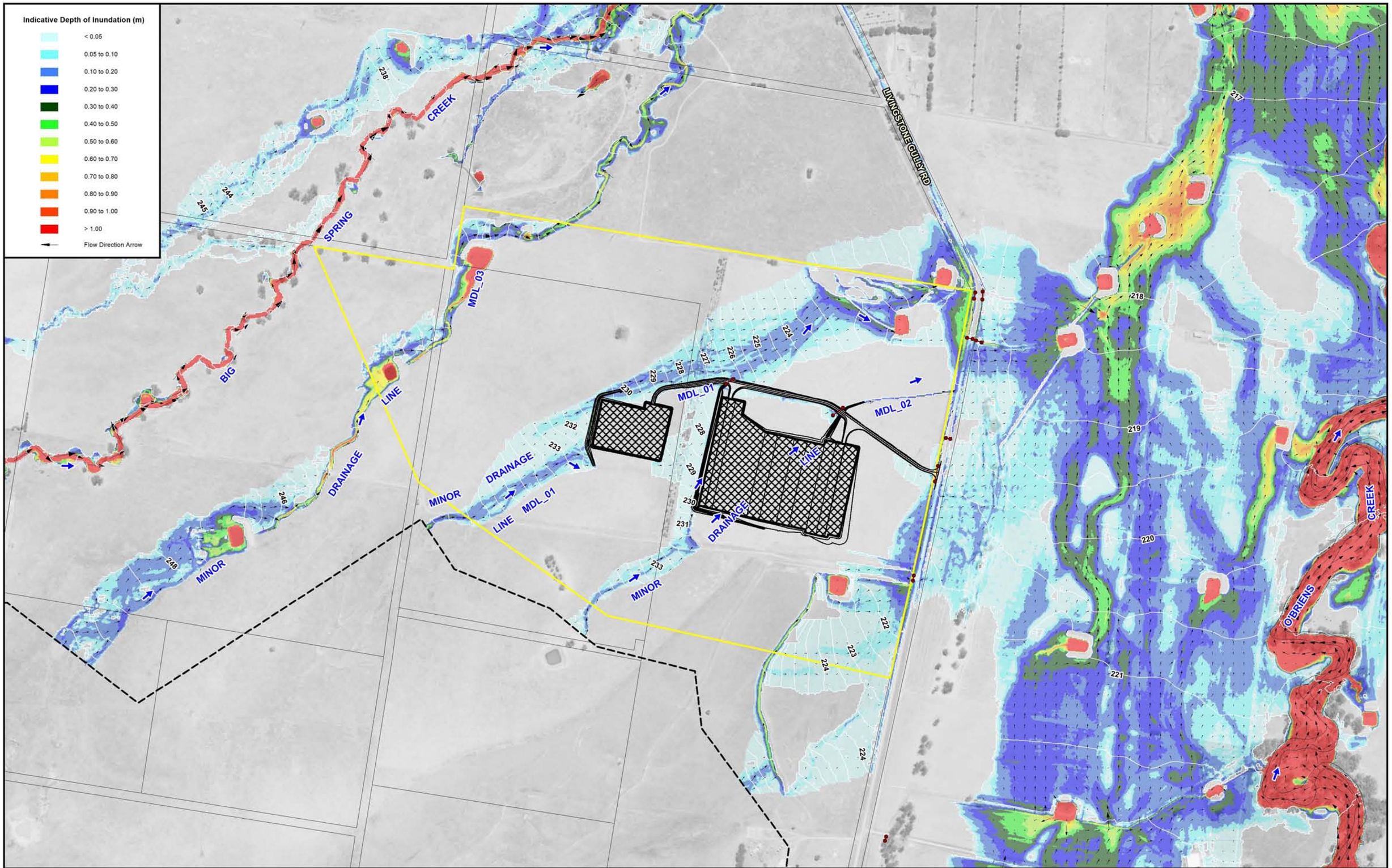
LEGEND

- Extent of Substation Bench (Indicative)
- Site Access Road (Indicative)
- Site Boundary
- Modelled Stormwater Drainage Network
- TUFLOW Model Extent

GUGAA 500 kV SUBSTATION ADDENDUM FLOODING REPORT

Figure 27

IMPACT OF GUGAA 500 kV SUBSTATION ON MAXIMUM FLOW VELOCITIES
10% AEP



N

80 0 80 160 240 m

Scale: 1:8,000

LEGEND

- Extent of Substation Bench (Indicative)
- Site Access Road (Indicative)
- Site Boundary
- Modelled Stormwater Drainage Network
- TUFLOW Model Extent
- 221 Water Surface Elevation Contours (m AHD)

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GUGAA 500 kV SUBSTATION ADDENDUM FLOODING REPORT

Figure 28

INDICATIVE EXTENT AND DEPTH OF INUNDATION
POST-GUGAA 500 kV SUBSTATION CONDITIONS - 5% AEP

Afflux (m)

- < -0.2
- -0.20 to -0.10
- -0.10 to -0.01
- -0.01 to 0.01
- 0.01 to 0.02
- 0.02 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.30
- 0.30 to 0.50
- > 0.50
- Land Rendered Flood Free as a Result of Change
- Additional Area of Land Flooded as a Result of Change

LIVINGSTONE GULLY RD
CREEK
SPRING
MDL_03
BIG
LINE
DRAINAGE
MINOR
DRAINAGE
MDL_01
LINE
MINOR
MDL_01
MDL_02
LINE
DRAINAGE
CREEK
O'BRIENS

N

80 0 80 160 240 m

Scale: 1:8,000

Lyall & Associates

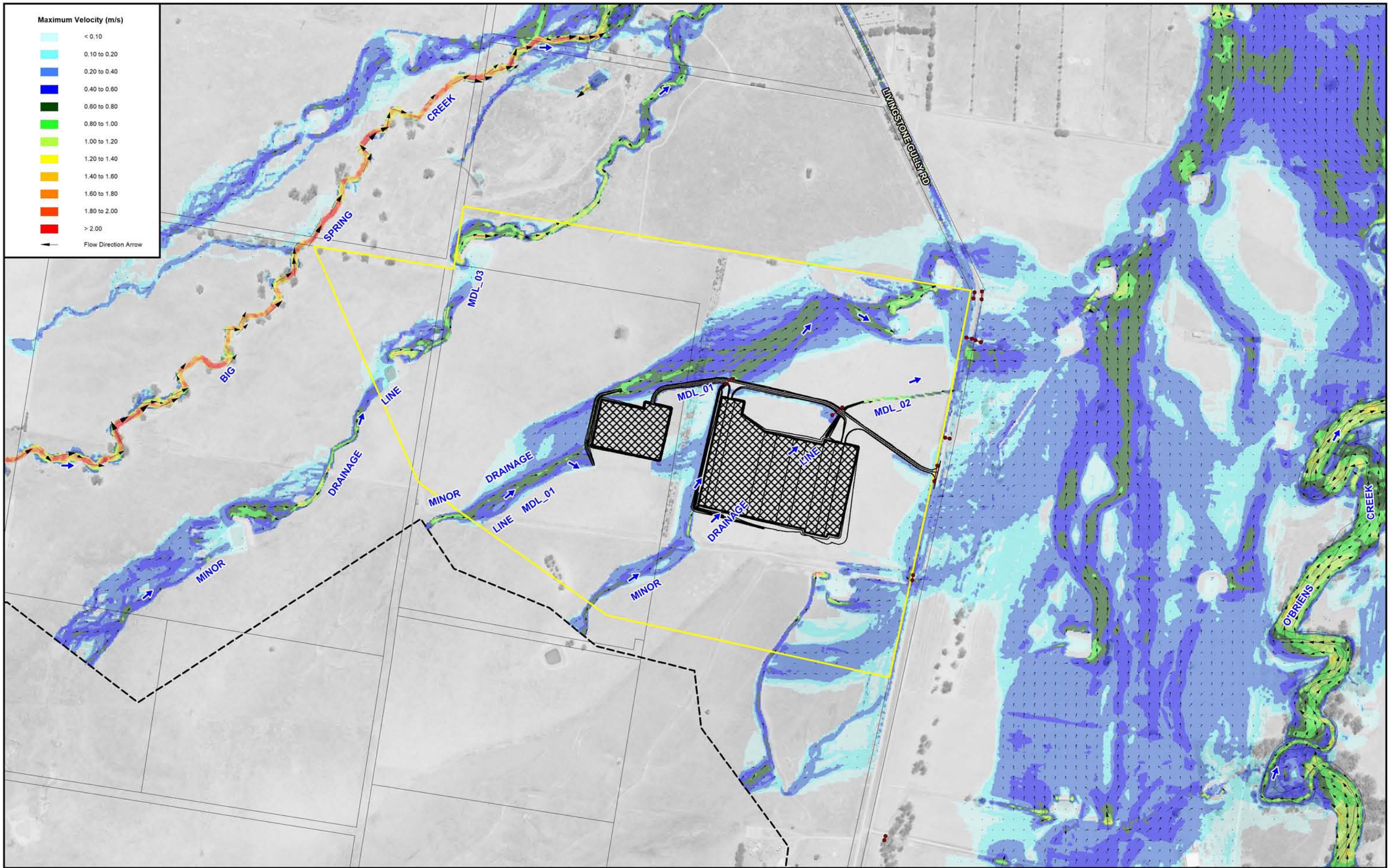
LEGEND

- Extent of Substation Bench (Indicative)
- Site Access Road (Indicative)
- Site Boundary
- Modelled Stormwater Drainage Network
- TUFLOW Model Extent

GUGAA 500 kV SUBSTATION ADDENDUM FLOODING REPORT

Figure 29

IMPACT OF GUGAA 500 kV SUBSTATION ON FLOOD BEHAVIOUR
5% AEP



N

80 0 80 160 240 m

Scale: 1:8,000

Lyall & Associates

LEGEND

- Extent of Substation Bench (Indicative)
- Site Access Road (Indicative)
- Site Boundary
- Modelled Stormwater Drainage Network
- TUFLOW Model Extent

