APPENDIX T UPDATED FLOOD IMPACT ASSESSMENT

THE PLAINS WIND FARM

PROJECT AMENDMENT REPORT

TECHNICAL PAPER:
FLOODING

March 2025

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NOTE ON FLOOD FREQUENCY TERMINOLOGY

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

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

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

In this report, the frequency of flood events is referred to in terms of their AEP, for example a 1% AEP flood.

Reference is also made in the report to the Extreme Flood on the Murrumbidgee River floodplain and the Probable Maximum Flood (PMF) in relation to local catchment flooding. Both the Extreme Flood and the PMF define the upper limit of flooding that could reasonably be expected to occur and are much rarer than the 1% AEP flood which is usually adopted for planning purposes.

The PMF occurs as a result of the Probable Maximum Precipitation (PMP). The PMP is the result of the optimum combination of the available moisture in the atmosphere and the efficiency of the storm mechanism as regards rainfall production. While the PMP is used to estimate PMF discharges using a model which simulates the conversion of rainfall to runoff, the discharge hydrograph of the Extreme Flood was derived by applying a multiplication factor of three (3) to the corresponding 1% AEP discharge hydrograph.

GLOSSARY OF TERMS AND ABBREVIATIONS

Term	Meaning
Access tracks	Temporary and permanent access tracks to internal wind farm infrastructure including transmission lines, wind turbines, construction compounds, construction camps substation, and operations and maintenance (O&M) building.
AEP	Annual exceedance probability. The chance of a rainfall or a flood event exceeding a nominated level in any one year, usually expressed as a percentage. For example, if a peak flood level has an AEP of five per cent, it means that there is a five per cent chance (that is one-in-20 chance) of being exceeded in any one year. The frequency of floods is generally referred to in terms of their AEP or ARI. In this report the frequency of floods generated by runoff from the study catchments is referred to in terms of their AEP, for example a 1% AEP flood.
Afflux	Increase/decrease in water level resulting from a change in conditions. The change may relate to the watercourse, floodplain, flow rate, tailwater level, etc.
AHD	Australian height datum. A common national surface level datum approximately corresponding to mean sea level.
Applicant	ENGIE
ARI	Average recurrence interval. An indicator used to describe the frequency of a rainfall or a flood event, expressed as an average interval in years between events of a given magnitude. For example, over a long period of say 200 years, a flood equivalent to or greater than a 20 year ARI event would occur 10 times. A 20 year ARI flood has a one-in-5 chance of occurrence in any one year. See also AEP.
ARR 2019	*Australian Rainfall and Runoff* (Geosciences Australia (GA) 2019).
BoM	Bureau of Meteorology.
Catchment	The land area draining through the mainstream, as well as tributary streams, to a particular site. It always relates to an area above a specific location.
Climate change	A change in the state of the climate that can be identified (for example by statistical tests) by changes in the mean and/or variability of its properties, and that persists for an extended period of time, typically decades or longer (IPCC 2007).
Climate projection	A climate projection is the simulated response of the climate system to a scenario of future emission or concentration of greenhouse gases and aerosols, generally derived using climate models. Climate projections are distinguished from climate predictions by their dependence on the emission/concentration/radiative forcing scenario used, which in turn is based on assumptions concerning, for example, future socio-economic and technological developments that may or may not be realised (IPCC 2007).
CEMP	Construction Environmental Management Plan.

Term	Meaning
Construction area	Refers to the area that would be directly impacted by the construction of the project, including all project infrastructure elements (including the internal transmission line and towers, wind turbines, substation, and O&M building), access tracks to easements, communications infrastructure, workforce accommodation camps, construction compounds, brake and winch sites and laydown and staging areas. The amended construction footprint occupies an area of 1887.1 ha, this represents a reduction of 109.8 ha compared to the area presented in the EIS
Construction compound	The key construction compound that would support construction of the project. The current project layout includes one main compound and two secondary compounds. It does not refer to work areas along the internal transmission line.
Cumulative impact	The combined impacts of the project on a matter with other relevant future projects.
DCCEEW	Department of Climate Change, Energy, the Environment and Water
DCP	Development control plan, not applicable to SSD Projects.
DECC	Department of Environment and Climate Change (now DCCEEW).
DECCW	Department of Environment, Climate Change and Water (now DCCEEW).
Detailed design	The detailed design of the project, including construction methodology. This term represents the next phase of project development and will further develop the design and construction methodology of the project considering: • the performance outcomes as recommended in the EIS • mitigation measures as recommended in the EIS • any conditions of approval.
DIPNR	Department of Infrastructure, Planning and Natural Resources (now DCCEEW).
Discharge	The rate of flow of water measured in terms of volume per unit time, for example, cubic metres per second (m^3/s). Discharge is different from the speed or velocity of flow, which is a measure of how fast the water is moving (e.g. metres per second [m/s]).
DPE	Department of Planning and Environment (now Department of Planning, Housing and Infrastructure)
DPHI	Department of Planning, Housing and Infrastructure
Drainage	Natural or artificial means for the interception and removal of surface or subsurface water.
Earthworks	All operations involving the loosening, excavating, placing, shaping and compacting of soil or rock.
Emergency management	A range of measures to manage risks to communities and the environment. In the flood context it may include measures to prevent, prepare for, respond to and recover from flooding.
Extreme Flood	Defines the upper limit of flooding that could reasonably be expected to occur on the Murrumbidgee River floodplain and is much rarer than the 1% AEP flood which is usually adopted for planning purposes. The discharge hydrograph of the Extreme Flood was derived by applying a multiplication factor of three (3) to the corresponding 1% AEP discharge hydrograph.
EIS	Environmental Impact Statement.

Term	Meaning
Erosion	A natural process where wind or water detaches a soil particle and provides energy to move the particle.
FDM	*Floodplain Development Manual* (Department of Planning, Infrastructure and Natural Resources (DIPNR) 2005).
FRMM	*Flood Risk Management Manual* (Department of Planning and Environment (DPE 2023)
Flood	Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or local overland flooding associated with major drainage before entering a watercourse, and/or coastal inundation resulting from super-elevated sea levels and/or waves overtopping coastline defences excluding tsunamis.
Flood affectation	The extent to which a property or area of land is affected by flooding.
Flood fringe area	The remaining area of flood prone land after floodway and flood storage areas have been defined.
Flood immunity	Relates to the level at which a particular structure would be clear of a certain flood event.
Flood prone land	Land susceptible to flooding by the Probable Maximum Flood. Note that the flood prone land is synonymous with flood liable land.
Flood storage area	Those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood. The extent and behaviour of flood storage areas may change with flood severity, and loss of flood storage can increase the severity of flood impacts by reducing natural flood attenuation. Hence, it is necessary to investigate a range of flood sizes before defining flood storage areas.
Floodplain	Area of land which is subject to inundation by floods up to and including the probable maximum flood event (i.e. flood prone land).
Floodplain Risk Management Plan	A management plan developed in accordance with the principles and guidelines in the *Floodplain Development Manual* (FDM), (DIPNR 2005) or *Flood Risk Management Manual* (FRMM), (DPE 2023). Usually includes both written and diagrammatic information describing how particular areas of flood prone land are to be used and managed to achieve defined objectives.
Floodway area	Those areas of the floodplain where a significant discharge of water occurs during floods. They are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flow, or a significant increase in flood levels.
Flow velocity	A measure of how fast how fast water is moving, for example, metres per second (m/s).
FPA	Flood Planning Area. The area of land below the Flood Planning Level and thus subject to flood planning controls.
FPLs	Flood Planning Levels. The combination of flood levels (derived from significant historical flood events or floods of specific AEPs) and freeboards selected for floodplain risk management purposes, as determined in management studies and incorporated in management plans.

Term	Meaning
Freeboard	A factor of safety typically used in relation to the setting of floor levels, levee crest levels, etc. It is usually expressed as the difference in height between the adopted Flood Planning Level and the peak height of the flood used to determine the Flood Planning Level. Freeboard provides a factor of safety to compensate for uncertainties in the estimation of flood levels across the floodplain, such as wave action, localised hydraulic behaviour and impacts that are specific event related, such as levee and embankment settlement, and other effects such as "greenhouse" and climate change. Freeboard is included in the Flood Planning Level.
GSDM	Generalised Short Duration Method. A method prescribed by BoM for estimating the Probable Maximum Precipitation for catchments up to 1,000 square kilometres in area.
Hazard	A source of potential harm or a situation with a potential to cause loss. In relation to the *Flood Risk Management Manual* (FRMM), (DPE 2023) the hazard is flooding which has the potential to cause damage to the community.
Hydraulics	The term given to the study of water flow in waterways, in particular the evaluation of flow parameters such as water level and velocity.
Hydrograph	A graph which shows how the discharge or stage/flood level at any particular location varies with time during a flood.
Hydrology	The term given to the study of the rainfall and runoff process; in particular, the evaluation of peak flows, flow volumes and the derivation of discharge hydrographs for a range of floods.
Impact	Influence or effect exerted by a project or other activity on the natural, built and community environment.
Inbank area	The area of a creek or watercourse below its top of bank levels.
Inundation	The spreading of a flood over an area.
IPCC	Intergovernmental Panel on Climate Change.
LGA	Local government area.
LiDAR	Light detection and ranging. A form of aerial survey used to measure ground elevations.
Local drainage	Smaller scale drainage systems in urban areas. Commonly defined as areas where the depth of inundation along overland flow paths is less than 150 millimetres during a 1% AEP storm.
m	Metres. Used to define a length.
m AHD	Metres above Australian Height Datum. Used to define an elevation above Australian Height Datum.
km^2	Square kilometres. Used to define an area.
m^3/s	Cubic metres per second. Used to quantify a flowrate.
m/s	Metres per second Used to quantify flow velocity.

Term	Meaning
Mathematical/ computer models	The mathematical representation of the physical processes involved in runoff generation and stream flow. These models are often run on computers due to the complexity of the mathematical relationships between runoff, stream flow and the distribution of flows across the floodplain.
Merits based approach	The merits-based approach weighs social, economic and environmental impacts of land use options for different flood prone areas together with flood damage, hazard and behaviour implications, and environmental protection and well-being of the State's rivers and floodplains.
Operation area	The area that would be occupied by permanent components of the project, including transmission line easements, internal transmission line and towers, wind turbines and hardstands, O&M building substations, and permanent access tracks. The amended operational footprint occupies an area of 347.16 ha.
Peak flood level	The maximum water level occurring during a flood event.
PMF	Probable maximum flood. The flood that occurs as a result of the Probable Maximum Precipitation (PMP) on a study catchment. The PMF is the largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation coupled with the worst flood producing catchment conditions. Generally, it is not physically or economically feasible to provide complete protection against this event. The PMF defines the extent of flood prone land (i.e. the floodplain).
PMP	Probable maximum precipitation. The PMP is the result of the optimum combination of the available moisture in the atmosphere and the efficiency of the storm mechanism as regards rainfall production. The PMP is used to estimate PMF discharges using a catchment hydrologic model which simulates the conversion of rainfall to runoff.
Pre-project conditions	Conditions (within the study area) prior to the construction of the project.
Project	The construction and operation of The Plains Wind Farm inclusive of all activities impacting areas within the overall project boundary.
Probability	A statistical measure of the expected chance of flooding (see annual exceedance probability).
Renewable energy zone	An area with high energy potential for wind and solar power generation in locations where it can be efficiently stored and transmitted across NSW.
Representative Concentration Pathway	A greenhouse gas concentration trajectory adopted by the Intergovernmental Panel on Climate Change.
Risk	Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. In the context of the *NSW Floodplain Development Manual* (DIPNR 2005) it is the likelihood of consequences arising from the interaction of floods, communities and the environment.
RL	Reduced level. The reduced level is the vertical distance between an elevation and an adopted datum plane such as the Australian Height Datum (AHD).
Runoff	The amount of rainfall which actually ends up as stream flow, also known as rainfall excess.
Scour	The erosion of material by the action of flowing water.

Term	Meaning
SEARs	Secretary's Environmental Assessment Requirements and specifications for an environmental assessment prepared by the Secretary of the NSW Department of Planning and Environment under Division 4.1 of the Environmental Planning and Assessment Act 1979 (NSW).
NSW SES	NSW State Emergency Service.
South West REZ	South West Renewable Energy Zone (REZ) to be developed around Hay, stretching from the Murrumbidgee LGA in the east to Buronga in the west, in the South-West Region of NSW.
Spoil	Surplus excavated material.
Stage	Equivalent to water level (measured with reference to a specified datum).
Stockpile	Temporarily stored materials such as soil, sand, gravel and spoil/waste.
Substation	A facility used to increase or decrease voltages between incoming and outgoing lines (e.g. 330 kV to 500 kV)
Surcharge	Overflow from a creek, waterbody, overland flow or drainage system.
Surface water	Water flowing or held in streams, rivers and other water bodies in the landscape.
Transmission line easement	An area surrounding and including the internal transmission line which provides legal access and allows for ongoing access and maintenance of the lines. Landowners can typically continue to use most of the land within transmission line easements, subject to some restrictions for safety and operational reasons.
WTG	Wind turbine generators

ES1 EXECUTIVE SUMMARY

Overview

This technical paper deals with the findings of an investigation that has been undertaken to assess flood related issues associated with the construction and operation of The Plains Wind Farm south of Hay, NSW (the project). The project is located within the South West Renewable Energy Zone and is one of two projects that are planned as part of The Plains Renewable Energy Park Project, the other being The Plains Solar Farm. **Figures 1.1** and **1.2** in **Section 1.3** of this technical paper show location and extent of the area comprising the wind farm project (project area).