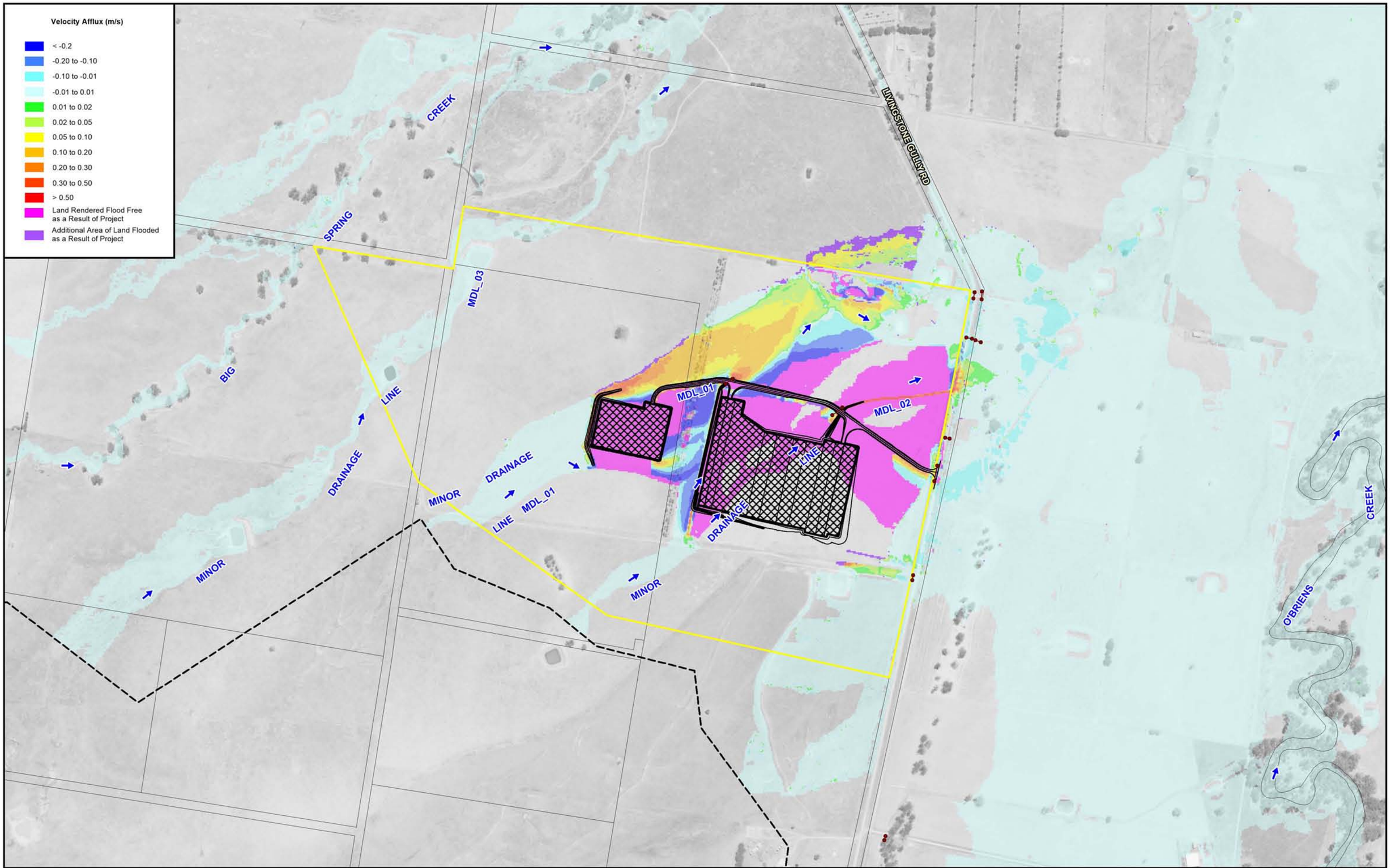
GUGAA 500 kV SUBSTATION ADDENDUM FLOODING REPORT

Figure 30

MAXIMUM FLOW VELOCITIES
POST-GUGAA 500 kV SUBSTATION CONDITIONS - 5% AEP

Velocity Afflux (m/s)

- < -0.2
- -0.20 to -0.10
- -0.10 to -0.01
- -0.01 to 0.01
- 0.01 to 0.02
- 0.02 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.30
- 0.30 to 0.50
- > 0.50
- Land Rendered Flood Free as a Result of Project
- Additional Area of Land Flooded as a Result of Project



N

80 0 80 160 240 m

Scale: 1:8,000

LEGEND

- Extent of Substation Bench (Indicative)
- Site Access Road (Indicative)
- Site Boundary
- Modelled Stormwater Drainage Network
- TUFLOW Model Extent

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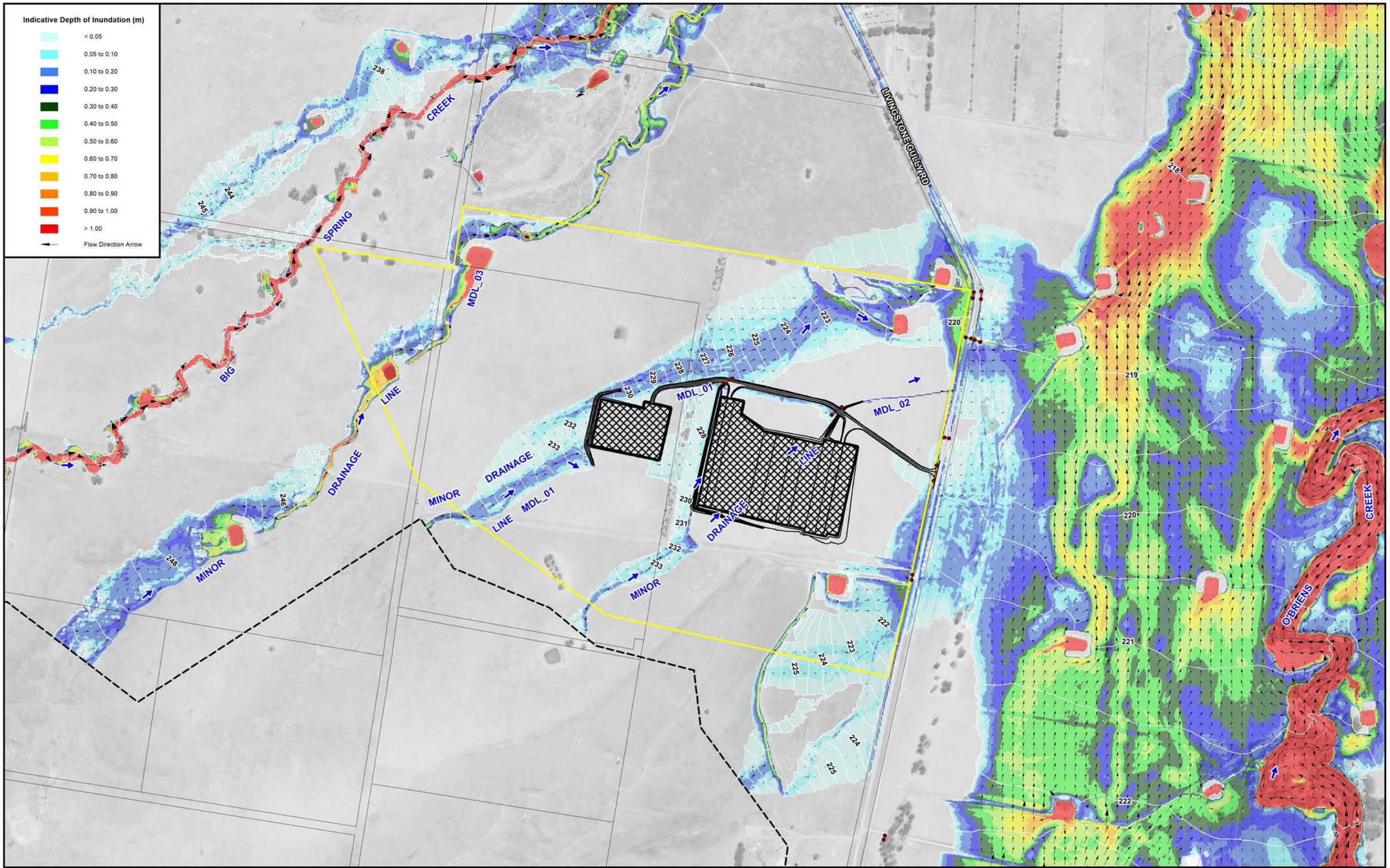
GUGAA 500 kV SUBSTATION ADDENDUM FLOODING REPORT

Figure 31

IMPACT OF GUGAA 500 kV SUBSTATION ON MAXIMUM FLOW VELOCITIES
5% AEP



N

80 0 80 160 240 m

Scale: 1:8,000

LEGEND

- Extent of Substation Bench (Indicative)
- Site Access Road (Indicative)
- Site Boundary
- Modelled Stormwater Drainage Network
- TUFLOW Model Extent
- 224 Water Surface Elevation Contours (m AHD)

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GUGAA 500 kV SUBSTATION ADDENDUM FLOODING REPORT

Figure 32

INDICATIVE EXTENT AND DEPTH OF INUNDATION
POST-GUGAA 500 kV SUBSTATION CONDITIONS - 2% AEP

Afflux (m)

- < -0.2
- -0.20 to -0.10
- -0.10 to -0.01
- -0.01 to 0.01
- 0.01 to 0.02
- 0.02 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.30
- 0.30 to 0.50
- > 0.50
- Land Rendered Flood Free as a Result of Change
- Additional Area of Land Flooded as a Result of Change

LIVINGSTONE GULLY RD
CREEK
SPRING
MDL_03
BIG
LINE
DRAINAGE
MINOR
DRAINAGE
MDL_01
LINE
MDL_01
MDL_02
LINE
DRAINAGE
MINOR
MINOR
CREEK
O'BRIENS

N

80 0 80 160 240 m

Scale: 1:8,000

Lyall & Associates

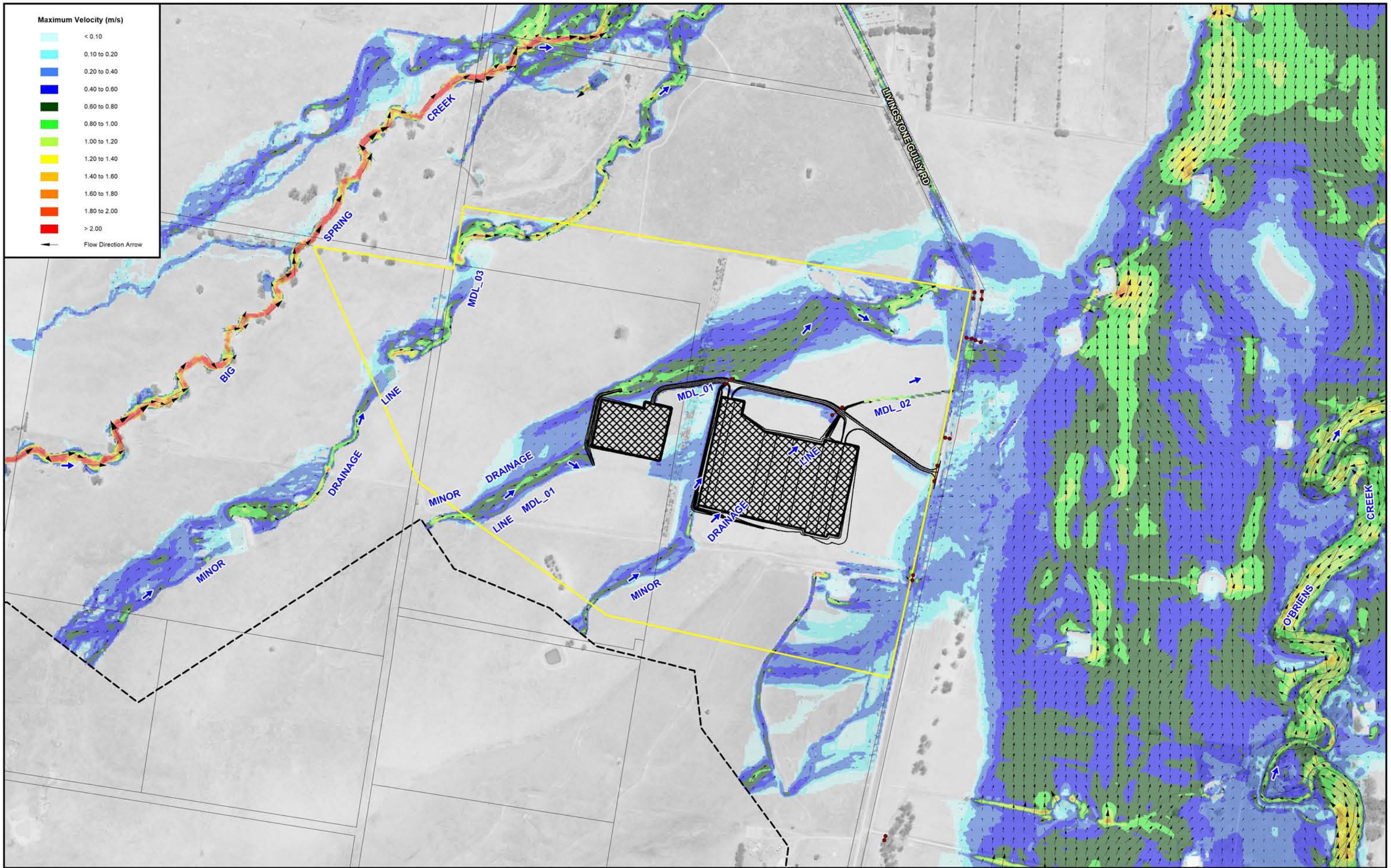
LEGEND

- Extent of Substation Bench (Indicative)
- Site Access Road (Indicative)
- Site Boundary
- Modelled Stormwater Drainage Network
- TUFLOW Model Extent

GUGAA 500 kV SUBSTATION ADDENDUM FLOODING REPORT

Figure 33

IMPACT OF GUGAA 500 kV SUBSTATION ON FLOOD BEHAVIOUR
2% AEP



N

80 0 80 160 240 m

Scale: 1:8,000

Lyall & Associates

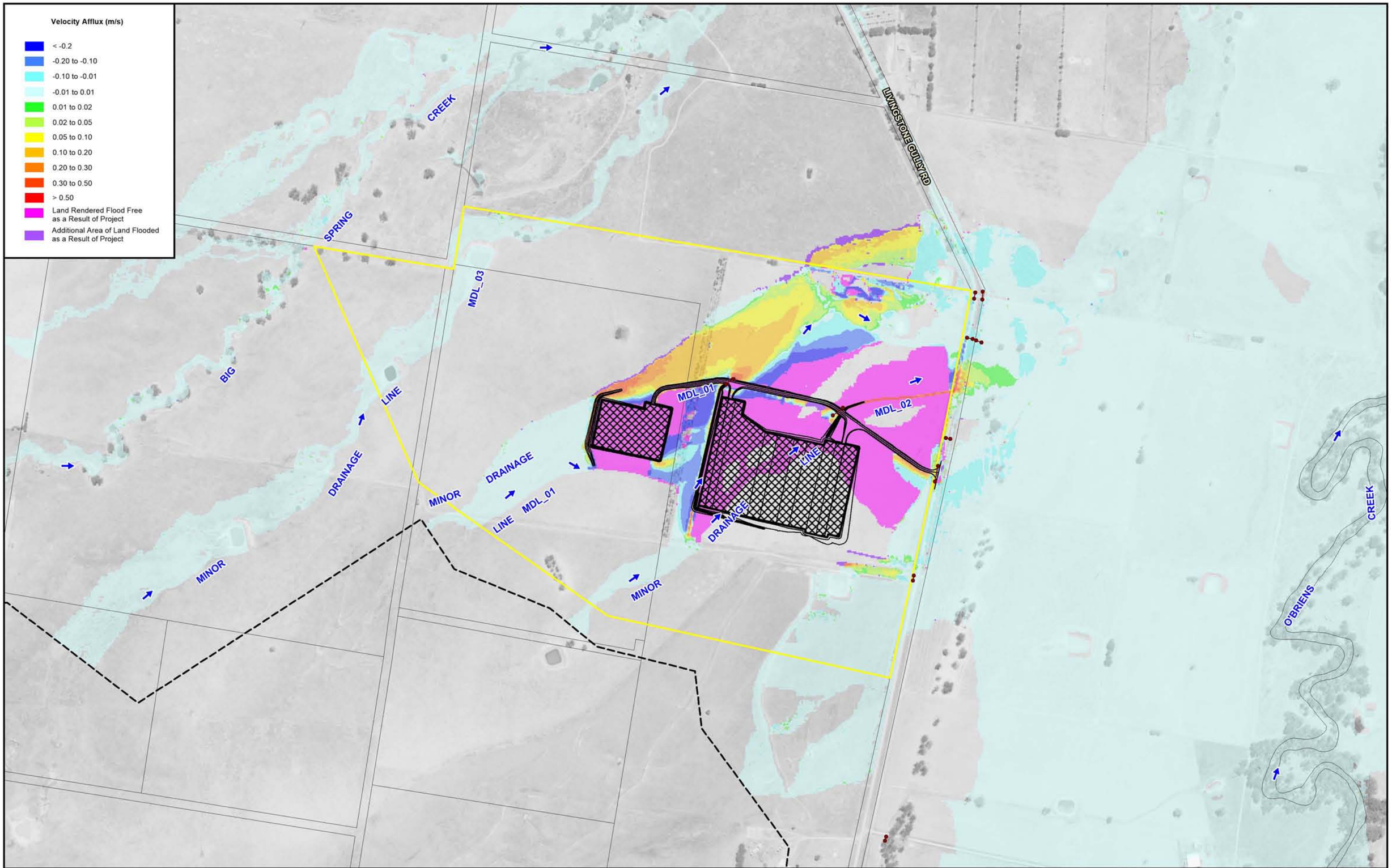
LEGEND

- Extent of Substation Bench (Indicative)
- Site Access Road (Indicative)
- Site Boundary
- Modelled Stormwater Drainage Network
- TUFLOW Model Extent