This technical paper has been prepared to support the preparation of the Project Amendment and Response to Submission (RtS) reports. **Section 1** provides an overview of the amended project, as well as an outline of the purpose and structure of this technical paper. **Section 2** contains an outline of relevant government legislation, policies and guidelines that were taken into consideration in the assessment, while **Section 3** provides details of the methodology that was adopted in the definition of flood behaviour in the vicinity of the project and the impact that it would have on flood behaviour.

This technical paper addresses the Secretary's Environmental Assessment Requirements (SEARs) relating to flooding and hydrology as outlined in **Section 1.2**.

Existing environment

The project area is located to the south of the Murrumbidgee River and the township of Hay in an area referred to as the Hay Plains. A series of waterways drain in generally a south-westerly direction to the south of the river, which includes the project area. While these waterways are generally non-perennial in nature, they do include several irrigation canals. **Figure 4.1** (6 sheets) at the end of this technical paper shows the key features of the existing drainage system in the vicinity of the various elements which comprise the project.

While the non-perennial streams convey flow generated by their directly connected catchments (referred to herein as “local catchment type flooding”), they also convey floodwater which surcharges the southern bank of the Murrumbidgee River, albeit for floods of varying magnitude (referred to herein as “riverine type flooding”).

Section 4 of this technical paper contains a brief description of the characteristics of the project area and its immediate environs, as well as a description of the nature of both riverine and local catchment type flooding under present day (or pre-project) conditions for events ranging between 5% and 1% Annual Exceedance Probability (AEP), as well as the Extreme Flood on the Murrumbidgee River and the Probable Maximum Flood (PMF) in relation to local catchment flooding.

While the eastern limits of the project area are subject to riverine type flooding during a 1% AEP, an Extreme Flood on the Murrumbidgee River results in floodwaters in major drainage lines within the project area. Wind farm infrastructure is distributed across the project area, with access tracks and transmission cables connecting individual wind turbines to substations. This infrastructure crosses major drainage lines and has the potential to be impacted by floodwater during an Extreme Flood on the Murrumbidgee River. While depths of flow vary in the major drainage line, maximum depths of flow of about up to 2.2 metres and velocity of about 0.3-0.4 metres per second are predicted.

Flooding from local catchment flooding during intense or long-durations rainfall events results in floodwater in major drainage lines and widespread shallow ponding across the projected area, albeit generally to depths not exceeding 0.3 metres during storms up to 1% AEP in intensity. Inbank waterway areas experience flow at depths and velocities of about 1.0 metres and 0.4 metres per second, respectively during a 1% AEP storm event. During a PMF event, the maximum depth and velocity of flow in major drainage lines would increase to about 1.5 metres and 0.6 metres per second, respectively.

Floodway areas internal to the project area during a 1% AEP local catchment flood event are limited to the inbank areas of Telegraph Creek, Abercrombie Creek, Curtains Creek and Eurolie Creek. A portion of the project area is classified as flood storage areas, particularly in off channel areas adjacent to major drainage lines and upstream of impediments to overland flow (i.e. eastern side of Cobb Highway). The remainder of the flood affected areas internal to the project are categorised as flood fringe.

The flood hazard in the project area is generally classified as H1 (generally safe for vehicles, people and buildings) due to the shallow depths and slow surface water velocities, with areas of H2 classified flooding generally aligned with aforementioned flood storage areas. Flow within the inbank area of Telegraph Creek, Abercrombie Creek, Curtains Creek and Eurolie Creek is generally classified as H3, which is unsafe for vehicles, children and the elderly, with some deeper areas classified as H4 and H5.

Due to the relatively flat nature of the Hay Plains, most of the project area lies on land which is located below the Flood Planning Level (FPL), which has been defined as land which lies below the 1% AEP flood level (based on the higher of either Murrumbidgee River or local catchment flooding) plus 0.5 metres of freeboard.

Construction impact assessment

An assessment was carried out of the flood risk associated with the construction of the project, as well as the potential impacts that proposed construction activities could have on flood behaviour.

Potential flood risk to construction activities

The assessment found that the greatest potential construction related flood risk is associated with the construction of the project infrastructure within the inbank areas of Telegraph Creek, Abercrombie Creek and Curtains Creek. Although no wind turbines or substation infrastructure is situated within inbank areas, access tracks, underground and overhead 33 kV and 330 kV transmission lines cross major drainage lines. These inbank areas are subject to deeper depths of flow and higher velocities than the remainder of the project area.

The occurrence of localised heavy or long-duration storm events also has the potential to result in the “wetting-up” of the unsealed access tracks, which if appropriate management measures are not implemented, may hinder the movement of construction equipment and personnel for extended periods of time.

Potential impacts of the proposed construction activities on flood behaviour

As the project does not propose to alter the landform of the floodplain, there is unlikely to be measurable changes in flood levels or flood behaviour as a result of the project construction activities. That said, the construction of the temporary access tracks may result in localised ponding of floodwaters and altered drainage pathways adjacent to their alignment if not designed appropriately.

Operational impact assessment

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

Potential flood risk to the project

Major drainage lines of Telegraph Creek, Abercrombie Creek, Curtains Creek and Eurolie Creek situated within the project area all convey floodwaters during local catchment events and riverine based flood events at and above the 1% AEP Murrumbidgee River flood event. Project infrastructure which crosses these waterways, including access tracks, and underground and overhead 33 kV and 330 kV transmission lines, would be subject to flow at depths and velocities exceeding 1.0 metre and 0.4 metres per second, respectively.

Some project infrastructure on the floodplain is currently situated within identified flood storage and flood fringe areas, noting that the project is still under design development. This includes the base of several wind turbines, as well as numerous access tracks. The proposed switching station is also located on land that would be inundated during local catchment floods as frequent as 5% AEP, as well as an extreme flood on the Murrumbidgee River. Due to the spatial extent of the wind farm infrastructure, flood events could result in isolation of workers and equipment.

No substation or construction worker accommodation sites are predicted to be subject to inundation, however, ponding of surface waters is expected during local catchment rainfall events.

Potential impact of the project on flood behaviour

As the project does not propose to alter the landform of the floodplain, there would be no measurable changes in flood levels or flood behaviour as a result of the project.

Consistency with council and state government flood related plans

As the project will not have a measurable impact on flood behaviour, it can be concluded that it will:

a) not impact the FPL both internal and external to the project area;

b) not increase the overall flood hazard both internal and extent to the project area; and

c) not have an adverse impact on the NSW State Emergency Service's (NSW SES's) emergency response arrangements as set out in the *Hay Shire Local Flood Plan* (NSW SES, 2014) and *Edwards River Local Flood Emergency Sub Plan* (NSW SES, 2023).

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

Potential increases in localised 1% AEP rainfall intensities associated with future climate change have the potential to result in a minor increase in the depth of flooding across the project area. A minor increase in the depth and velocity of flow in Telegraph Creek, Abercrombie Creek and Curtains Creek which runs through the project area. There would also be a minor increase in the depth and extent of the flood fringe and flood storage areas that are present within the project area, including in the immediate vicinity of the proposed switching station.

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

As the project does not propose to alter the landform of the floodplain and given that potential increases in rainfall intensities will result in only minor increases in the depth, extent and velocity of flow internal to the project area, it is concluded that the project would not have a measurable impact on flood behaviour under future climate change conditions.

Cumulative impacts

The assessment found that the construction of the project in combination with other wind and solar farms that are planned in the South West Renewable Energy Zone would not result in adverse flooding conditions being experienced in the watercourses which drain through the project area.

Management of impacts

Section 8 of this technical paper outlines the measures that will be adopted during the detailed design phase to manage the flood risk to the project, as well as the potential for it to impact flood behaviour through:

i. documenting procedures and measures that are aimed at managing the risk of flooding to the project, as well as the potential for adverse impacts on existing flood behaviour within its vicinity

ii. identifying appropriate design standards for managing the flood risk during the construction and operational phases of the project

iii. including procedures aimed at reducing the flooding threat to human safety and infrastructure

iv. including controls that are aimed at mitigating the impact of the project (during construction and operation) on flood behaviour.

While the findings of the assessment presented in **Section 5.3** of this technical paper provide an indication of the potential impact construction activities would have on flood behaviour, further investigations would need to be undertaken during detailed design with the benefit of more detailed site layouts and staging diagrams. **Table 8.1** in **Section 8** contains a range of potential measures which could be implemented to reduce the impact of construction activities on flood behaviour.

The assessment of flood behaviour during the operation of the project has provided an understanding of the scale and nature of the flood risk to the project infrastructure, as well as its potential impact on flood behaviour. A broad outline of measures which would need to be implemented during detailed design to manage the project related flood risks and impacts are outlined in **Table 8.1** in **Section 8** of this technical paper.

1 INTRODUCTION

1.1 Background

The NSW Government is leading the establishment of Renewable Energy Zones (REZs) across NSW to deliver a coordinated approach to renewable energy generation and storage, supported by transmission infrastructure. A REZ groups new renewable energy power generation into locations where it can be efficiently stored and transmitted across NSW, requiring the coordination of power generation, power storage and transmission infrastructure. By doing so, REZs capitalise on economies of scale to deliver clean, affordable and reliable energy for homes, businesses and industry in NSW.

The South West REZ was formally declared on 5 November 2021 under the *Electricity Infrastructure Investment Act 2020*. The South West REZ is one of five REZs currently declared for NSW.

ENGIE (the applicant), a French multinational organisation that specialises in the development, operation and maintenance of large-scale energy assets, aims to develop The Plains Wind Farm (the project). The project is part of The Plains Renewable Energy Park which is situated within the South West REZ. The applicant is seeking State Significant Development (SSD) consent for the project under Division 4.7, Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act).

Lyall & Associates has been engaged by the applicant to undertake a flooding assessment associated with the construction and operation of the project as part of the broader Environmental Impact Statement (EIS) submitted in 2024 and to support the preparation of the Project Amendment and Response to Submission (RtS) reports.

1.2 Purpose of this technical paper

This technical paper assesses the potential flooding impacts from the construction and operation of the amended project design and has been prepared to support and inform the Project Amendment Report. The technical paper:

- describes the existing environment with respect to flood behaviour
- assesses the impacts of constructing and operating the project on existing flood behaviour, as well as the impact that flooding could have on the construction and operation of the project
- recommends measures to mitigate the identifiable flood related impacts that are attributable to the project.

This technical paper has been prepared to address the relevant Secretary's Environmental Assessment Requirements (SEARs) for the project issued on 16 December 2022. Whilst flooding is broadly mentioned in the SEARs relating to quantifying the flood impact of the proposed development, Attachment A of the letter provided by the NSW Department of Planning and Environment (DPE, now Department of Planning, Housing and Infrastructure (DPHI)) Biodiversity and Conservation Division (dated 30 November 2022) provides the most comprehensive flood assessment requirements for the project EIS submitted in 2024 and to support the preparation of the Project Amendment and Response to Submission (RtS) reports. The assessment requirements outlined in Attachment A of the DPE letter encompass all flood assessment requirements mentioned in other parts of the SEARs and are presented in **Table 1.1**.

TABLE 1.1
SEARS RELEVANT TO THIS ASSESSMENT

Requirement	Where addressed in this report
7. The EIS must map the following features relevant to flooding as described in the Floodplain Development Manual 2005 (NSW Government 2005) including: *a. Flood prone land.* *b. Flood planning area, the area below the flood planning level.* *c. Hydraulic categorisation (floodways and flood storage areas).* *d. Flood hazard.*	7.a.b. The project area is mapped as partially flood prone land. This is further discussed in Sections 4.3 and 4.6. c. Hydraulic characterisation is provided in Section 4.4. d. Flood hazard vulnerability classification for 1% AEP flood events if outlined in Section 4.5.
8. The EIS must describe flood assessment and modelling undertaken in determining the design flood levels for events, including a minimum of the 5% Annual Exceedance Probability (AEP), 1% AEP flood levels and the probable maximum flood, or an equivalent extreme event.	8. The flood assessment methodology is described in Section 0. Model results for 5% AEP, 1% AEP and the Extreme Flood/PMF are detailed in Section 4.3.
9. The EIS must model the effect of the proposed development (including fill) on the flood behaviour under the following scenarios: *a. Current flood behaviour for a range of design events as identified in 7 above. This includes the 0.5% and 0.2% AEP year flood events as proxies for assessing sensitivity to an increase in rainfall intensity of flood producing rainfall events due to climate change.*	9.a The proposed development does not include substantial changes in the floodplain landform or modification of waterways or floodway flow paths. Subsequently the impact of the proposed development is highly localised and limited. Chapter 5 discusses the construction impact assessment, while Chapter 6 details the operational impact assessment. The potential impact of flooding on the development is summarised in Section 4.3 and 0.5% and 0.2% AEP events are discussed in Section 6.3 in relation to climate change.
10. Modelling in the EIS must consider and document: *a. Existing council flood studies in the area and examine consistency to the flood behaviour documented in these studies.* *b. The impact on existing flood behaviour for a full range of flood events including up to the probable maximum flood.* *c. Impacts of the development on flood behaviour resulting in detrimental changes in potentialflood affection of other developments or land. This may include redirection of flow, flow velocities, flood levels, hazards and hydraulic categories.* *d. Relevant provisions of the NSW Floodplain Development Manual 2005.*	10.a. The existing flood model adopted by Hay Shire Council does not include the project area. The existing model was used as a basis for this study and the model domain expanded to include the project area. This is discussed in Section 3.3. b. Existing flood behaviour for 5% AEP, 1% AEP and the PMF are detailed in Section 4.3. c. The impact of the project on flood behaviour is negligible. This is discussed in Sections 5.3 and 6.1. d. Relevant provisions of the FDM (now FRMM) are outlined in Section 2.2.2 and are addressed throughout the report.
11. The EIS must assess the impacts on the proposed development on flood behaviour, including: *a. Whether there will be detrimental increases in the potential flood affectation of otherproperties, assets and*	11.a. There is no detrimental change (increase or decrease) in present day behaviour as a result of the project which may affect other properties, assets or