GUGAA 500 kV SUBSTATION ADDENDUM FLOODING REPORT

Figure 34

MAXIMUM FLOW VELOCITIES
POST-GUGAA 500 kV SUBSTATION CONDITIONS - 2% AEP



N

80 0 80 160 240 m

Scale: 1:8,000

Lyall & Associates

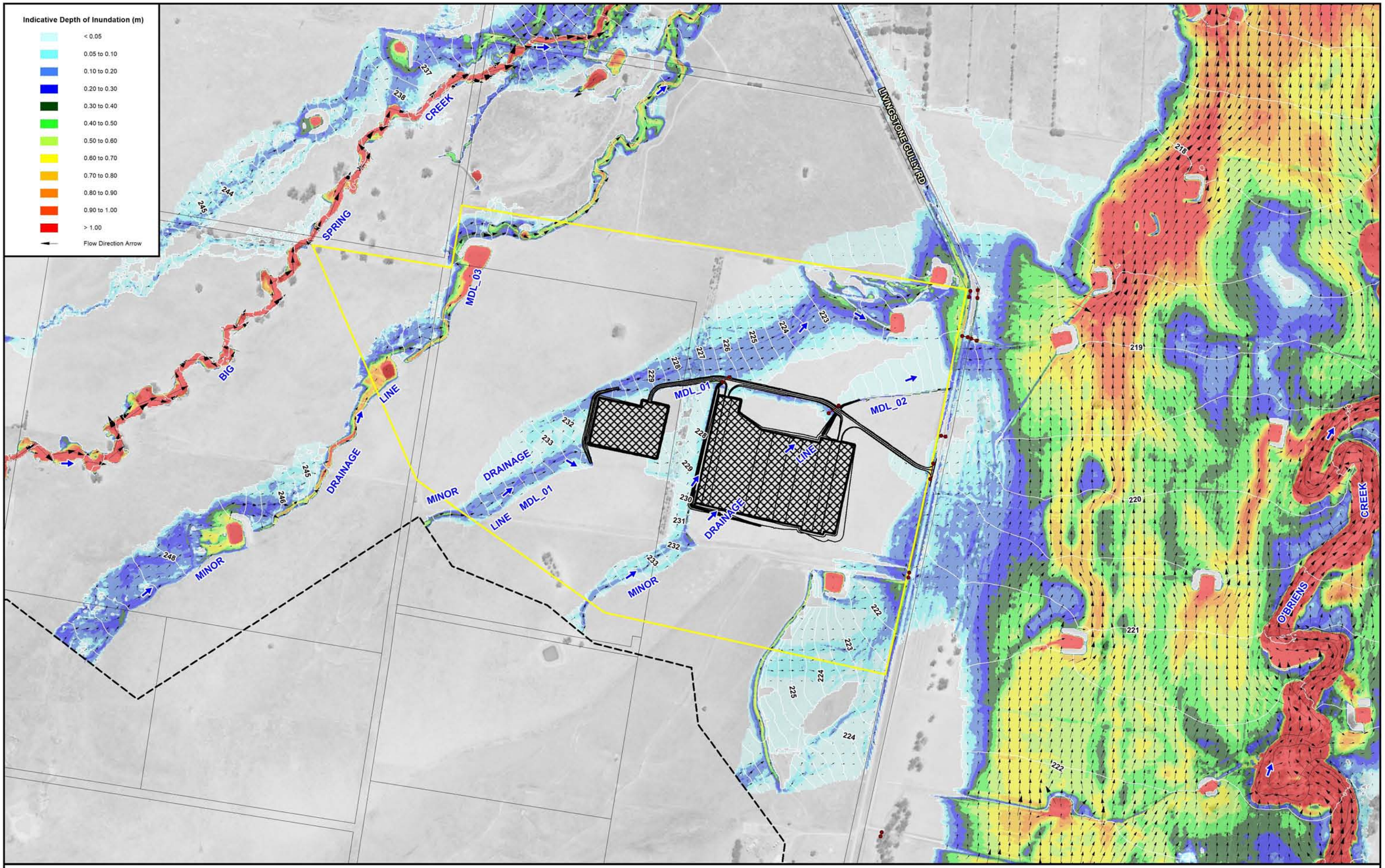
LEGEND

- Extent of Substation Bench (Indicative)
- Site Access Road (Indicative)
- Site Boundary
- Modelled Stormwater Drainage Network
- TUFLOW Model Extent

GUGAA 500 kV SUBSTATION ADDENDUM FLOODING REPORT

Figure 35

IMPACT OF GUGAA 500 kV SUBSTATION ON MAXIMUM FLOW VELOCITIES
2% AEP



N

80 0 80 160 240 m

Scale: 1:8,000

LEGEND

- Extent of Substation Bench (Indicative)
- Site Access Road (Indicative)
- Site Boundary
- Modelled Stormwater Drainage Network
- TUFLOW Model Extent
- 226 Water Surface Elevation Contours (m AHD)

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GUGAA 500 kV SUBSTATION ADDENDUM FLOODING REPORT

Figure 36

INDICATIVE EXTENT AND DEPTH OF INUNDATION
POST-GUGAA 500 kV SUBSTATION CONDITIONS - 1% AEP

Afflux (m)

- < -0.2
- -0.20 to -0.10
- -0.10 to -0.01
- -0.01 to 0.01
- 0.01 to 0.02
- 0.02 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.30
- 0.30 to 0.50
- > 0.50
- Land Rendered Flood Free as a Result of Change
- Additional Area of Land Flooded as a Result of Change

CREEK
SPRING
BIG
LINE
DRAINAGE
MINOR
MDL_03
MDL_01
MDL_02
LIVINGSTONE GULLY RD
O'BRIENS

N

80 0 80 160 240 m

Scale: 1:8,000

LEGEND

- Extent of Substation Bench (Indicative)
- Site Access Road (Indicative)
- Site Boundary
- Modelled Stormwater Drainage Network
- TUFLOW Model Extent

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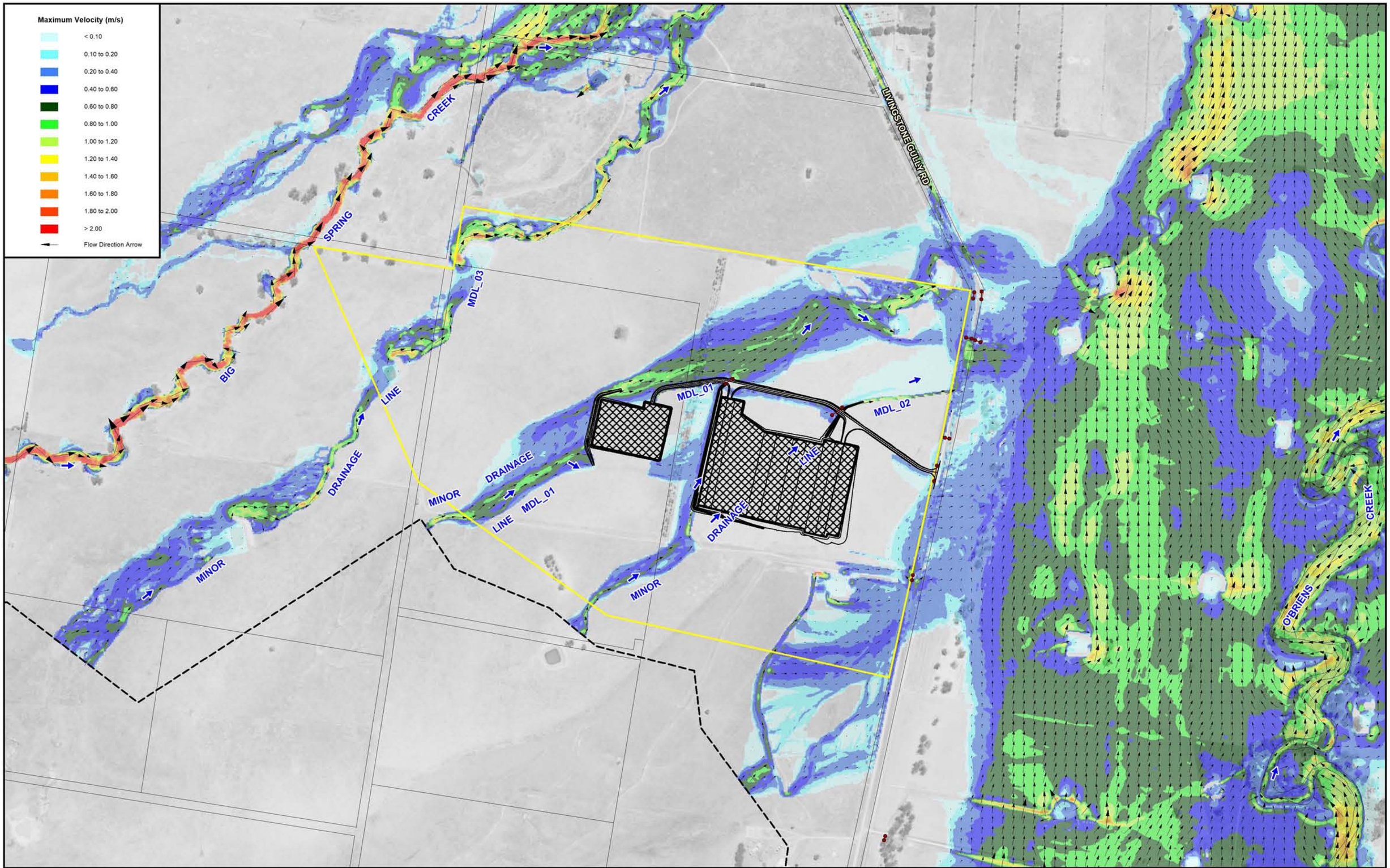
GUGAA 500 kV SUBSTATION ADDENDUM FLOODING REPORT