Requirement	Where addressed in this report
infrastructure. b. *Consistency with Council Floodplain Risk Management Plans.* c. *Consistency with any Rural Floodplain Management Plans.* d. *Compatibility with the flood hazard of the land.* e. *Compatibility with the hydraulic functions of flow conveyance in floodways and storage inflood storage areas of the land.* f. *Whether there will be adverse effect to beneficial inundation of the floodplain environment,on, adjacent to or downstream of the site.* g. *Whether there will be direct or indirect increase in erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses.* h. *Any impacts the development may have upon existing community emergency management arrangements for flooding. These matters are to be discussed with the SES and Council.* i. *Whether the proposal incorporates specific measures to manage risk to life from flood. Thesematters are to be discussed with the SES and Council.* j. *Emergency management, evacuation and access, and contingency measures for the development considering the full range or flood risk (based upon the probable maximumflood or an equivalent extreme flood event). These matters are to be discussed with andhave the support of Council and the SES.* k. *Any impacts the development may have on the social and economic costs to the community as consequence of flooding.*	infrastructure. This is discussed explicitly in Section 6.1. b.c. Relevant management plans are outlined in Section 2.2 and discussed further in Section 6.2. In summary the proposed developed aligns with existing management plans and does not increase flooding risk on the floodplain. d. Flood hazard for the 1% AEP flood event is described in Section 4.5. e. The hydraulic categorisation of the floodplain during a 1% AEP event is detailed in Section 4.4. f. Floodplain inundation is not altered as a result of the proposed development. Flood behaviour for 5%, 1% AEP and PMF events are described in Section 4.3 and the corresponding model result figures. g. Transmission line infrastructure and access tracks situated within waterways may result in localised increases in scour and erosion. This is further described in Section 4.3. h.- i. The proposed development will not impact existing emergency management arrangements for flooding or increase risk to life from flooding. See Section 6.2.

1.3 Project overview

ENGIE proposes to construct and operate the project as part of The Plains Renewable Energy Park Project, a renewable energy development located south of Hay in the Riverina Murray Region of New South Wales (NSW). The project is a proposed wind farm that will include up to 171 wind turbine generators (WTGs), with each having a hub height of up to 180 metres and tip height of up to 270 metres, and a total maximum capacity of up to 1,230 megawatts. The project is situated on Mungadal Station and neighbouring properties to the east and west of the Cobb Highway in the Riverina Murray Region of NSW. The project area covers a total area of 46,431ha, with a development footprint of 1,887.1 ha. The development footprint represents the expected impacts associated with the construction and operation of the Project.

The final layout remains subject to further detailed design and refinement. To allow the Applicant to make general design refinements without the need to modify the application, the EIS and Project Amendment Report have assessed impacts for an area that includes temporary and permanent project infrastructure with, generally, a 100 m micro-siting buffer applied (the project area).

1.3.1 Features

The project features a range of permanent wind turbine and ancillary infrastructure, and temporary facilities related to construction activities. Project components are detailed in **Table 1.2**, while **Figure 1.1** over shows the layout of the project.

TABLE 1.2
PROJECT COMPONENTS

Project Component	Description
Project description	Wind Turbine Generators (WTG's) • Up to 171 WTG locations, with a maximum installed capacity of 1,230 MW (based on 7.2 MW turbine generator size currently available) • Maximum tip height of up to 270 m • Crane hardstand areas, turbine laydown areas, concrete batching plants, internal access tracks • Site entrance points off Cobb Highway
WTG Parameters	• Maximum blade tip height: 270 m • Blade length: 90 m • Hub height: 180 m
Ancillary Infrastructure	• Internal project access roads to connect WTG's and ancillary project infrastructure • Collector groups connected with predominately 33 kV underground cabling and occasionally overhead lines • Up to 10 Permanent Meteorological Masts • Accommodation compound on-site as well as accommodation housing for workers in Hay • 330 kV High-voltage overhead lines connecting collector groups of turbines to the main substations, and a switchyard for connection to the project energy connect • Operations and Maintenance Building • Switchyard to connect into Project EnergyConnect (PEC). • Main substations, facilitating connection to the NEM includes transformers, voltage controls, storage units and potentially power quality control equipment • Up to 3 collector substations, with overhead 330kV lines running back to main substation • Four main access points to project site off the Cobb Highway
Construction program and staging	<u>Duration</u>: 3-year construction <u>Staging</u>: Wind Farm will be built within the same construction period and will be staggered to start after completion of the Plains Solar Farm. <u>Construction workforce</u>: • Peak workforce: 700 jobs • Average workforce: Approximately 550 Jobs <u>Operations workforce</u>: • Full time equivalents (FTE) (on site): 40 • FTEs off site: 6

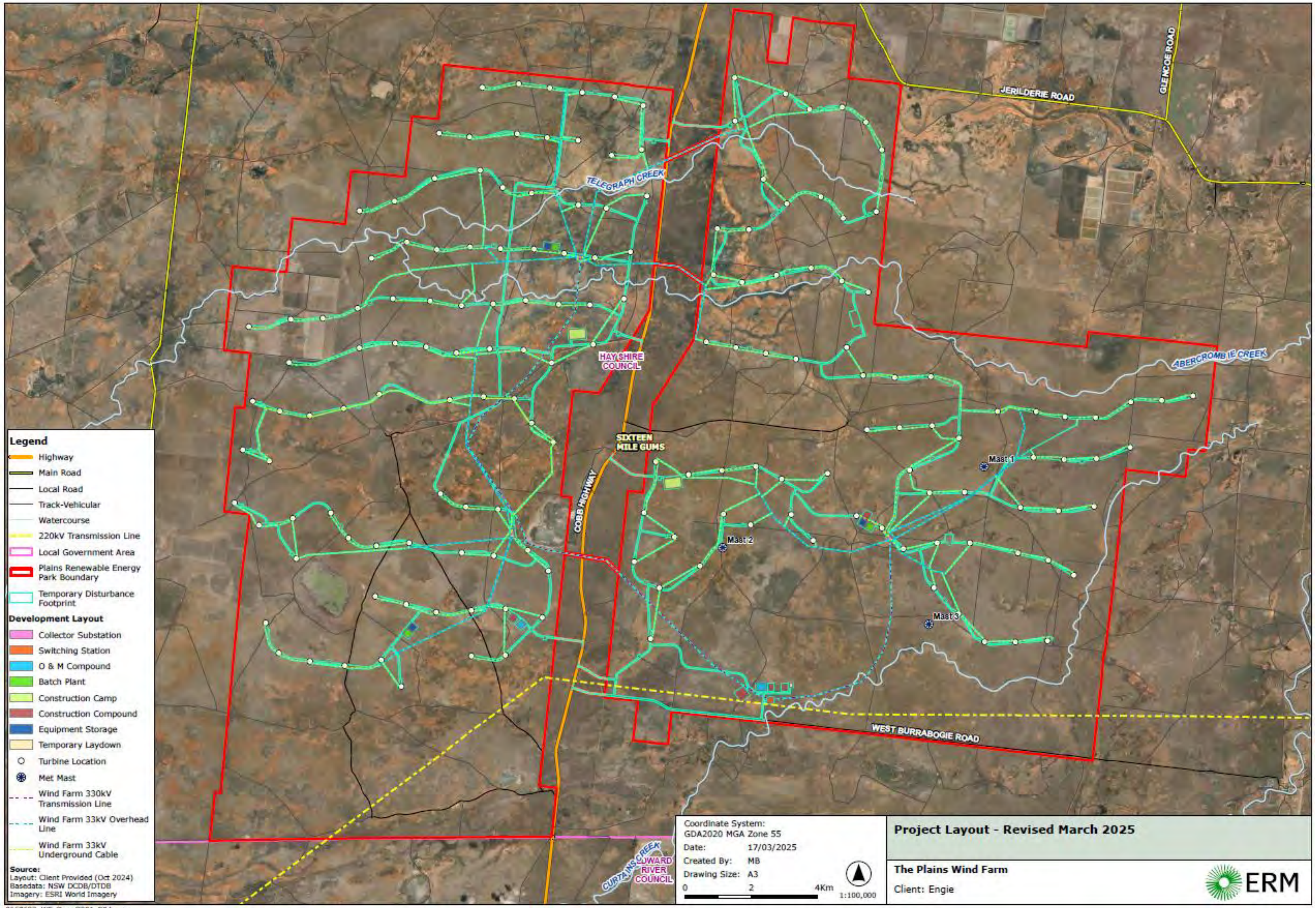

Figure 1.1 – Project layout

1.3.2 Location

The project is situated on the Hay Plains approximately 720 kilometres west of Sydney. The closest population centre is the township of Hay, which is located about 15 kilometres to the north of the project area. The location of the project area relative to the township of Hay is shown in **Figure 1.2** over.

The project area is located within the Murrumbidgee Catchment of the Murray-Darling Basin. The Murrumbidgee Catchment covers an area of about 84,000 square kilometres and comprises 8 percent of the Murray-Darling Basin (MDBA, 2021). The project area is located a minimum distance of 11.8 kilometres south of the Murrumbidgee River and 5.6 kilometres north of Coleambally Outfall Drain, the latter which is an irrigation channel. There are several non-perennial creeks which are situated within the project area which include Abercrombie and Telegraph Creeks to the north, and Curtains Creek which flow within the western and southern boundaries of the project area.

Due to the flat topography of the Hay Plains, water courses meander the floodplain, generally draining towards the south-west. Due to the flat topography, waterway connectivity has the potential to vary during different rainfall and flood events. Direct rainfall in the study area generally flows through surface waterways in a south-west direction to ultimately join the Edwards River, with riverine based flood risk originating from the Murrumbidgee River from the north-east.

The Cobb Highway bisects the Plains Wind Farm, with project infrastructure situated on both the eastern and western side of the road corridor. New 330 kV overhead transmission line will be required to connect the substations to main substation and switchyard located on the western side of the Cobb Highway. Electrical connections between wind turbines and substations will primarily be underground although may also include overhead power lines. Access to the wind turbines and substations and associated infrastructure utilises a combination of existing roadways and newly constructed private access tracks.

The topography of the study area is relatively flat, with a nominal elevation of 90 metres AHD. The smaller creeks and waterways in the area are non-perennial which only carry surface water during/following periods of high rainfall and/or high flow in the main rivers and remain dry at other times.

1.3.3 Timing

Construction of the project would commence in early-2027, subject to NSW Government and Commonwealth planning approvals, and is estimated to take approximately 40 months to complete, including commissioning the project to achieve full grid support. The project is expected to be commissioned/energised (i.e., become operational) in early-2030. An indicative timeline of activities is outline in **Table 1.3**.

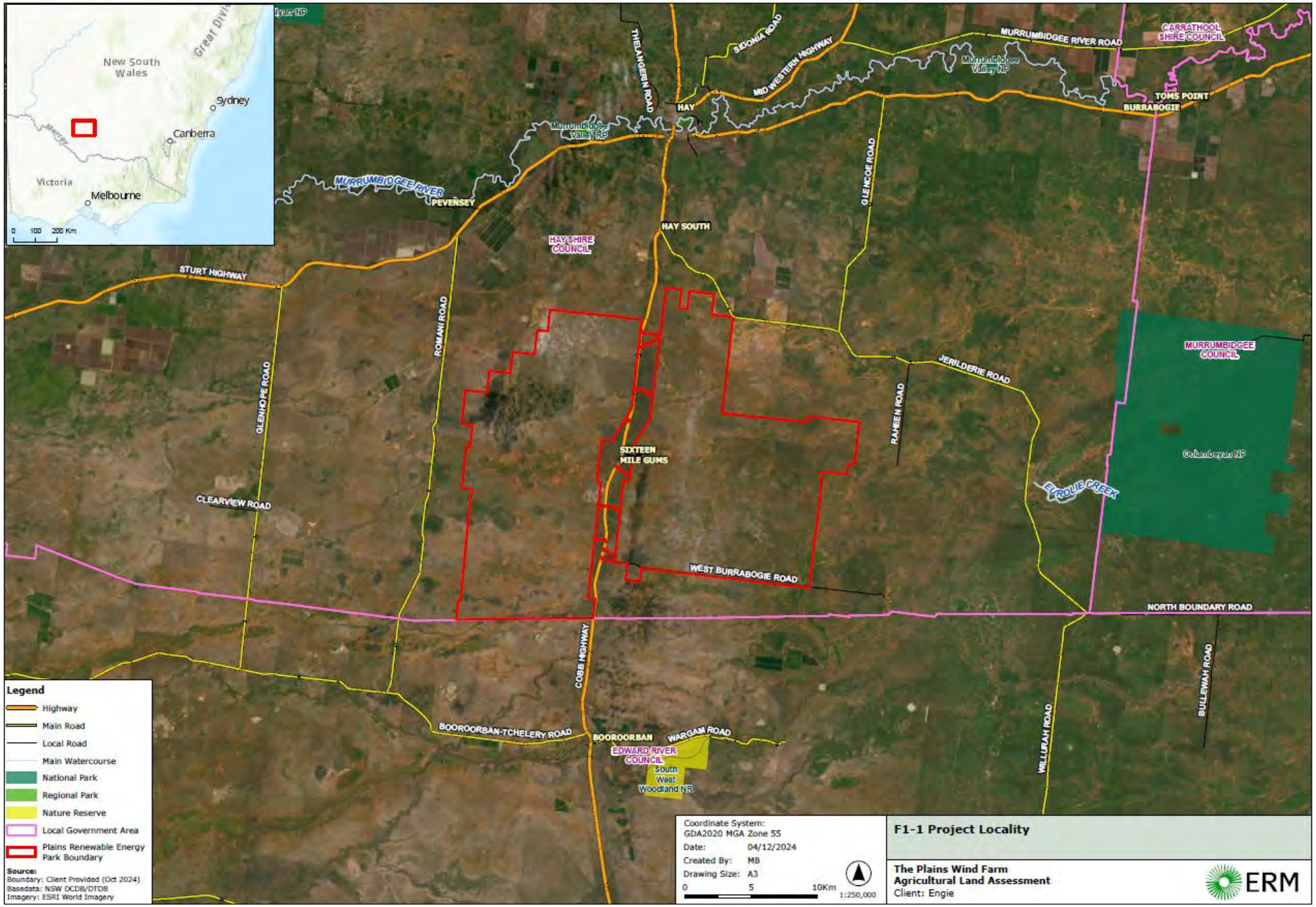

Figure 1.2 – Project location

TABLE 1.3
INDICATIVE CONSTRUCTION TIMELINE

Stage	Activities	Start Date	Approx. Duration
1	Site mobilisation and set up	January 2027	2 months
2	Construction of roads	March 2027	24 months
3	Construction of foundations and hardstands	April 2027	24 months
4	Electrical installation	May 2027	25 months
5	Substations construction and commissioning	April 2027	9 months
6	Transmission line construction and commissioning	June 2027	7 months
7	Delivery of WTG components	July 2027	30 months
8	WTG installation	September 2027	30 months
9	WTG commissioning and testing	November 2027	18 months
Total Duration			40 months

1.3.4 Construction

Key construction activities for the project would occur in the stages as outlined in Table 1.3. During the construction phase, a peak workforce of 700 direct full time equivalent (FTE) employees will be required, with an average workforce of 550 FTE employees over the duration of construction. Temporary construction worker accommodation may be sited within the project area or may be located off site.

Excavation works within the construction footprint for the project would be required for transmission line tower construction, site preparation works at the wind turbine generators and switching station sites to provide level surfaces, to create trenches for local drainage and subsurface cabling, earthing, communications infrastructure and electrical conduits, local road upgrades and to construct access tracks.

Construction vehicle movements would comprise heavy and light vehicles transporting equipment and plant, construction materials, spoil and waste from construction facilities, and workforce accommodation camp sites. There would also be additional vehicle movements associated with construction workers travelling to and from construction areas, and accommodation camp sites. These movements would occur daily for the duration of construction.

To support the construction of the project, several construction compounds would be required including staging and laydown facilities, concrete batching plants, workforce accommodation camps and construction support facilities. The main construction compounds would be established as enabling works and demobilised at the completion of construction.

Further detail regarding project related infrastructure, and construction and temporary facilities is provided in the EIS and Project Amendment Report.

1.3.5 Operation

Operations will commence for a period of up to 30 years. During the operation of the project, the workforce will consist of 40 permanent on-site staff and 6 permanent off-site staff undertaking operational and maintenance activities. The majority of maintenance undertaken on the operational wind farm will be preventative maintenance through a schedule which will cycle through all hardware to ensure service intervals are met. In addition to the preventative maintenance schedule, some repair work will be required should break downs occur within the system.

1.4 Structure of this technical paper

The structure and content of this flooding technical paper is as follows:

- **Chapter 1** introduces this technical paper (this chapter).
- **Chapter 2** provides an overview of the regulatory context for the assessment, including an overview of the flood related legislation, policy and guidelines that apply to the project.
- **Chapter 3** sets out the methodology that has been adopted in the definition of flood behaviour in the vicinity of the project and the impact that the project would have on flood behaviour. The chapter also contains a summary of the criteria and standards that have been adopted for the assessment based on consideration of the relevant government legislation, policies and guidelines.
- **Chapter 4** describes the existing environment as it relates to flooding, including a brief description of the catchments within which the project is located, and which form the study area for the assessment. The chapter also provides a description of flood behaviour in the vicinity of the project under present day (i.e. pre-project) conditions.
- **Chapter 5** describes the potential flood risks to the project and its impact on flood behaviour during its construction.
- **Chapter 6** describes the potential flood risks to the project and its impact on flood behaviour during the operation of the project. The chapter also presents the findings of an assessment of the potential impact of future climate change on flood behaviour.
- **Chapter 7** describes the potential cumulative impacts of flood behaviour from the project in combination with other known major developments within its vicinity.
- **Chapter 8** provides recommended mitigation and management measures to avoid, minimise and manage any potential flood related risks and impacts associated with the construction and/or operation of the project.
- **Chapter 9** contains a list of references cited in this paper.
- **Appendix A** contains a series of figures which show the layout of the TUFLOW flood models. **Appendix A** also contains a series of model result figures for the October – November 2022 flood event.
- **Appendix B** contains a series of Figures showing the indicative extent and depth of inundation under pre-project conditions across the project during a 0.5% and 0.2% AEP Murrumbidgee River flood event.
- **Appendix C** contains a series of figures showing the indicative extent and depth of inundation under pre-project conditions across the project during a 0.5% and 0.2% AEP local catchment flood event.

- **Appendix D** contains a series of figures showing maximum flow velocities under pre-project conditions in the vicinity of the project during a 5% and 1% AEP Murrumbidgee River flood event.
- **Appendix E** contains a series of figures showing maximum flow velocities under pre-project conditions in the vicinity of the project during a 5% and 1% AEP local catchment flood event.
- **Appendix F** contains a series of figures showing the hydraulic categorisation and flood hazard vulnerability classification in the vicinity of the project during a 1% AEP Murrumbidgee River flood event.
- **Appendix G** contains a series of figures showing the hydraulic categorisation and flood hazard vulnerability classification in the vicinity of the project during a 1% AEP local catchment flood event.

The figures that are referred to in **Chapters 4, 5** and **6** are located after **Chapter 9** of this technical paper.

2 LEGISLATIVE AND POLICY CONTEXT

This chapter summarises the legislation, guidelines and policies governing the approach to the flooding assessment. Relevant commonwealth, state and local government legislation, guidelines and policies are discussed in **Sections 2.1**, **2.2** and **2.3**, respectively.

2.1 Commonwealth guidelines

2.1.1 Australian Rainfall and Runoff

Australian Rainfall and Runoff (ARR) is a national guideline for the estimation of design flood characteristics in Australia. The application of the procedures, inputs and parameters set out in ARR is an important component in the provision of reliable and robust estimates of design flood behaviour to ensure that the project is planned, designed, constructed and operated in a manner that best manages flood risk.

The third edition of ARR was released in 1987 (ARR 1987) (Institute of Engineers Australia (IEAust) 1987), while a fourth edition of ARR was issued in 2019 (ARR 2019) (Geoscience Australia (GA) 2019). The hydrologic and hydraulic models (collectively referred to as 'flood models') that were relied upon for the present investigation were developed using the procedures set out in ARR 2019. ARR 2019 includes:

- procedures for the derivation of design rainfall intensities, temporal rainfall distributions and rainfall losses for application to hydrologic models that define the rainfall runoff process
- guidance on the development of hydraulic models, including the procedures for the derivation of blockage factors to apply to culverts and small bridges, that define how runoff is conveyed in waterways and across the land
- guidance on how design rainfall intensities could be impacted by future climate change.

In regard to the last dot point, ARR 2019 contains a series of tables that are available through the *ARR 2019 Data Hub* of projected temperature increase and corresponding increase in rainfall intensity with varying representative concentration pathway (RCP)[1] and projection date for each of the eight Natural Resource Management (NRM) clusters set out in the Commonwealth Science Industrial Research Organisation's (CSIRO's) *Future Climates Tool* website. The values have been derived based on an analysis of the actual predicted temperature increase from global climate models across each NRM cluster.

Based on a projection date of 2090, ARR 2019 shows that:

- for an RCP of 4.5, the predicted rise in temperature is 1.9°C, which corresponds to an increase in rainfall intensity of 9.2 per cent in the vicinity of the project
- for an RCP of 8.5, the predicted rise in temperature is 3.7°C, which corresponds to an increase in rainfall intensity of 20.2 per cent in the vicinity of the project.

[1] RCPs are a measure of greenhouse gas concentration trajectories and are used to described different climate futures that are considered possible depending on the level of future greenhouse gas emissions. The RCPs are named according to the radiative forcing values (W m-2) in the year 2100 relative to pre-industrial values.

2.2 State legislation, policies and guidelines

2.2.1 Environmental Planning and Assessment Act 1979

The *Environmental Planning and Assessment Act 1979* (EP&A Act) and associated regulations set out the system of environmental planning and assessment for the state of New South Wales. The Applicant is seeking SSD consent for the Project under Part 4, Division 4.7 of the *Environmental Planning & Assessment Act 1979* (EP&A Act).

In July 2009, the NSW Minister for Planning issued a list of directions to local councils under section 117(2) of the EP&A Act. These directions were later amended on 14 July 2021 as part of the NSW Government's update of its Flood Prone Land package. *Direction 4.1 – Flood Prone Land* (Direction 4.1) (previously issued in July 2021 as Direction 4.3) applies to all councils that contain flood prone land within their LGA and requires that:

A planning proposal must include provisions that give effect to and are consistent with:

(a) the NSW Flood Prone Land Policy,

(b) the principles of the Floodplain Development Manual 2005,

(c) the Considering flooding in land use planning guideline 2021, and

(d) any adopted flood study and/or floodplain risk management plan prepared in accordance with the principles of the Floodplain Development Manual 2005 and adopted by the relevant council.

A planning proposal must not rezone land within the flood planning area from Recreation, Rural, Special Purpose or Environmental Protection Zones to a Residential, Business, Industrial or Special Purpose Zones.

A planning proposal must not contain provisions that apply to the flood planning area which:

(a) permit development in floodway areas,

(b) permit development that will result in significant flood impacts to other properties,

(c) permit development for the purposes of residential accommodation in high hazard areas,

(d) permit a significant increase in the development and/or dwelling density of that land,

(e) permit development for the purpose of centre-based childcare facilities, hostels, boarding houses, group homes, hospitals, residential care facilities, respite day care centres and seniors housing in areas where the occupants of the development cannot effectively evacuate,

(f) permit development to be carried out without development consent except for the purposes of exempt development or agriculture. Dams, drainage canals, levees, still require development consent,

(g) are likely to result in a significantly increased requirement for government spending on emergency management services, flood mitigation and emergency response measures, which can include but are not limited to the provision of road infrastructure, flood mitigation infrastructure and utilities, or

(h) permit hazardous industries or hazardous storage establishments where hazardous materials cannot be effectively contained during the occurrence of a flood event.

A planning proposal must not contain provisions that apply to areas between the flood planning area and probable maximum flood to which Special Flood Considerations apply which:

- *(a) permit development in floodway areas,*
- *(b) permit development that will result in significant flood impacts to other properties,*
- *(c) permit a significant increase in the dwelling density of that land,*
- *(d) permit the development of centre-based childcare facilities, hostels, boarding houses, group homes, hospitals, residential care facilities, respite day care centres and seniors housing in areas where the occupants of the development cannot effectively evacuate,*
- *(e) are likely to affect the safe occupation of and efficient evacuation of the lot, or*
- *(f) are likely to result in a significantly increased requirement for government spending on emergency management services, and flood mitigation and emergency response measures, which can include but not limited to road infrastructure, flood mitigation infrastructure and utilities.*

For the purposes of preparing a planning proposal, the flood planning area must be consistent with the principles of the Floodplain Development Manual 2005 or as otherwise determined by a Floodplain Risk Management Study or Plan adopted by the relevant council.

Direction 4.1 also states that a planning proposal may be inconsistent with the terms of this direction only if the planning proposal authority can satisfy the Secretary of the Department of Planning and Environment (or their nominee) that:

- *(a) the planning proposal is in accordance with a floodplain risk management study or plan adopted by the relevant Council in accordance with the principles and guidelines of the Floodplain Development Manual 2005, or*
- *(b) where there is no council adopted floodplain risk management study or plan, the planning proposal is consistent with the flood study adopted by the council prepared in accordance with the principles of the Floodplain Development Manual 2005 or*
- *(c) the planning proposal is supported by a flood and risk impact assessment accepted by the relevant planning authority and is prepared in accordance with the principles of the Floodplain Development Manual 2005 and consistent with the relevant planning authorities' requirements, or*
- *(d) the provisions of the planning proposal that are inconsistent are of minor significance as determined by the relevant planning authority.*

As with Planning Circular PS 21-006, Direction 4.1 specifically relates to planning proposals under Part 3 of the EP&A Act. However, it is relevant to the project under Division 5.2 of the EP&A Act in that it sets out the approach to establishing flood-related planning controls for surrounding development and is therefore an important consideration in assessing the impact of the project on existing flood risk, as well as the future development potential for land outside the project footprint.