Figure 37

IMPACT OF GUGAA 500 kV SUBSTATION ON FLOOD BEHAVIOUR
1% AEP



N

80 0 80 160 240 m

Scale: 1:8,000

Lyall & Associates

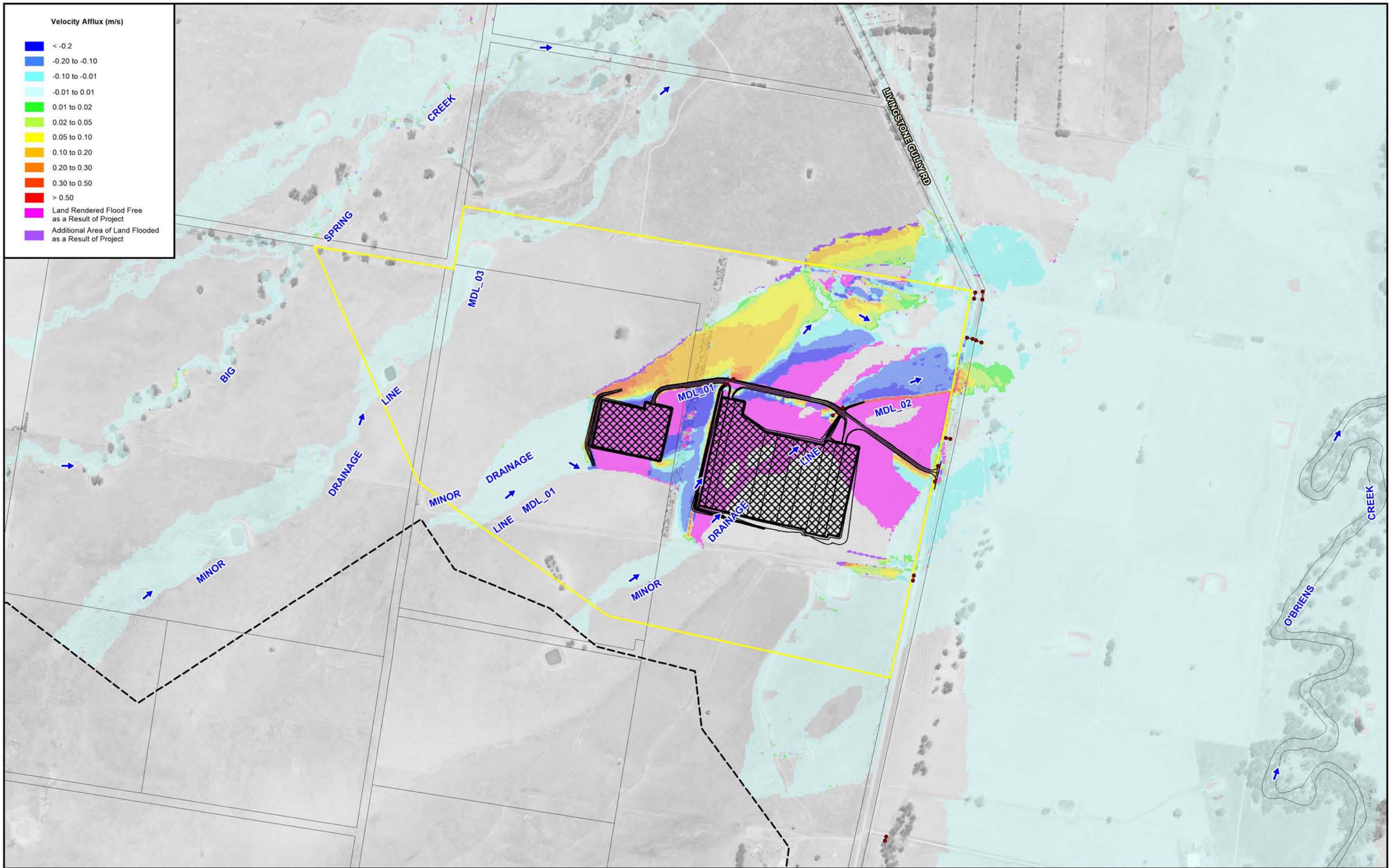
LEGEND

- Extent of Substation Bench (Indicative)
- Site Access Road (Indicative)
- Site Boundary
- Modelled Stormwater Drainage Network
- TUFLOW Model Extent

GUGAA 500 kV SUBSTATION ADDENDUM FLOODING REPORT

Figure 38

MAXIMUM FLOW VELOCITIES
POST-GUGAA 500 kV SUBSTATION CONDITIONS - 1% AEP



N

80 0 80 160 240 m

Scale: 1:8,000

Lyall & Associates

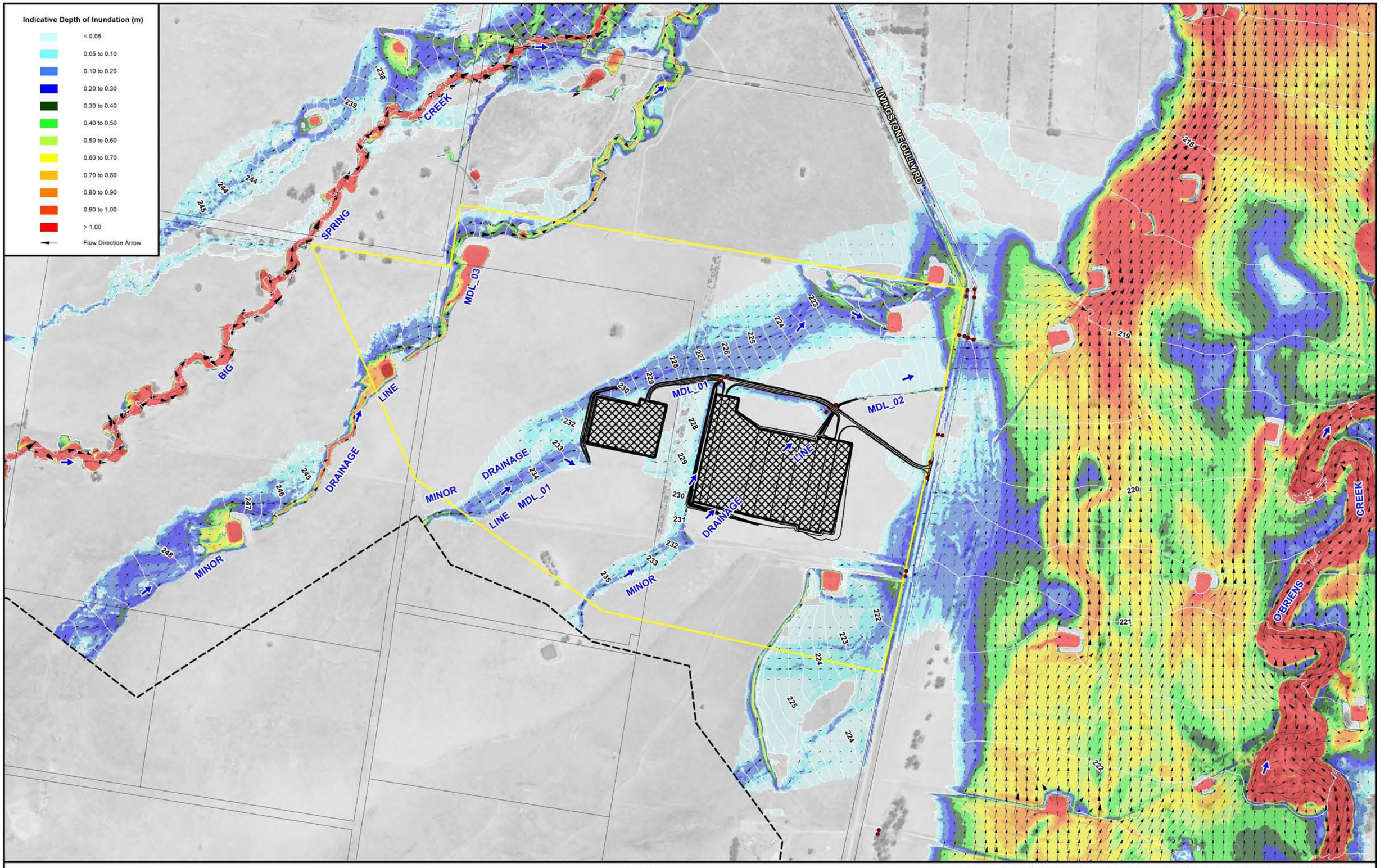
LEGEND

- Extent of Substation Bench (Indicative)
- Site Access Road (Indicative)
- Site Boundary
- Modelled Stormwater Drainage Network
- TUFLOW Model Extent

GUGAA 500 kV SUBSTATION ADDENDUM FLOODING REPORT

Figure 39

IMPACT OF GUGAA 500 kV SUBSTATION ON MAXIMUM FLOW VELOCITIES
1% AEP



N

80 0 80 160 240 m

Scale: 1:8,000

LEGEND

- Extent of Substation Bench (Indicative)
- Site Access Road (Indicative)
- Site Boundary
- Modelled Stormwater Drainage Network
- TUFLOW Model Extent
- 227 Water Surface Elevation Contours (m AHD)

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GUGAA 500 kV SUBSTATION ADDENDUM FLOODING REPORT

Figure 40

INDICATIVE EXTENT AND DEPTH OF INUNDATION
POST-GUGAA 500 kV SUBSTATION CONDITIONS - 0.5% AEP

Afflux (m)

- < -0.2
- -0.20 to -0.10
- -0.10 to -0.01
- -0.01 to 0.01
- 0.01 to 0.02
- 0.02 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.30
- 0.30 to 0.50
- > 0.50
- Land Rendered Flood Free as a Result of Change
- Additional Area of Land Flooded as a Result of Change

LIVINGSTONE GULLY RD
CREEK
SPRING
MDL_03
BIG
LINE
DRAINAGE
MINOR
DRAINAGE
MDL_01
LINE
MDL_01
MDL_02
LINE
DRAINAGE
MINOR
MINOR
CREEK
O'BRIENS