2.2.2 Flood risk management manual

The *Flood Risk Management Manual* (FRMM) (DPE 2023) incorporates the NSW Government's Flood Prone Land Policy, the primary objectives of which are to reduce the impact of flooding and flood liability on owners and occupiers of flood prone property and to reduce public and private losses resulting from floods, whilst also recognising the benefits of use, occupation and development of flood prone land.

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

Flood and floodplain risk management studies undertaken by local councils as part of the NSW Government's Floodplain Management Program are carried out in accordance with the merits-based approach set out in the FRMM. In accordance with the FRMM, the hydraulic and hazard categorisation of the floodplain was considered when assessing the impact that the project could have on existing flood behaviour, as well as the impact of flooding to the project and its users.

2.2.3 Guideline on development controls on flood prone land

In July 2021 the NSW Government issued Planning Circular PS 21-006 *Considering flooding in land use planning: guidance and statutory requirements*. The circular provides advice on a package of changes regarding how land use planning considers flooding and flood-related constraints. The package includes:

- an amendment to clause 7A of Schedule 4 to the *Environmental Planning and Assessment Regulation 2000* (the Regulation);
- a revised local planning direction regarding flooding issued under section 9.1 of the EP&A Act;
- two local environmental plan clauses which introduce flood related development controls;
- a new guideline: *Considering Flooding in Land Use Planning (2021)* (the guideline); and
- revoking the *Guideline on Development Controls on Low Flood Risk Areas (2007)*.

While Planning Circular PS 21-006 specifically relates to planning proposals under Part 3 of the EP&A Act, it is relevant to the project, in that it sets out the approach to establishing flood-related planning controls for surrounding development and is therefore an important consideration in assessing the impact of the project on existing flood risk, as well as the future development potential of land outside the project footprint.

Planning proposals are required to be consistent with directions issued under section 9.1 of the EP&A Act. Direction 4.1 requires, among other matters, a planning proposal to be consistent with the principles of the FRMM. The direction has been revised to remove the need to obtain exceptional circumstances to apply flood-related residential development controls above the 1% AEP flood event. It also ensures that planning proposals consider the flood risks and do not permit residential accommodation in high hazard areas and other land uses on flood prone land where the development cannot effectively evacuate. The direction also makes provision for special flood considerations where councils have chosen to adopt the optional *Special flood considerations* clause in an LEP. The revised direction will apply to planning proposals that have not been issued with a gateway determination under section 3.34(2) of the EP&A Act.

The guideline supports the principles of the FRMM and provides advice to councils on land-use planning on flood prone land. It provides councils with greater flexibility in defining the areas to which flood-related development controls apply, with consideration of defined flood events, freeboards, low-probability/high-consequence flooding and emergency management considerations. The guideline and the FRMM state that a defined flood event (DFE) of 1% AEP, or a historic flood of similar scale, plus a freeboard should generally be used as the minimum level for setting residential flood planning levels (FPL). Choosing different DFEs and freeboards requires justification based on a merits-based assessment that is consistent with the floodplain risk management process and principles of the FRMM. Special flood considerations apply to sensitive and hazardous development in areas between the flood planning area (FPA) and the PMF and to land that may cause a particular risk to life and other safety considerations that require additional controls. These controls relate to the management of risk to life and the risk of hazardous industry/hazardous storage establishments to the community and the environment in the event of a flood.

A similar merits-based approach to that described in the guideline has been adopted in the assessment of the impacts that the project would have on existing flood behaviour and also in the development of a range of potential measures which would be aimed at mitigating the impact of the project on the existing environment. Consistent with the guideline, the assessment that is presented in this report has taken into consideration floods larger than the 1% AEP event, up to the PMF.

2.2.4 Floodplain risk management guidelines on climate change

Scientific evidence shows that climate change is expected to lead to an increase in flood producing rainfall intensities and sea levels. The significance of these effects on flood behaviour would vary depending on geographic location and local topographic conditions. Given the location and elevation of the project footprint and the watercourses that it crosses, future sea level rise would not impact on flood behaviour in its vicinity. Consideration of flood behaviour under future climate change has therefore focused on potential increases in rainfall intensities. Current guidance on the impact of future climate change on increased rainfall intensities and how this has been taken into consideration in the flood assessment for the project is outlined below.

The NSW Government's *Floodplain Risk Management Guideline: Practical Considerations of Climate Change* (DECC 2007) recommends that until more work is completed in relation to the climate change impacts on rainfall intensities, sensitivity analyses should be undertaken based on increases in rainfall intensities of between 10 and 30 per cent. Under current climatic conditions, increasing the 1% AEP design rainfall intensities by 10 per cent would produce about a 0.5% AEP flood; and increasing those rainfalls by 30 per cent would produce about a 0.2% AEP flood. On current projections, the increase in rainfalls within the design life of the project is likely to be around 10 per cent, with the higher value of 30 per cent representing an upper limit.

Based on the recommendations set out in DECC 2007, the 0.5% AEP and 0.2% AEP design storms were adopted as being analogous to an increase in 1% AEP design rainfall intensities of 10 and 30 per cent respectively. This range of potential increases also encompasses the values given in ARR 2019, which suggests a potential increase in rainfall intensities of between 9.2% and 20.2% by 2090 for Representative Concentration Pathways (RCPs) of between 4.5 and 8.5.

2.2.5 Local Flood Plan

NSW SES has prepared local flood plans for both the Hay Shire and Edward River Local Government Areas (LGAs). Both the *Hay Shire Local Flood Plan* (NSW SES, 2014) and the *Edwards River Local Flood Emergency Sub Plan* (NSW SES, 2023) provide a plan for the operation of emergency response to flooding within the two LGAs. The two documents set out the preparedness measures, the process for carrying out response operations and the coordination of immediate recovery measures from flooding.

The *Hay Shire Local Flood Plan* also includes a brief overview of the existing flood risk within the respective local government area. While the *Hay Shire Local Flood Plan* includes information relating to predicted flood behaviour at Hay based on flood modelling that was undertaken as part of the *Hay Town Levees – Hydraulic Assessment* (WMAwater, 2009), updated flood modelling was recently completed as part of Lyall & Associates, 2023a.

2.3 Council policies and guidelines

2.3.1 Local environmental plans

As mentioned, the project is located within the local government areas of Hay Shire Council. The *Hay Local Environmental Plan 2011* (Hay LEP 2011) contains flood planning clauses that apply to the determination of a Part 4 development application by a consent authority under the EP&A Act. While not a mandatory requirement of the project under the EP&A Act, the flood planning clause in the Hay LEP 2011 has been taken into consideration in establishing the approach to assessing the impact of the project on flood behaviour.

Clause 5.21 of the Hay LEP 2011 titled 'Flood planning" state the following:

"(1) The objectives of this clause are as follows -

(a) to minimise the flood risk to life and property associated with the use of land,

(b) to allow development on land that is compatible with the flood function and behaviour on the land, taking into account projected changes as a result of climate change,

(c) to avoid adverse or cumulative impacts on flood behaviour and the environment,

(d) to enable the safe occupation and efficient evacuation of people in the event of a flood.

(2) Development consent must not be granted to development on land the consent authority considers to be within the flood planning area unless the consent authority is satisfied the development -

(a) is compatible with the flood function and behaviour on the land, and

(b) will not adversely affect flood behaviour in a way that results in detrimental increases in the potential flood affectation of other development or properties, and

(c) will not adversely affect the safe occupation and efficient evacuation of people or exceed the capacity of existing evacuation routes for the surrounding area in the event of a flood, and

(d) incorporates appropriate measures to manage risk to life in the event of a flood, and

(e) will not adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses.

(3) In deciding whether to grant development consent on land to which this clause applies, the consent authority must consider the following matters -

(a) the impact of the development on projected changes to flood behaviour as a result of climate change,

(b) the intended design and scale of buildings resulting from the development,

(c) whether the development incorporates measures to minimise the risk to life and ensure the safe evacuation of people in the event of a flood,

(d) the potential to modify, relocate or remove buildings resulting from development if the surrounding area is impacted by flooding or coastal erosion.

(4) A word or expression used in this clause has the same meaning as it has in the Considering Flooding in Land Use Planning Guideline unless it is otherwise defined in this clause.

(5) In this clause -

***Considering Flooding in Land Use Planning Guideline** means the Considering Flooding in Land Use Planning Guideline published on the Department's website on 14 July 2021.*

***flood planning area** has the same meaning as it has in the Floodplain Development Manual.*

***Floodplain Development Manual** means the Floodplain Development Manual (ISBN 0 7347 5476 0) published by the NSW Government in April 2005."*

In May 2021, the NSW Government issued the Standard Instrument (Local Environmental Plans) Amendment (Flood Planning) Order 2021 that sets out changes to the flood planning clauses of the Local Environmental Plans of the respective councils that took effect on 14 July 2021. The updates to the above flood planning clauses under the Standard Instrument (Local Environmental Plans) Amendment (Flood Planning) Order 2021 are aimed at supporting better management of flood risk and building greater resilience in communities located on floodplains during floods greater than 1% AEP up to the Extreme Flood/PMF. The assessment that is presented in this report has taken into consideration floods larger than the 1% AEP event, up to the Extreme Flood/PMF and is therefore considered to be consistent with the updates to clause 5.21.

Hay Shire Council has prepared a Development Control Plan (DCP) to guide development in accordance with Hay LEP 2011. As with the flood planning clause in Hay LEP 2011, the requirements set in the DCP are not applicable to the project under the EP&A Act. However, the flood related requirements of the DCP have been taken into consideration in establishing the approach to assessing the impact of the project on existing flood behaviour.

3 METHODOLOGY

This chapter describes the methodology that was used to undertake the flooding assessment.

3.1 Key tasks

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

- review of available data and existing flood studies of the catchments within which the project is located;
- update and expand the existing set of hydrologic (rainfall-on-grid) and riverine hydraulic models (collectively referred to as 'flood models') of the catchments that are located within the study area;
- flood modelling and preparation of exhibits showing flood behaviour under present day (i.e. pre-project) conditions for design floods with AEPs of 5%, 1%, 0.5% and 0.2%, as well as the Extreme Flood/PMF;
- assessment of the potential impact of the project (both during its construction and operation) on flood behaviour for the aforementioned design flood events;
- assessment of the impact future climate change would have on flood behaviour under operational conditions; and
- assessment of potential measures that are aimed at mitigating the risk of flooding to the project and its impact on existing flood behaviour.

The following sections of this technical paper set out the methodology which was adopted in the assessment of flood behaviour under pre-project conditions, and during both the construction and operational phases of the project.

3.2 Summary of adopted assessment criteria and standards

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

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

Table 3.1
SUMMARY OF ADOPTED ASSESSMENT CRITERIA AND STANDARDS

Aspect	Requirement
Flood risks to the project	
Impact of flooding on proposed construction activities	• Construction related flood risks need to be evaluated in the context of the construction period to set requirements that are commensurate to the period of time that the risk exposure occurs. To this end, this report identifies the risks associated with each construction activity such that informed decisions can be made on the flood criteria that are set as part of the Construction Environmental Management Plan (CEMP) for the project.
Upgrade and construction of existing roads	• As a minimum, the construction of access tracks and any potential upgrade of the existing roads that service the project is to ensure that the existing level of flood immunity is not reduced by the project.
Impact of future climate change on flooding to the project	• The assessment of the potential impact future climate change could have on flood behaviour in the vicinity of the project was based on increases in 1% AEP design rainfall intensities ranging between 10 and 30 per cent in accordance with the NSW Government's Floodplain Risk Management Guideline: Practical Considerations of Climate Change (DECC 2007).[1] • Due to the elevation of the land on which the project is located, a rise in sea level due to future climate change is not relevant to the flood assessment.
Impact of the project on flood behaviour	
Impact of construction activities on flood behaviour	• Construction related flood impacts are to be evaluated in the context of the construction period to set requirements that are commensurate to the period of time that the exposure to the potential impacts occurs. To this end, this report identifies the potential impacts associated with the project such that informed decisions can be made on the flood criteria that are set as part of the CEMP.
Impact of project on existing flood behaviour	• Floods up to 1% AEP in magnitude are to be considered in the assessment of measures that are required to mitigate any adverse impacts of the project on existing flood behaviour as a result of changes in the depth, velocity, extent or duration of flooding. • Changes in flood behaviour for larger floods up to the Extreme Flood/PMF event are also to be assessed to identify impacts on critical infrastructure (such as hospitals, police stations and NSW State Emergency Services headquarters) and vulnerable development (such as aged care facilities and schools), as well as to identify potentially significant changes in flood hazard as a result of the project.
Impact of the project on flood behaviour under future climate change conditions	• The assessment of the impact the project would have on flood behaviour under future climate change conditions was based on assessing its effect on pre-project flood behaviour during a 0.5% and 0.2% AEP event.[1]

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

3.3 Definition of flood behaviour under pre-project conditions

3.3.1 General

To define the nature of flooding across the study area, a flood model was developed covering The Plains Wind Farm project area. The project area is situated a minimum distance of 11.8 kilometres south of the Murrumbidgee River, with smaller creeks and waterways providing drainage of the southern Murrumbidgee River floodplain including the project area. Flooding of the project area occurs due to the following hydrologic conditions:

- riverine type flooding, which occurs when flow originating from up-river surcharges the banks of the Murrumbidgee River in the vicinity of the project area; and
- local catchment type flooding, which occurs when heavy and/or prolonged rain falls over the catchments which feed the usually dry (non-perennial) streams which run through and adjacent to the project area.

To investigate flood risk in the project area from both riverine and local catchment type flooding, it was necessary to develop two separate hydraulic (TUFLOW) models as part of the present study.

The TUFLOW model that was developed to define the nature of riverine type flooding in the vicinity of the project area (Murrumbidgee River TUFLOW Model) was based on three models that have been developed as part of the following studies:

- *Hay and Maude Flood Study* (Lyall & Associates, 2023a), which extended from a location a short distance to the east (upstream) of Hay to a location about 19 kilometres west (downstream) of Maude.
- *Murrumbidgee River at Darlington Point and Environs Flood Study* (BMT, 2018), which extended a short distance to the east (upstream) and west (downstream) of Darlington Point.
- *Narrandera Flood Study Review and Levee Options Assessment* (Lyall & Associates, 2015), which extended from a short distance to the east (upstream) of Narrandera to a location a short distance to the east (upstream) of Darlington Point.

As the primary objective of the three models was to define the nature of riverine type flooding in the immediate vicinity of the townships of Narrandera, Darlington Point, Hay and Maude, it was necessary to stitch them together and to also extend the combined two-dimensional model domain further to the north and south. **Section 3.3.2** of this report provides further background to the development of the Murrumbidgee River TUFLOW Model.

The TUFLOW model that was developed to define the nature of local catchment type flooding in the vicinity of the project area was unique to the present study and only covered the catchments which are directly connected to the usually dry (non-perennial) streams which run through and adjacent to the project area (Local Catchment TUFLOW Model). **Section 3.3.3** of this report provides further background to the development of the Local Catchment TUFLOW Model.

3.3.2 Murrumbidgee River TUFLOW Model

The Murrumbidgee River TUFLOW Model extends across about 21,400 square kilometres and is centred around the Murrumbidgee River and the adjacent floodplains to the north and south, inclusive of the project area. The layout of the Murrumbidgee River TUFLOW Model is shown in **Figure A1** (3 sheets).

The upstream boundary of the Murrumbidgee River TUFLOW Model is situated a short distance upstream of the township of Narrandera, while its downstream boundaries are located both on the Murrumbidgee River west of Maude, and on the minor tributaries and ephemeral streams which drain to its north and south.

The two-dimensional model domain utilised publicly available LiDAR survey topography data which were captured over the period February 2014 to May 2021, and supplemented by photogrammetric survey data that were captured over the period December 2011 to October 2017. Additionally, LiDAR survey of The Plains Renewable Wind Farm project area was commissioned by Engie in February 2023 using aerial photogrammetry on a one metre grid resolution.

The Murrumbidgee River TUFLOW Model comprises a parent grid with a resolution of 200 metres x 200 metres with nested grids with a resolution of 50 metres x 50 metres along the 400 kilometre reach of the Murrumbidgee River between Narrandera and the Downstream Hay Weir stream gauge and 12.5 metres x 12.5 metres along sections of the Cobb Highway, Sturt Highway and Kidman Way. The sub-grid sampling modelling approach was also incorporated in the Murrumbidgee River TUFLOW model, which resulted in a sub-grid sample size of between 20 metres and 1.25 metres.

The inbank area of the Murrumbidgee River was represented as a one-dimensional channel between Darlington Point and the downstream boundary of the model, the cross sections of which were taken from either the respective individual models or were derived from bathymetric survey which was commissioned by DPEWater (DPEW). The inbank area of the Murrumbidgee River upstream of Darlington Point was incorporated in the two-dimensional model domain which is consistent with the approach adopted by Lyall & Associates, 2015.

The main physical parameter in TUFLOW is hydraulic roughness, which is required to represent each of the surfaces comprising the inbank areas of watercourses and overland flow paths in the two-dimensional domain. In addition to the energy lost by bed friction, obstructions to flow also dissipate energy by forcing water to change direction and velocity, and by forming eddies. Hydraulic modelling traditionally represents all of these effects via the surface roughness parameter known as “Manning’s n”. Hydraulic roughness values adopted for design purposes were selected based on site inspection, past experience and values contained in the engineering literature (refer **Table 3.2**) over the page.

Major bridge crossings of the Murrumbidgee River at Darlington Point, Hay and Maude were incorporated into the model as one-dimensional bridge elements. The cross-sectional area of the bridges at Hay and Maude were defined by survey data and design drawings, respectively, while the hydraulic losses associated with the bridge piers were derived based on the procedures set out in Austroads (1994).

The alignment and dimensions of the piped elements beneath the roads and railway lines that are located on the broader Murrumbidgee River floodplain were taken from data that were provided by Council, Transport for NSW and the rail operators, while the inverts were derived using the available LiDAR survey data.

The Murrumbidgee River TUFLOW Model was calibrated to the major flood that occurred over the months of October, November and December in 2022, recorded rainfall, river water levels and rating-curve-derived discharge hydrographs for which are shown on **Figure A2**.

The inflow hydrograph to the Murrumbidgee River TUFLOW Model comprised the rating-curve derived discharge hydrograph associated with WaterNSW's *Murrumbidgee River at Narrandera* stream gauge.

TABLE 3.2
"BEST ESTIMATE" OF HYDRAULIC ROUGHNESS VALUES
MURRUMBIDGEE RIVER TUFLOW MODEL

Reach of Murrumbidgee River	Surface Treatment	Manning's n Value
Upstream of Darlington Point	Bed of Murrumbidgee River	0.03
	Mildly dense vegetation	0.06
	Dense Vegetation	0.08
	Highly Dense Vegetation	0.10
	Densely vegetated riparian corridor	0.20
Downstream of Darlington Point	Reinforced concrete pipes and box culverts	0.015
	Asphalt or concrete road surface	0.02
	Standing water bodies (dams, billabongs etc.)	0.04
	Bed of Murrumbidgee River	0.045
	Bare earth / cleared or maintained section of floodplain	0.05
	Allotments in urban centres	0.05
	General floodplain roughness	0.055
	Mildly dense vegetation	0.12
	Dense Vegetation	0.16
	Highly Dense Vegetation	0.18
	Densely vegetated riparian corridor	0.20
	Banks of Murrumbidgee River	0.20

Figure A2 shows that the Murrumbidgee River TUFLOW Model, once calibrated, was able to reproduce the stage and rating-curve derived discharge hydrographs for the various stream gauges that are located along the modelled reach of the river. **Figure A3** (2 sheets) shows the indicate extent and depth of inundation generated by the Murrumbidgee River TUFLOW Model for the October-December 2022 flood event.

Flood behaviour in the vicinity of the project area was defined for a range of design flood events with AEPs of between 5% and 0.2%, as well as the Extreme Flood, the discharge hydrographs for which were taken from Lyall & Associates, 2015.

Figures were prepared for each event showing the indicative extent and depth of inundation. Figures were also prepared showing the hydraulic and hazard categorisation during a 1% AEP event, which were defined based on industry best practice and the procedures set out in the FRMM.

3.3.3 Local Catchment TUFLOW Model

The Local Catchment TUFLOW Model extends across an area of about 12,400 square kilometres to the south of the Murrumbidgee River, inclusive of the project area. The layout of the Local Catchment TUFLOW Model is shown in **Figure A4**.

Natural surface levels in the Local Catchment TUFLOW Model are based on the same LiDAR and photogrammetric based data as incorporated in the Murrumbidgee River TUFLOW Model. The Local Catchment TUFLOW Model comprises a parent grid with a resolution of 200 metres x 200 metres with nested grids with a resolution of 50 metres x 50 metres covering an area of about 1,100 square kilometres in the immediate vicinity of the project area and 12.5 metres x 12.5 metres along sections of the Cobb Highway, Sturt Highway and Kidman Way. The sub-grid sampling modelling approach was also incorporated in the Local Catchment TUFLOW Model, which resulted in a sub-grid sample size of between 20 metres and 5 metres.

To define the nature of flooding resulting from localised rainfall events, a hydrologic modelling approach was required to be capable of simulating catchment runoff and surface water flows in waterways within and surrounding the project area. The 'rainfall-on-grid' approach that is built into the TUFLOW software was used for this purpose.

The 'rainfall-on-grid' approach involves the application of rainfall excess (obtained from applying losses to design rainfall depths) to the two-dimensional domain of the model. The routing of runoff (rainfall excess) is then simulated across each grid cell within the model. The use of a two-dimensional hydraulic model in this way integrates both the hydrologic and hydraulic modelling aspects of defining flood behaviour into a single model.

Rainfall depths for design storms with AEPs of 5%, 1%, 0.5% and 0.2% were obtained from the Bureau of Meteorology (BoM) website. These were then applied to the Local Catchment TUFLOW Model using the procedures outlined in ARR 2019 for storm durations ranging between 30 minutes and 7 days.

Estimates of Probable Maximum Precipitation (PMP) were derived using the Generalised Short Duration Method (GSDM) as described in *The Estimation of Probable Maximum Precipitation in Australia: Generalised Short-Duration Method* (BoM, 2003). This method is recommended in ARR 2019 for the estimation of extreme rainfall depths for catchments up to 1,000 square kilometres in area and storm durations up to six hours.

Adopted values for initial and continuing loss were derived using the procedures set out in ARR 2019. As the catchments draining to the project are predominantly pervious in nature, the storm losses derived using the procedures in ARR 2019 for pervious surfaces were applied to the full extent of the TUFLOW models.

3.4 Assessment of construction related impacts

A qualitative assessment was made of the construction related issues associated with flooding based on indicative construction areas and activities. The various elements of the project were overlaid onto the indicative flood extents for events with AEPs of 5% and 1%, as well as the Extreme Flood/PMF. This provided an understanding of the likelihood that flooding could occur in the vicinity of construction activities.

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

Section 5 of this report deals with the impact that flooding could have on construction activities. It also includes an assessment of the impact that construction activities could have on flood behaviour external to the project area.

3.5 Assessment of operational related impacts

Commensurate with the potential flood impacts, as well as the current level of design development, a qualitative assessment has been carried out of the potential flood related impacts based on an understanding of existing flood behaviour, as well as the general nature of the proposed operational works.

Section 6.1 of this report deals with the impact that flooding could have on the project, as well as the potential impact that it could have on flood behaviour during its operation.

3.6 Impact of future climate change on flood behaviour

3.6.1 Impact of future climate change on flooding to the project

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

- Scenario 1 – based on an assumed 10 per cent increase in currently adopted 1% AEP design rainfall intensities.
- Scenario 2 – based on an assumed 30 per cent increase in currently adopted 1% AEP design rainfall intensities.

The findings of this assessment are contained in **Section 6.3** of this technical paper.

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

The predicted impact that the project may have on flood behaviour under potential future climate change conditions was based on assessing its effect on pre-project flood behaviour during a 0.5% and 0.2% AEP event as proxies for assessing the sensitivity to an increase in rainfall intensity on the 1% AEP event due to future climate change. The findings of this assessment are contained in **Section 6.3** of this technical paper.

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

4 EXISTING ENVIRONMENT

4.1 Catchment description

The project area is located to the south of the Murrumbidgee River and the township of Hay in an area referred to as the Hay Plains. A series of waterways drain in generally a south-westerly direction to the south of the river, which includes the project area. **Figure 4.1** shows the various waterways that comprise the existing drainage system in the vicinity of the project area.

The Murrumbidgee River has a catchment area of about 84,000 square kilometres and contains several sites of international significance, including the Lowbidgee Wetlands and Fivebough and Wuckerbil Swamps which are each over 100 km to the west and east of the project area, respectively (MDBA, 2021). The Murrumbidgee River is subject to large flood events in which significant overbank flows can occur, including bifurcation of flows into adjacent waterways which can convey floodwaters into adjacent catchments and/or reconnect with the main Murrumbidgee River. Yanco Creek and Coleambally Outfall Drain, for example, convey floodwaters from the Murrumbidgee River to Billabong Creek, and ultimately the Edwards River during major flood events. Conversely, Gum Creek allows floodwaters to bypass the Murrumbidgee River at Carrathool, bifurcating from the main channel downstream of Darlington Point, and reconnecting with the Murrumbidgee River upstream of Hay.

There are several waterways which lie adjacent to and traverse the project area. These waterways provide drainage of the floodplain south of the Murrumbidgee River. These waterways are typically dry (non-perennial) during average conditions, only carrying water during periods of high rainfall. Identified major waterways within the project area include Telegraph Creek, Abercrombie Creek, Curtains Creek and Eurolie Creek. The proposed wind turbine and internal electrical line and transmission line infrastructure crosses waterways situated within the project area at multiple locations.