N

80 0 80 160 240 m

Scale: 1:8,000

Lyall & Associates

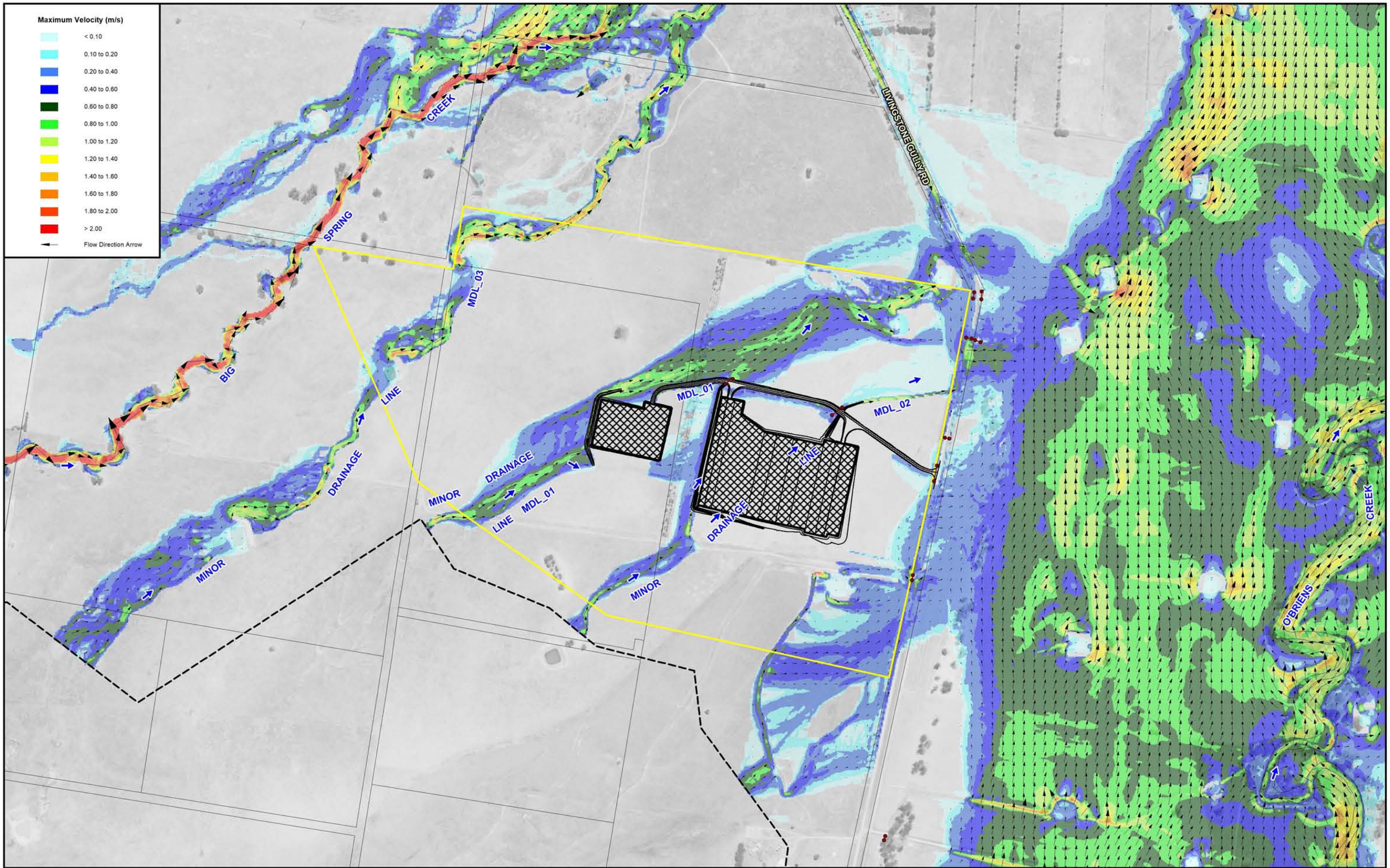
LEGEND

- Extent of Substation Bench (Indicative)
- Site Access Road (Indicative)
- Site Boundary
- Modelled Stormwater Drainage Network
- TUFLOW Model Extent

GUGAA 500 kV SUBSTATION ADDENDUM FLOODING REPORT

Figure 41

IMPACT OF GUGAA 500 kV SUBSTATION ON FLOOD BEHAVIOUR
0.5% AEP



N

80 0 80 160 240 m

Scale: 1:8,000

Lyall & Associates

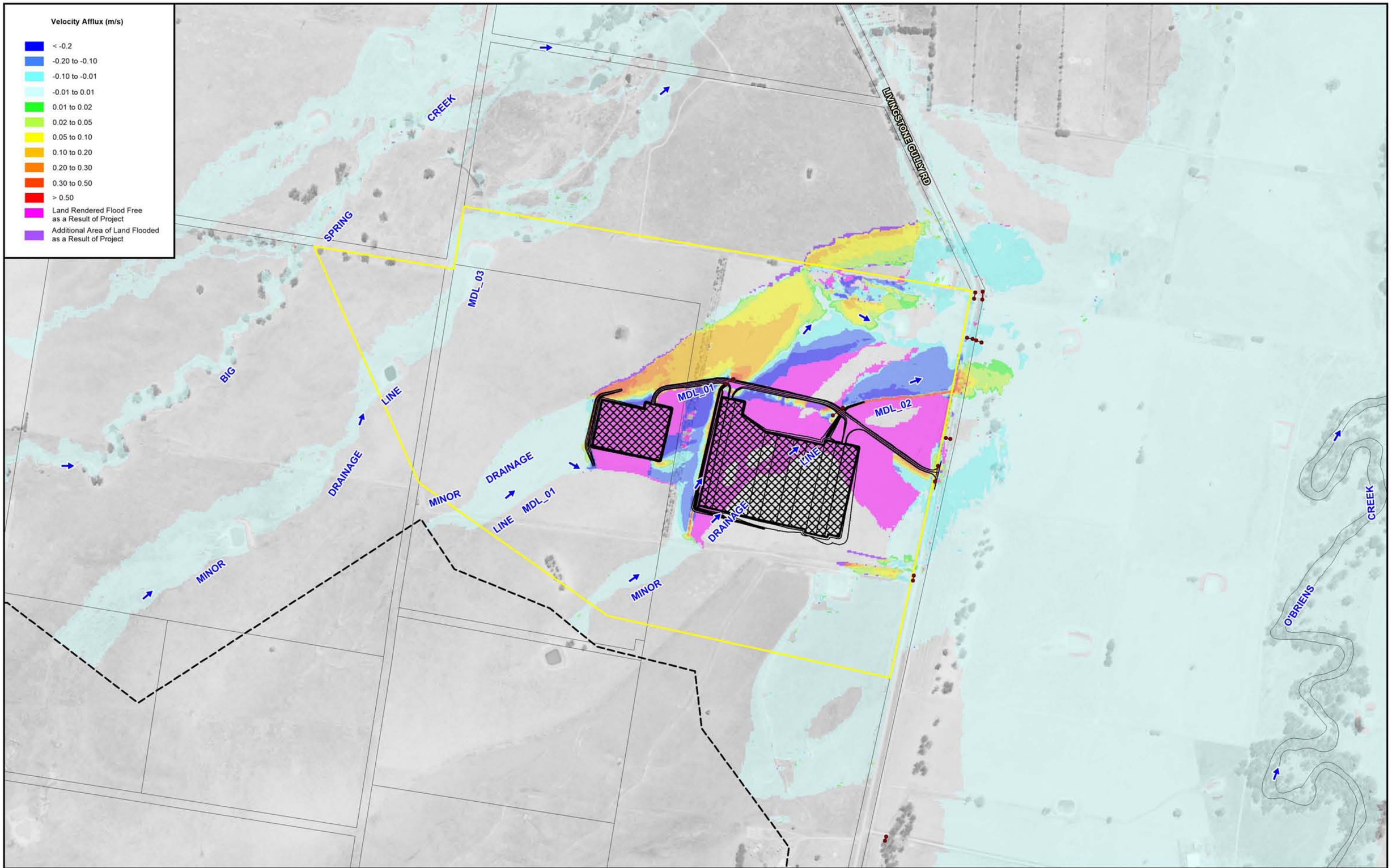
LEGEND

- Extent of Substation Bench (Indicative)
- Site Access Road (Indicative)
- Site Boundary
- Modelled Stormwater Drainage Network
- TUFLOW Model Extent

GUGAA 500 kV SUBSTATION ADDENDUM FLOODING REPORT

Figure 42

MAXIMUM FLOW VELOCITIES
POST-GUGAA 500 kV SUBSTATION CONDITIONS - 0.5% AEP



N

80 0 80 160 240 m

Scale: 1:8,000

LEGEND

- Extent of Substation Bench (Indicative)
- Site Access Road (Indicative)
- Site Boundary
- Modelled Stormwater Drainage Network
- TUFLOW Model Extent

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GUGAA 500 kV SUBSTATION ADDENDUM FLOODING REPORT

Figure 43

IMPACT OF GUGAA 500 kV SUBSTATION ON MAXIMUM FLOW VELOCITIES
0.5% AEP

Indicative Depth of Inundation (m)

- < 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.30
- 0.30 to 0.40
- 0.40 to 0.50
- 0.50 to 0.60
- 0.60 to 0.70
- 0.70 to 0.80
- 0.80 to 0.90
- 0.90 to 1.00
- > 1.00
- Flow Direction Arrow

N

80 0 80 160 240 m

Scale: 1:8,000

LEGEND

- Extent of Substation Bench (Indicative)
- Site Access Road (Indicative)
- Site Boundary
- Modelled Stormwater Drainage Network
- TUFLOW Model Extent
- 234 Water Surface Elevation Contours (m AHD)

GUGAA 500 kV SUBSTATION ADDENDUM FLOODING REPORT

Figure 44

INDICATIVE EXTENT AND DEPTH OF INUNDATION
POST-GUGAA 500 kV SUBSTATION CONDITIONS - PMF

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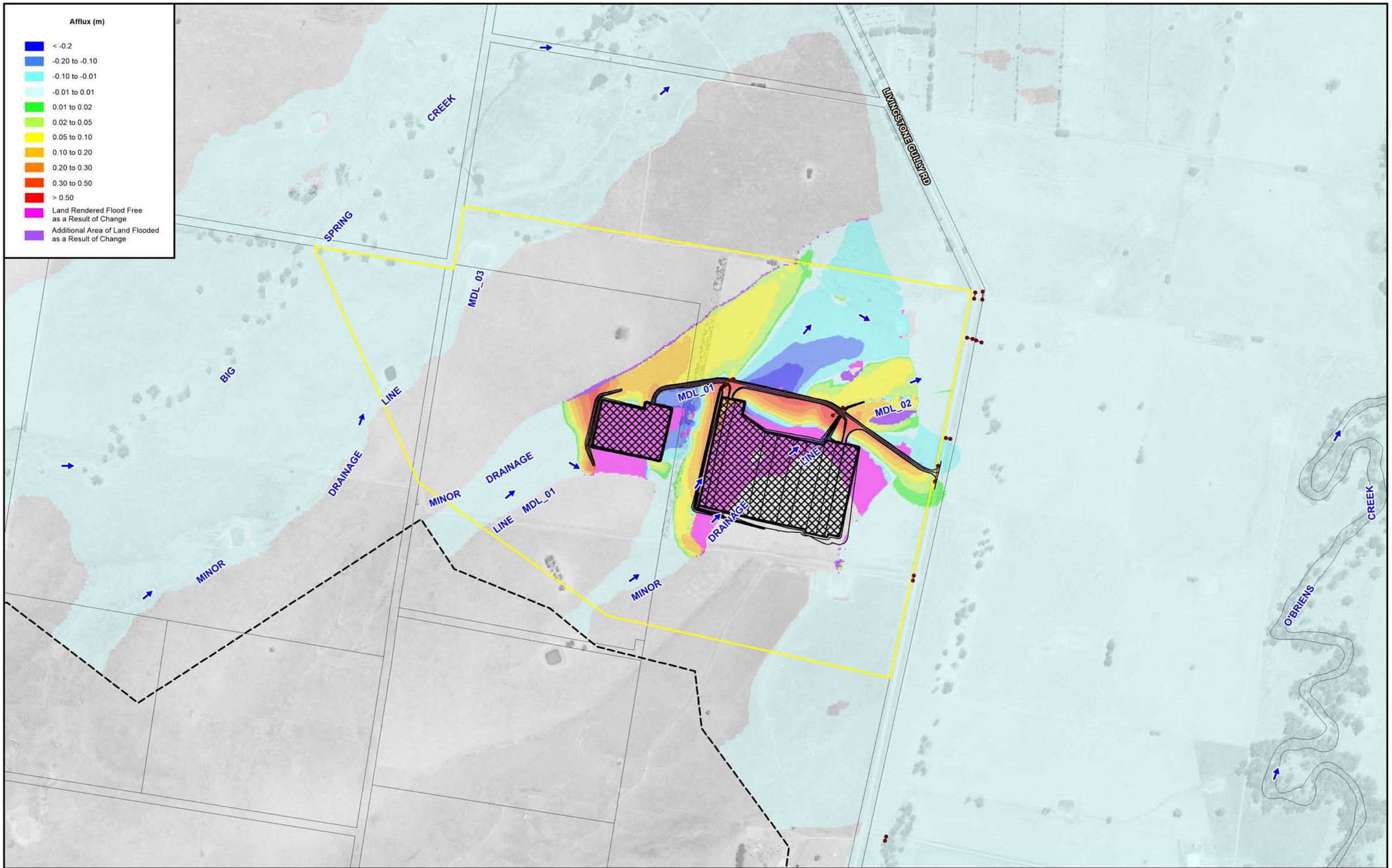