The Cobb Highway is a single carriageway road which bisects the project area, connecting from Hay in the north, to Deniliquin in the south. The main wind farm infrastructure is located either side of the Cobb Highway for a 29.7 km length of the Highway, with multiple access points to the project area situated along this length. The Cobb Highway passes over several non-perennial waterways, with bridges and culverts providing drainage beneath the roadway. The roadway surface is generally situated approximately 0.5 metres above the surrounding topography.

4.2 Project area

The project area is situated a minimum distance of 11.8 kilometres south of the Murrumbidgee River within the local region called Hay Plains. The Hay Plains in the vicinity of the project area is characterised by relatively flat terrain (approx. 0.036% gradient sloping east to west) resulting in the relative slow movement of water, whereby the inundation of normally dry land can often last for several months (SES, 2014).

The existing land uses across the project area are for irrigated cropping and pasture, with large pockets of farmland, isolated buildings/sheds and unsealed roads (Aurecon, 2021). The project area is situated on Mungadal Station, which is a large-scale sheep property specialising in Merino Sheep and wool production (ERM, 2022).

The area is characterised by extensive floodplains and is often dominated by shrublands and grasslands (ERM, 2022). The climate is semiarid with low, winter dominated rainfall, hot summers and cool winters (ERM, 2022). ERM, 2022 notes that the project area is largely dominated by cracking clay soils, which display strong cracking when dry, and shrink and swell significantly during wetting and drying phases.

4.3 Description of existing flood behaviour

The following sections of this technical paper provide a brief description of patterns of both riverine and local catchment type flooding in the vicinity of the project area under present day (i.e., pre-project) conditions. The following figures are also referred to in the following discussion:

- **Figures 4.2** (2 sheets), **4.3** and **4.4** (6 sheets each) show the indicative extent and depth of inundation velocities in the vicinity of the project resulting from Murrumbidgee River floods with AEPs of 5% and 1%, as well as the Extreme Flood.
- **Figures 4.5**, **4.6** and **4.7** (6 sheets each) show the indicative extent and depth of inundation velocities in the vicinity of the project resulting from local catchment floods with AEPs of 5% and 1%, as well as the PMF.
- **Appendix B** contains figures showing the indicative extent and depth of inundation velocities in the vicinity of the project resulting from Murrumbidgee River floods with AEPs of 0.5% and 0.2%.
- **Appendix C** contains figures showing the indicative extent and depth of inundation velocities in the vicinity of the project resulting from local catchment floods with AEPs of 0.5% and 0.2%.
- **Appendix D** contains figures showing maximum flow velocities in the vicinity of the project resulting from Murrumbidgee River floods with AEPs of 5% and 1%, as well as the Extreme Flood.
- **Appendix E** contains figures showing maximum flow velocities in the vicinity of the project resulting from local catchment floods with AEPs of 5% and 1%, as well as the PMF.
- **Appendix F** contains figures showing the hydraulic categorisation and flood hazard vulnerability classification of the floodplain in the vicinity of the project for a 1% AEP Murrumbidgee River flood event.
- **Appendix G** contains figures showing the hydraulic categorisation and flood hazard vulnerability classification of the floodplain in the vicinity of the project for a 1% AEP local catchment flood event.

Flood behaviour has been defined using the hydrologic and hydraulic models that are described in **Section 3.3**.

4.3.1 Murrumbidgee River flood events

5% AEP

Figure 4.2 (2 sheets) shows the indicative extent and depth of inundation under pre-project conditions across the project area, while **Figure D1** shows the corresponding maximum flow velocities during a 5% AEP Murrumbidgee River flood event.

Floodwaters experience some bifurcation from the main Murrumbidgee River to connected waterways which flow south-west across the Hay Plains, south of the project area. Coleambally Outfall Drain conveys some riverine floodwaters approximately 10 kilometres south of the project area. The project area itself is not impacted by floodwater which originates from the Murrumbidgee River during a 5% AEP event.**1% AEP**.

Figure 4.3 (2 sheets) shows the indicative extent and depth of inundation under pre-project conditions across the project area, while **Figure D2** shows the corresponding maximum flow velocities during a 1% AEP Murrumbidgee River flood event.

Floodwater originating from the Murrumbidgee River bifurcates upstream of Darlington Point where it is conveyed to the east and south of the project area via several waterways, the nearest in proximity being Eurolie Creek and Nyangay Creek.

Extreme Flood

Figure 4.4 (6 sheets) shows the indicative extent and depth of inundation under pre-project conditions across the project area, while **Figure D3** shows the corresponding maximum flow velocities for the Extreme Flood.

During the Extreme Flood, depths of flow would occur through the local drainage lines and across the Hay Plains area. While widespread flooding of the project area is not predicted to occur during an Extreme Flood on the Murrumbidgee River, flow would be experienced in Telegraph Creek, Abercrombie Creek, Curtains Creek, Eurolie Creek and Nyangay Creek to maximum depths of about 2.2 metres and velocity of about 0.3-0.4 metres per second.

4.3.2 Local catchment flood events

5% AEP

Figure 4.5 (6 sheets) shows the indicative extent and depth of inundation under pre-project conditions across the project area, while **Figure E1** (5 sheets) shows the corresponding maximum flow velocities during a 5% AEP local catchment flood event.

While the project area depths of flow occur in local drainage lines of 1.0-1.5 metres with corresponding velocity of about 0.2–0.3 metres per second, shallow ponding of surface waters is shown to occur to depths of up to about 0.25 metres. Existing unsealed roads are also inundated to depths of between about 0.2-0.3 metres on the floodplain, with existing roads which cross major waterways inundated to depths of 1.0 metres at several locations. Maximum depths are experienced in existing water storages within the project area and upstream (i.e. east) of the Cobb Highway before flowing through culverts beneath the roadway.

Direct catchment rainfall flows through local drainage lines, including via Telegraph Creek, Abercrombie Creek, Curtains Creek and Eurolie Creek. Depths of flow of about 0.8 metres with corresponding flow velocity of about 0.2-0.3 metres per second are experienced where these creeks run through the project area.

Standing surface water is predicted across the wider project area, including beneath the proposed transmission line corridor and wind turbines at numerous locations at depths of approximately 0.2–0.3 metres. Standing water of similar depths is predicted within the area five kilometres east of the Cobb Highway.

1% AEP

Figure 4.6 (6 sheets) shows the indicative extent and depth of inundation under pre-project conditions across the project area, while **Figure E2** (5 sheets) shows the corresponding maximum flow velocities during a 1% AEP local catchment flood event.

While the project area and substation infrastructure are generally impacted by local catchment flooding during a 1% AEP local catchment flood at a similar extent as during a 5% AEP local catchment event, depths of flow in local drainage lines are increased and the depth and extent of shallow ponding of surface waters increases a nominal amount. Local ponding of surface water is also expected across the wider project area. Existing roads and proposed access tracks on the floodplain experience inundation at depths of up to approximately 0.5 metres.

PMF

Figure 4.7 (6 sheets) shows the indicative extent and depth of inundation under pre-project conditions across the project area, while **Figure E3** (5 sheets) shows the corresponding maximum flow velocities during a PMF local catchment flood event.

Widespread flooding across the wider Hay Plains area is predicted during the PMF local catchment flood event, with all local drainage lines conveying flow at depth. The Cobb Highway presents as a barrier to overland flow, with extensive aggregation of surface waters predicted on the eastern side of the highway.

4.4 Hydraulic Categorisation of Floodplain During 1% AEP Flood Events

According to the FRMM, 2023, the floodplain may be sub-divided into the following three hydraulic categories:

- Floodways;
- Flood storage; and
- Flood fringe.

Floodways are generally areas which convey a significant portion of water during floods and are particularly sensitive to changes that impact flow conveyance. They often align with naturally defined channels.

Flood storage areas are areas outside of floodways, are generally areas that store a significant proportion of the volume of water and where flood behaviour is sensitive to changes that impact on the storage of water during a flood.

Flood fringe areas are areas within the extent of flooding for the event, but which are outside floodways and flood storage areas. Flood fringe areas are not sensitive to changes in either flow conveyance or storage.

Flood Risk Management Guideline FB02 – Flood Function, offers guidance in relation to three alternative procedures for identifying floodways. They are:

- **Indicator techniques**, which rely on physical and hydraulic properties to indicate the location of floodways.
- **Encroachment techniques**, which involve a trial-and-error approach and can be used to identify floodways in one-dimensional (1D) model, or to check and refine floodways in a two-dimensional (2D) model that have been estimated using another technique.

- **Conveyance techniques**, which are the most robust option for identifying floodways because they determine the relative contribution of parts of the floodplain to flow conveyance.

Given the limited nature to which concentrated flow impacts the project area, a modified version of the indicator method that is presented in *Howells et al, 2004* was adopted as the basis of defining the location of floodways. *Howells et al, 2004* recommended defining the floodway based on the following criteria:

- Velocity x Depth greater than 0.25 square metres per second **and** Velocity greater than 0.25 metres per second; or
- Velocity greater than 1 metre per second.

Lyall & Associates, 2023a found that the above criteria were not suitable at Hay and Maude due to the relatively flat flood slope (generally about 0.00014 metres per metre) which results in flow velocities substantially lower than 0.25 metres per second on the overbank area of the river. As such, the floodway was defined as areas where the Velocity x Depth product was greater than 0.1 square metres per second for Murrumbidgee River flood events.

While FDMM, 2023 provides guidance on the identification of flood storage areas, a similar approach to that adopted as part of Lyall & Associates, 2023a has been adopted as part of the present investigation, whereby flood storage areas have been identified as those areas which do not operate as floodways but where the depth of inundation exceeds 0.3 metres.

Hydraulic categorisation mapping for the project area during a 1% AEP Murrumbidgee River flood event is presented in **Figure F1**. As noted in **Section 4.3.1**, flooding from a 1% AEP Murrumbidgee River flood event does not interact with the project area.

Hydraulic categorisation mapping for the project area during a 1% AEP local catchment flood event is presented in **Figure G1** (5 sheets). As noted in **Section 4.3.2**, local waterways convey surface water runoff during significant local catchment rainfall events, with shallow ponding of surface water in the project area.

Floodways are confined to the main channels of Telegraph Creek, Abercrombie Creek, Curtains Creek and Eurolie Creek where the waterways run through the project area. The floodway of Telegraph Creek crosses the alignment of internal transmission line with the floodway shown to cross the alignment of access tracks and the proposed 33kV overhead cable at several locations. Abercrombie Creek similarly crosses access tracks and overhead cable at several locations. The Curtains Creek floodway is shown to cross the proposed 330kV overhead cable at two locations, while the Eurolie Creek floodway lies to the east of the proposed wind farm infrastructure.

While flood storage and flood fringe areas are present across the project area, wind farm infrastructure is generally limited to areas that are affected by the latter.

4.5 Flood Hazard During 1% AEP Flood Events

The flood hazard vulnerability classification is a function of water depth and velocity (hazard = depth*velocity) and has a classification scale ranging from H1 to H6. A lower hazard classification (i.e. H1) relates to a lower flood hazard for vehicles, people and buildings, whilst a higher classification (i.e. H6) relates to and increased flood hazard.

Flood hazard vulnerability classification mapping for the project area during a 1% AEP Murrumbidgee River flood event is presented in **Figure F2**. As noted in **Section 4.3.1**, flooding from a 1% AEP Murrumbidgee River flood event only effects the eastern portion of the project area remote from any proposed wind farm infrastructure, with floodwater principally conveyed by waterways that are situated to its east and south. The corresponding flood hazard within these waterways ranges between H1 (generally safe for vehicles, people and buildings) and H4 (unsafe for vehicles and people).

Flood hazard vulnerability classification mapping for the project area during a 1% AEP local catchment flood event is presented in **Figure G2** (5 sheets). As noted in **Section 4.3.2,** local waterways convey surface water runoff during significant local catchment rainfall events, with shallow ponding of surface water across the project area. The resulting flood hazard on the floodplain within the project area is generally classified as H1 (generally safe for vehicles, people and buildings) to H2 (unsafe for small vehicles) due to the shallow depths and slow surface water velocities, aligning with flood storage areas. Local drainage lines which align with floodway areas are generally classified as H3 (unsafe for vehicles, children and the elderly) with H4 (unsafe for vehicles and people) identified in some sections of major waterways. Two areas within the project area are classified as H5 due to the deeper water depths at these locations. Access tracks and underground and overhead lines cross waterways classified as H3 and H4, which is unsafe for vehicles and people.

4.6 Flood Planning Area

The Flood Planning Area (FPA) in the vicinity of the project area was defined as land which lies below the 1% AEP flood level (based on the higher of either Murrumbidgee River or local catchment flooding) plus 0.5 metres of freeboard (defined as the Flood Planning Level (**FPL**)). By inspection of **Figure 4.8** the majority of The Plains Wind Farm and more specifically the project area are located on land which lies below the FPL.

5 CONSTRUCTION IMPACT ASSESSMENT

5.1 General

This chapter provides an assessment of the flood risk associated with the construction of the project, as well as an overview of the potential impacts that the proposed construction activities could have on flood behaviour.

Currently, detailed design and construction planning has not been completed. It is therefore not possible to comment on the flood risk on construction related activities in detail. However, there is no proposed change to the floodplain landform or waterways which would result in a change (increase or decrease) to present day flood behaviour. This includes no increases to the flood risk of other properties, assets or infrastructure.