N

80 0 80 160 240 m

Scale: 1:8,000

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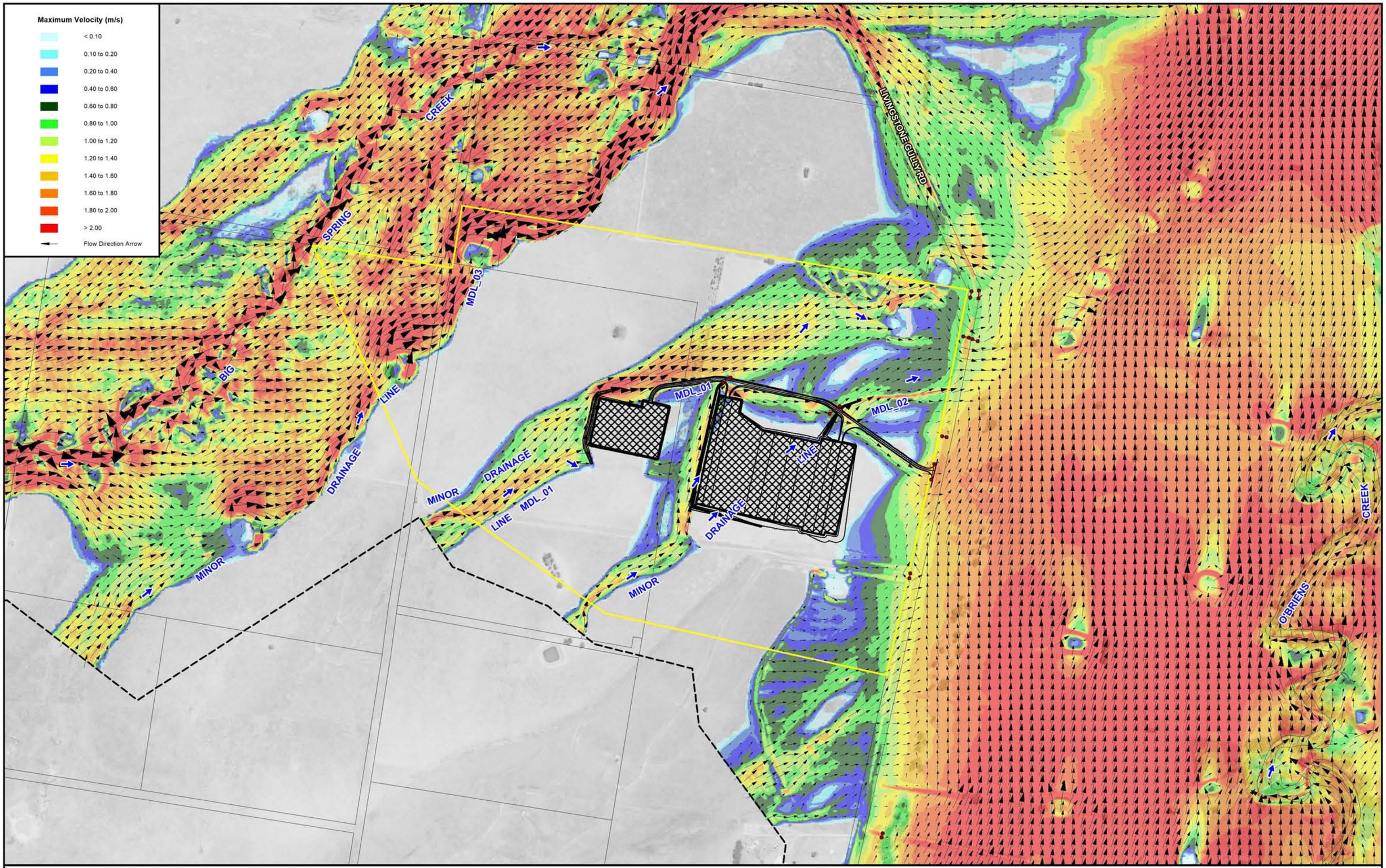
LEGEND

- Extent of Substation Bench (Indicative)
- Site Access Road (Indicative)
- Site Boundary
- Modelled Stormwater Drainage Network
- TUFLOW Model Extent

GUGAA 500 kV SUBSTATION ADDENDUM FLOODING REPORT

Figure 45

IMPACT OF GUGAA 500 kV SUBSTATION ON FLOOD BEHAVIOUR
PMF



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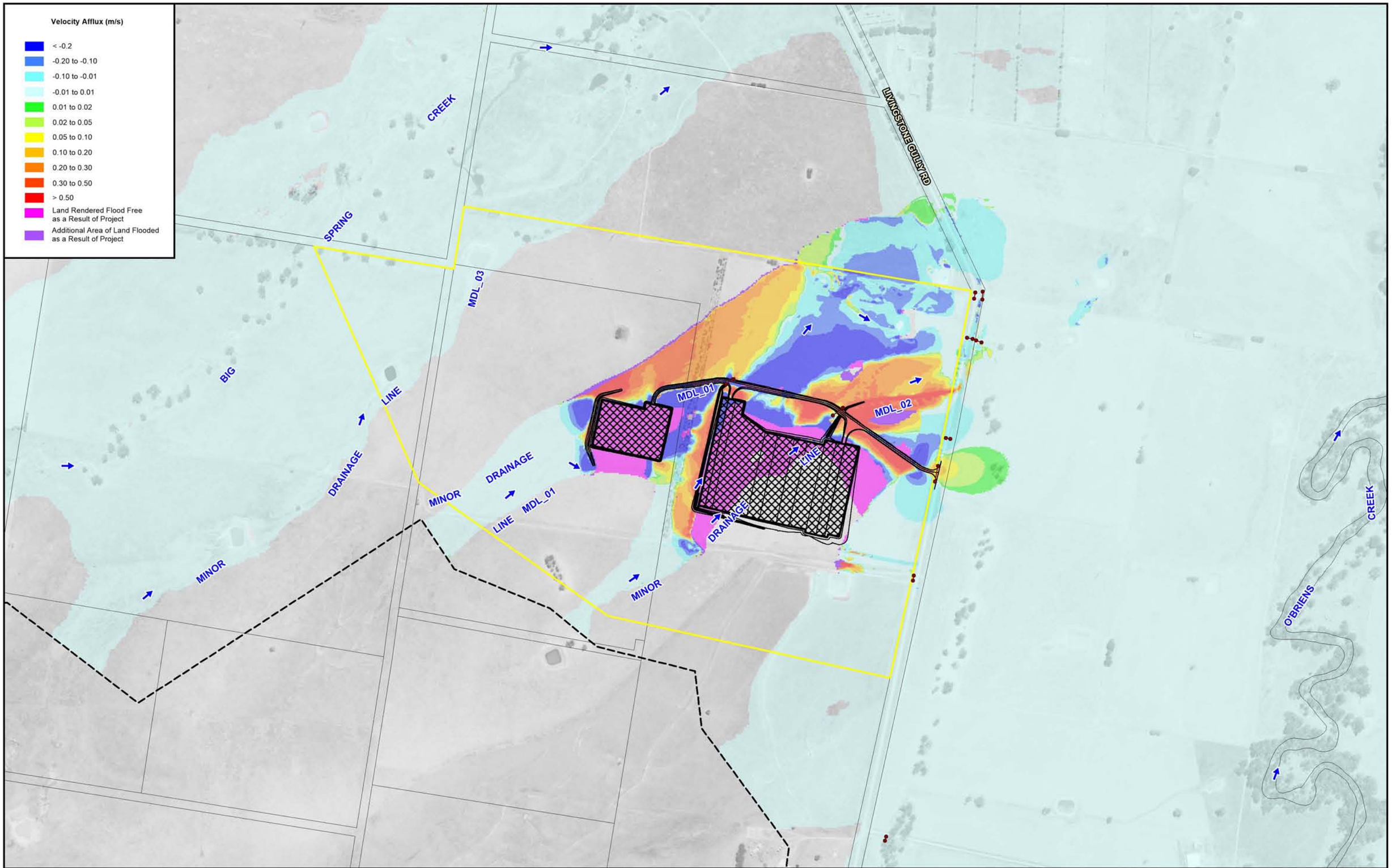
GUGAA 500 kV SUBSTATION ADDENDUM FLOODING REPORT

Figure 46

MAXIMUM FLOW VELOCITIES
POST-GUGAA 500 kV SUBSTATION CONDITIONS - PMF



N

80 0 80 160 240 m

Scale: 1:8,000

LEGEND

- Extent of Substation Bench (Indicative)
- Site Access Road (Indicative)
- Site Boundary
- Modelled Stormwater Drainage Network
- TUFLOW Model Extent

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GUGAA 500 kV SUBSTATION ADDENDUM FLOODING REPORT

Figure 47

IMPACT OF GUGAA 500 kV SUBSTATION ON MAXIMUM FLOW VELOCITIES
PMF

ANNEXURE A

APPENDIX C FLOODING QUANTITATIVE DESIGN LIMITS AND MODELLING REQUIREMENTS

SCHEDULE 1 QUANTITATIVE DESIGN LIMITS

TABLE 1: QUANTITATIVE DESIGN LIMITS (QDLs)

(These QDLs are only applicable beyond the CSSI corridor, unless otherwise noted, and do not apply to model noise[2])

Parameter	Location or Land Use	Limit
Afflux i.e. increase in flood level resulting from implementation of CSSI.	Habitable floors and sensitive infrastructure[3]	10mm increase[4]
	Non-habitable floors[3]	20mm increase
	Surrounds of residential buildings, other urban, open space recreational land and infrastructure (excluding sensitive infrastructure)	100mm increase
	Agricultural	200mm increase
	Forest and unimproved grazing land	300mm increase
	Classified roads managed by TfNSW[6]	50mm on areas flooded under existing conditions. Otherwise, no increase.[5]
	Highways and sealed roads >80km/hr[6]	No afflux where aquaplaning risk exists and remains unmitigated. Otherwise 50mm increase[5]
	Unsealed roads and sealed roads <80km/hr[6]	100mm increase[5]
Velocity		

[2] Model noise is an artefact of the modelling process and does not provide any useful information and is not the same as model tolerance. Modelling noise is to be ignored when assessing compliance with the QDLs. All modelling noise exclusions are to be reviewed by the independent reviewer required under E43.

[3] Habitable floors/rooms are defined consistent with the use of this term in the NSW Floodplain Development Manual. In a residential situation this comprises a living or working area such as a lounge room, dining room, rumpus room, kitchen, bedroom or workroom. In an industrial, commercial or other building, this comprises an area used for an office or to store valuable possessions, goods or equipment susceptible to flood damage in the event of a flood.

[4] 10 mm has been set to provide a margin for modelling uncertainties/tolerances. The intent of this requirement is that existing flood levels above floor level do not increase and there is no new flooding of floors.

[5] Any variation must be negotiated with the roads authority in accordance with **Condition 50**

[6] Including where located within CSSI corridor.

Parameter	Location or Land Use	Limit
Ie. Increase in flood velocity resulting from the implementation of the CSSI (Both Flow Distribution and the Scour/Erosion velocity QDLs apply)		
Flow Distribution	All areas	20% increase in velocity[7]
Scour/Erosion Potential	Ground surfaces that have been sealed or otherwise protected against erosion. This includes roads and most urban, commercial, industrial, recreational and forested land	Velocities are not to exceed the limiting velocities which would erode the sealing or remove the protection that has been applied to the surface.
	Other areas including watercourses, agricultural land, unimproved grazing land and other unsealed or unprotected areas	An erosion threshold velocity (ETV) is to be determined through a site specific assessment(s) conducted by an experienced geotechnical or scour/erosion specialist in accordance with **Conditions E52** to **E55**.[8] An ETV of 0.5m/s is to be adopted in the absence of a site specific assessment(s). Where existing velocity exceeds ETV, velocity is limited to a 0.025m/s increase[9]. Where existing velocity is less than ETV, velocity is limited to the lesser of: • ETV • 20% increase or 0.5m/s whichever is greater
Flood Hazard i.e. increase in velocity~depth product (**vd**) resulting from implementation of CSSI. (Does not apply where vd<0.1m²/s).	Urban, commercial, industrial, highways[6] and sealed roadways[6]	10% increase in vd
	Classified roads managed by TfNSW[6]	10% increase in vd where this does not result in an increase in hazard category. Otherwise, no increase.[5]
	Elsewhere	20% increase in vd
	Habitable floors[3]	Where existing above floor flooding is: • less than 1 hour in flood duration, the post-development flood duration shall not exceed 1 hour

[7] Local variations in velocity can exceed a 20% change provided that when assessed over a 30m wide flowpath, the velocity change within the flowpath does not exceed 20%.
[8] An equivalent sheer stress may be substituted for an ETV determined through this process.
[9] Where velocity exceeds this QDL, the **Operational Erosion Mitigation and Monitoring Program** required by **Condition E71** must be prepared and implemented.

Parameter	Location or Land Use	Limit
Flood Duration i.e. increase in duration of inundation resulting from implementation of CSSI.		• greater than 1 hour in duration, up to 5% increased inundation duration Where existing below floor flooding is: • less than 1 hour in flood duration, the post-development flood duration shall not exceed 1 hour • greater than 1 hour in duration, up to 10% increased inundation duration
	Classified roads managed by TfNSW[6]	No increase in duration of flood inundation to sections of road not already inundated[5]. Otherwise 10% increase in inundation duration.
	Highways and sealed roads >80km/hr[6]	10% increase in inundation duration.
	Elsewhere	Where existing inundation is less than 1 hour in flood duration, the post-development flood duration shall not exceed 1 hour. Where existing inundation is greater than 1 hour in flood duration, up to 10% increase in duration of inundation No duration limits apply to newly flooded land no greater than 1000m^2 in area

APPENDIX C Flooding Quantitative Design Limits and Modelling Requirements

SCHEDULE 1 Quantitative Design Limits

TABLE 1: QUANTITATIVE DESIGN LIMITS (QDLs)

(These QDLs are only applicable beyond the CSSI corridor, unless otherwise noted, and do not apply to model noise[2])

Parameter	Location or Land Use	Limit
Afflux i.e. increase in flood level resulting from implementation of CSSI.	Habitable floors and sensitive infrastructure.[3]	10mm increase.[4]
	Non-habitable floors	20mm increase
	Surrounds of residential buildings, other urban, open space recreational land and infrastructure (excluding sensitive infrastructure)	100mm increase
	Agricultural	200mm increase
	Forest and unimproved grazing land	300mm increase
	Classified roads managed by TfNSW[6]	50mm on areas flooded under existing conditions. Otherwise, no increase.[5]
	Highways and sealed roads >80km/hr.[6]	No afflux where aquaplaning risk exists and remains unmitigated. Otherwise 50mm increase[5]
	Unsealed roads and sealed roads <80km/hr[6]	100mm increase[5]

[2] Model noise is an artefact of the modelling process and does not provide any useful information and is not the same as model tolerance. Modelling noise is to be ignored when assessing compliance with the QDLs. All modelling noise exclusions are to be reviewed by the independent reviewer required under ***Condition*** **E44**.

[3] Habitable floors/rooms are defined consistent with the use of this term in the NSW Floodplain Development Manual. In a residential situation this comprises a living or working area such as a lounge room, dining room, rumpus room, kitchen, bedroom or workroom. In an industrial, commercial or other building, this comprises an area used for an office or to store valuable possessions, goods or equipment susceptible to flood damage in the event of a flood.

[4] 10 mm has been set to provide a margin for modelling uncertainties/tolerances. The intent of this requirement is that existing flood levels above floor level do not increase and there is no new flooding of floors.

[5] Any variation must be negotiated with the roads authority in accordance with ***Condition*** **E55**

[6] Including where located within CSSI corridor.

Parameter	Location or Land Use	Limit
Velocity Ie. Increase in flood velocity resulting from the implementation of the CSSI (Both Flow Distribution and the Scour/Erosion velocity QDLs apply)		
Flow Distribution	All areas	20% increase in velocity[7]
Scour/Erosion Potential	Ground surfaces that have been sealed or otherwise protected against erosion. This includes roads and most urban, commercial, industrial, recreational and forested land	Velocities are not to exceed the limiting velocities which would erode the sealing or remove the protection that has been applied to the surface.
	Other areas including watercourses, agricultural land, unimproved grazing land and other unsealed or unprotected areas	An erosion threshold velocity (ETV) is to be determined through a site specific assessment(s) conducted by an experienced geotechnical or scour/erosion specialist.[8] An ETV of 0.5m/s is to be adopted in the absence of a site specific assessment(s). Where existing velocity exceeds ETV, velocity is limited to a 0.025m/s increase[9]. Where existing velocity is less than ETV, velocity is limited to the lesser of: • ETV • 20% increase or 0.5m/s whichever is greater
Flood Hazard i.e. increase in velocity~depth product (**vd**) and/or flood hazard category resulting from implementation of CSSI. (Does not apply where vd<0.1m^2/s).	Urban, commercial, industrial, highways[6] and sealed roadways[6]	10% increase in vd
	Classified roads managed by TfNSW[6]	10% increase in vd where this does not result in an increase in hazard category. Otherwise, no increase.[5]
	Elsewhere	20% increase in vd
	Habitable floors[3]	Where existing above floor flooding is:

[7] *Local variations in velocity can exceed a 20% change provided that when assessed over a 30m wide flowpath, the velocity change within the flowpath does not exceed 20%.*

[8] *The methods used to calculate the erosion threshold velocity must be independently peer reviewed in accordance with* ***Conditions E47 to E50****. Shear stress assessments may be used as an alternative method from which to describe the erosion threshold in a specific environment (i.e. soil type, depth, velocity). An erosion threshold shear stress (ETSS) can be used as an alternative to the ETV to ensure the erosion threshold is not exceeded beyond the limits of this velocity QDL. (If the ETSS is used, compliance with the limiting increases in velocities specified within this QDL are also required).*

[9] *Where velocity exceeds this QDL, the* ***Operational Erosion Mitigation and Monitoring Program*** *required by* ***Condition E71*** *must be prepared and implemented.*

Parameter	Location or Land Use	Limit
Flood Duration i.e. increase in duration of inundation resulting from implementation of CSSI.		• less than 1 hour in flood duration, the post-development flood duration shall not exceed 1 hour • greater than 1 hour in duration, up to 5% increased inundation duration Where existing below floor flooding is: • less than 1 hour in flood duration, the post-development flood duration shall not exceed 1 hour • greater than 1 hour in duration, up to 10% increased inundation duration
	Classified roads managed by TfNSW[6]	No increase in duration of flood inundation to sections of road not already inundated[5]. Otherwise 10% increase in inundation duration.
	Highways and sealed roads >80km/hr[6]	10% increase in inundation duration.
	Elsewhere	Where existing inundation is less than 1 hour in flood duration, the post-development flood duration shall not exceed 1 hour. Where existing inundation is greater than 1 hour in flood duration, up to 10% increase in duration of inundation No duration limits apply to newly flooded land no greater than 1000m^2 in area

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