5.2 Potential flood risks at construction work areas

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

- cause damage to the proposed works and delays in construction programming
- pose a safety risk to construction workers
- detrimentally impact the downstream waterways through the transport of sediments and construction materials by floodwater
- obstruct the passage of floodwater and overland flow, which in turn could exacerbate flooding conditions in areas located outside the construction footprint.

Construction facilities

Temporary construction facilities that would be required to support the construction of the project would include:

- a main construction compound
- construction infrastructure including concrete batch plants
- worker accommodation

The construction compounds and support facilities would include offices, staff amenities, parking, as well as areas to store plant, equipment, materials, waste and potable water tanks. Secure perimeter fencing would be provided around each construction ancillary facility.

While none of the construction compound or accommodation locations that have been identified are affected by either Murrumbidgee River or local catchment flooding, shallow surface water ponding may occur during localised rainfall events.

Earthworks

Earthworks would be required across all the construction work areas to construct the project, which would include:

- the construction of hardstands at wind generator locations
- earthworks to establish laydown areas for turbines
- the construction of pads at switching stations and ancillary infrastructure locations

- the construction of access tracks and associated drainage infrastructure along the transmission line corridor
- the installation of underground and overhead cabling
- road upgrades required for the transport haul route
- the installation of working platforms for piling machinery to install the footings for transmission line towers and for brake and winch machinery for stringing the transmission line
- the sourcing of material from onsite quarries.

While the impact of Murrumbidgee River flooding during a 1% AEP event on wind farm infrastructure is limited to localised areas, inundation from local catchment flooding would result in flow at depth in major waterways, and widespread ponding of surface waters across the wider project area. Flows and ponding during local catchment events would interact with wind farm infrastructure, namely access tracks. As many areas of the project area would intercept identified floodways, flood storage and flood fringe areas, there is potential for construction works associated with the wind farm to be impacted by floodwater, potentially resulting in damage to plant and equipment, as well as increased sediment load due to scour of disturbed surfaces.

Internal transmission line construction

A network of 33 kV overhead and underground cables connect the wind turbines to two lengths of 330 kV overhead transmission line. The construction of the internal overhead transmission lines comprising the 33 kV and 330 kV networks would typically involve the construction of tower footings, erection of the towers and then the stringing of the transmission lines between each tower.

Temporary access tracks would be required to move machinery to each tower location, while working platforms would be required to support piling rigs and cranes to construct tower footings and erect the towers. Working platforms would also be required to support the brake and winch machinery that would be required to string the transmission lines.

As mentioned, the 33 kV overhead cable traverse the site, crossing Telegraph Creek, Abercrombie Creek and Curtains Creek which convey floodwaters during local catchment flood events, and extreme riverine based flood events. The final location of support towers should consider the position of support towers in relation to the inbank area of major waterways.

Where alternative access routes are impractical, the temporary access tracks may need to cross the watercourse in areas that would be infrequently inundated by flow. Where required, it may be necessary to design and construct the temporary access tracks to manage the potential for scour and transport of material into Telegraph Creek, Abercombie Creek and Curtains Creek, whilst also maintaining a passage for the conveyance of floodwater through the construction sites.

Wind turbine footing and hardstand construction

Wind turbines will be fixed to concrete footings with an associated hardstand and laydown area required at each turbine location to facilitate erection of the turbine towers. As mentioned, numerous turbine locations and hardstand blocks are situated in or near flood fringe areas. Turbines situated in or near flood fringe areas may be subject to floodwaters during local catchment flood events, and extreme riverine based flood events. Flooding of construction sites may occur resulting in sediment transport and exposure of machinery to floodwaters.

Access tracks

The network of wind turbines and ancillary infrastructure is connected via access tracks which will be required for construction and ongoing maintenance. These access tracks traverse the project area and cross major waterways at numerous locations and may therefore be subject to depths of flow during local catchment flood events and extreme riverine based flood events. There is therefore potential for vehicles, machinery and construction workers to be exposed to flood hazards during flood events, as well as the stranding of personnel and machinery during events.

5.3 Potential impacts of construction activities on flood behaviour

As the project does not propose to alter the landform of the floodplain, there is unlikely to be measurable changes in flood levels or flood behaviour as a result of the project construction activities.

The construction of access tracks and roads may result in localised ponding of floodwaters and altered drainage pathways adjacent to the constructed tracks. However, broadscale flood behaviour is unlikely to be impacted.

6 OPERATIONAL IMPACT ASSESSMENT

This section provides an assessment of the flood risk to the project, as well as the impact it could have on flood behaviour during operation if appropriate mitigation measures are not incorporated into its design. The findings of an assessment into the potential impact of future climate change on flood behaviour under operational conditions are also presented.

6.1 Potential flood risk to the project and its impact on flood behaviour

As the amended project does not propose to alter the landform of the floodplain, there would be no measurable changes in flood levels or flood behaviour as a result of the project.

While the positioning of the wind farm infrastructure is unlikely to influence flood levels or velocities in the waterway due to the relatively small sectional area of the infrastructure, several elements of the project would be subject to relatively shallow inundation during local catchment flood events and extreme river based flood events (for example, the proposed switching station is located in an area that would be inundated during local catchment floods as frequent as 5% AEP, as well as an extreme flood on the Murrumbidgee River). Deeper, faster moving floodwater would also be experienced at the location where access tracks cross the defined waterways of Telegraph Creek and Abercrombie Creek.

While the vertical alignment and transverse drainage requirements for the new access tracks have yet to be determined, it may be necessary to consider a minimum hydrologic standard of 10% AEP to permit access to the key elements of the project during relatively frequent local catchment flood events.

6.2 Consistency with council and state government flood related plans

Based on the assessment of flood impacts associated with the project that is presented in **Section 6.1** of this technical paper, the project is expected to have no impact on peak flood levels during a 1% AEP design storm event, as well as the Extreme Flood/PMF. As a result, the project is not expected to have an impact on the extent of the flood planning area and therefore the area of land to which clause 5.21 of both the *Hay Local Environmental Plan 2011* and *Deniliquin Local Environmental Plan 2013* would apply.

It can also be concluded that it would not increase the overall flood hazard for all storms up to 1% AEP in intensity. It would also not have an adverse impact on NSW SES's emergency response arrangements as set out in the *Hay Shire Local Flood Plan* and *Edwards River Local Flood Emergency Sub Plan*.

As a result of the above, the project would not result in an increase in the social or economic costs associated with flooding.

6.3 Impact of future climate change on flood behaviour

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

As noted in **Section 3.6**, the 0.5% AEP and 0.2% AEP storms have been used as proxies to assess the impact that a 10% and 30% increase in 1% AEP rainfall intensities would have on flood behaviour.

0.5% AEP Murrumbidgee River flood event

Figure B1 (2 sheets) shows the indicative extent and depth of inundation under pre-project conditions across the project area during a 0.5% AEP Murrumbidgee River flood event.

Floodwaters during a 0.5% AEP flood on the Murrumbidgee River bifurcate upstream of Darling Point and flow through the same waterways as during a 1% AEP event. However, flow occurs at increased depths compared with a 1% AEP event, resulting in increased inundation of off-channel storage areas. Surface water velocities during a 0.5% AEP event are like those predicted during a 1% AEP event. That said, the project area is not impacted by riverine based flooding from the Murrumbidgee River during a 0.5% AEP event under pre-project conditions.

0.2% AEP Murrumbidgee River flood event

Figure B2 (2 sheets) shows the indicative extent and depth of inundation under pre-project conditions across the project area during a 0.2% AEP Murrumbidgee River flood event. In comparison to a 1% AEP event, flooding of waterways principally to the south of the project area more broadly occurs during a 0.2% AEP event.

Flow occurs through Abercrombie Creek, Eurolie Creek, Curtains Creek and Nyangay Creek. Floodwaters in Abercrombie Creek and Curtains Creek are predominantly contained in-bank, with some shallow overbank inundation (0.1-0.2 metres depth) in some sections of the two creeks. While floodwater in Abercrombie Creek impacts the project where infrastructure crosses its inbank area (i.e. access tracks and cable alignments), no wind turbine infrastructure is impacted by flow in the watercourse. While no wind turbine or substation infrastructure is impacted by floodwater in Curtains Creek, the 330 kV transmission line which crosses the waterway may be exposed to shallow inundation at the base of its support towers.

0.5% AEP local catchment flood event

Figure C1 (6 sheets) shows the indicative extent and depth of inundation under pre-project conditions across the project area during a 0.5% AEP local catchment flood event. In comparison to a 1% AEP event, flooding of waterways and inundation of the project area occurs to a similar extent during a 0.5% AEP, however inundation depths are increased.

Local drainage lines convey floodwaters at depths of 1.0 - 2.0 metres and velocities of 0.3 – 0.5 metres per second. Widespread ponding of shallow surface water occurs across the project area. Project infrastructure which crosses local drainage lines (i.e. access tracks and transmission lines) is exposed to floodwater. While no inundation of substation infrastructure is predicted, increased depths of inundation would be experienced at the location of the proposed switching station.

0.2% AEP local catchment flood event

Figure C2 (6 sheets) shows the indicative extent and depth of inundation under pre-project conditions across the project area during a 0.2% AEP local catchment flood event.

The extent and depth of inundation during a 0.2% AEP local catchment flood event is similar to that of a 0.5% AEP event, with an increase in the depth of inundation predicted. All major drainage lines convey floodwaters at depths of approximately 1.0 metres and up to 1.0 - 2.0 metres in some locations. Floodwater velocities in drainage lines is generally up to 0.3 metres per second, with some sections of waterway experiencing higher velocities of 0.5 metres per second.

Access tracks and 33 kV and 330 kV transmission line corridors are inundated by shallow ponding of surface waters at depths of up to 0.5 metres. Where this infrastructure crosses creek lines, inundation to depths exceeding 1.0 metres and flow velocities of up to 0.5 metres per second could be expected. While no inundation of substation infrastructure is predicted, increased depths of inundation would be experienced at the location of the proposed switching station.

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

As the project does not propose to alter the landform of the floodplain and given that potential increases in rainfall intensities will result in only minor increases in the depth, extent and velocity of flow internal to the project area, it is concluded that the project would not have a measurable impact on flood behaviour under future climate change conditions.

7 CUMULATIVE IMPACTS

The construction of multiple projects in a catchment has the potential to adversely impact flood behaviour on a cumulative basis. At the time of writing, it is understood that the following major projects are presently being planned for the area:

- Yanco Delta Wind Farm
- Bullawah Wind Farm
- The Plains Solar Farm
- Pottinger Wind Farm
- Pottinger Solar Farm
- Argoon Wind Farm
- Tchelery Wind Farm
- Dinawan Wind Farm

A similar flooding investigation that has recently been completed by Lyall & Associates on behalf of Engie for The Plains Solar Farm has demonstrated that it would only have a very localised impact on both riverine and local catchment type flooding.

The Yanco Delta, Bullawah, Pottinger, Argoon and Dinawan wind/solar farms are generally located to the east of the project and also lie in the watershed of watercourses which drain to its south. As a result, any flood related impacts associated with these projects are independent of the project.

While the Tcherlery Wind Farm is located to the west of the project and partially lies within the watershed of the watercourses which run through the project area, provided appropriate mitigation and management measures are incorporated into both projects, then their cumulative impacts on flood behaviour would be minor in nature.

8 MANAGEMENT OF IMPACTS

Table 8.1 sets out the environmental management measures that would be implemented to manage flood related impacts during the construction and operation of the project.

TABLE 8.1
FLOODING RELATED MITIGATION AND MANAGEMENT MEASURES

ID	Mitigation and management measure
Construction – flooding	
FL01	Detailed construction planning would consider flood risk at construction sites and support facilities, including: • reviewing construction site layouts and staging construction activities in order to avoid or minimise obstruction of overland flow paths and limiting the extent of flow diversion required. • designing the layout of construction facilities and implementing stormwater management controls during their establishment to manage the impact of flooding on construction personnel, equipment and materials. • measures to mitigate alterations to local runoff conditions due to construction activities.
FL02	Spoil stockpiles would be located in areas which are not subject to frequent inundation by floodwater, ideally outside the 10% AEP flood extent. The exact level of flood risk accepted at stockpile sites would depend on the duration of stockpiling operations, the type of material stored, the nature of the receiving drainage lines and also the extent to which it would impact flooding conditions in adjacent development.
FL03	Construction compounds and workforce accommodation camps would be located outside high flood hazard areas based on a 1% AEP flood.
FL04	Flood emergency management measures for construction of the project would be prepared and incorporated into relevant environmental and/or safety management documentation. This would include: • identification of how flood related risks to personal safety and damage to construction facilities and equipment will be managed. • procedures to monitor accurate and timely weather data and disseminate warnings to construction personnel of impending flood producing rain.
Operation – flooding	
FL05	The impact of the project on flood behaviour would be confirmed during detailed design. This would include consideration of future climate change.
FL06	The project would be designed to minimise adverse flood related impacts in waterways situation within the project area, including Telegraph Creek, Abercrombie Creek and Curtains Creek.
FL07	Where required, access tracks will be designed to have a minimum hydrologic standard of 10% AEP
FL08	Access track connections would be designed to ensure that the existing level of flood immunity of the Cobb Highway is maintained and increases in flood depths and hazards along the road network are minimised.
FL09	Localised increases in flow velocities at drainage outlets and waterway crossings would be mitigated through the provision of scour protection and energy dissipation measures.

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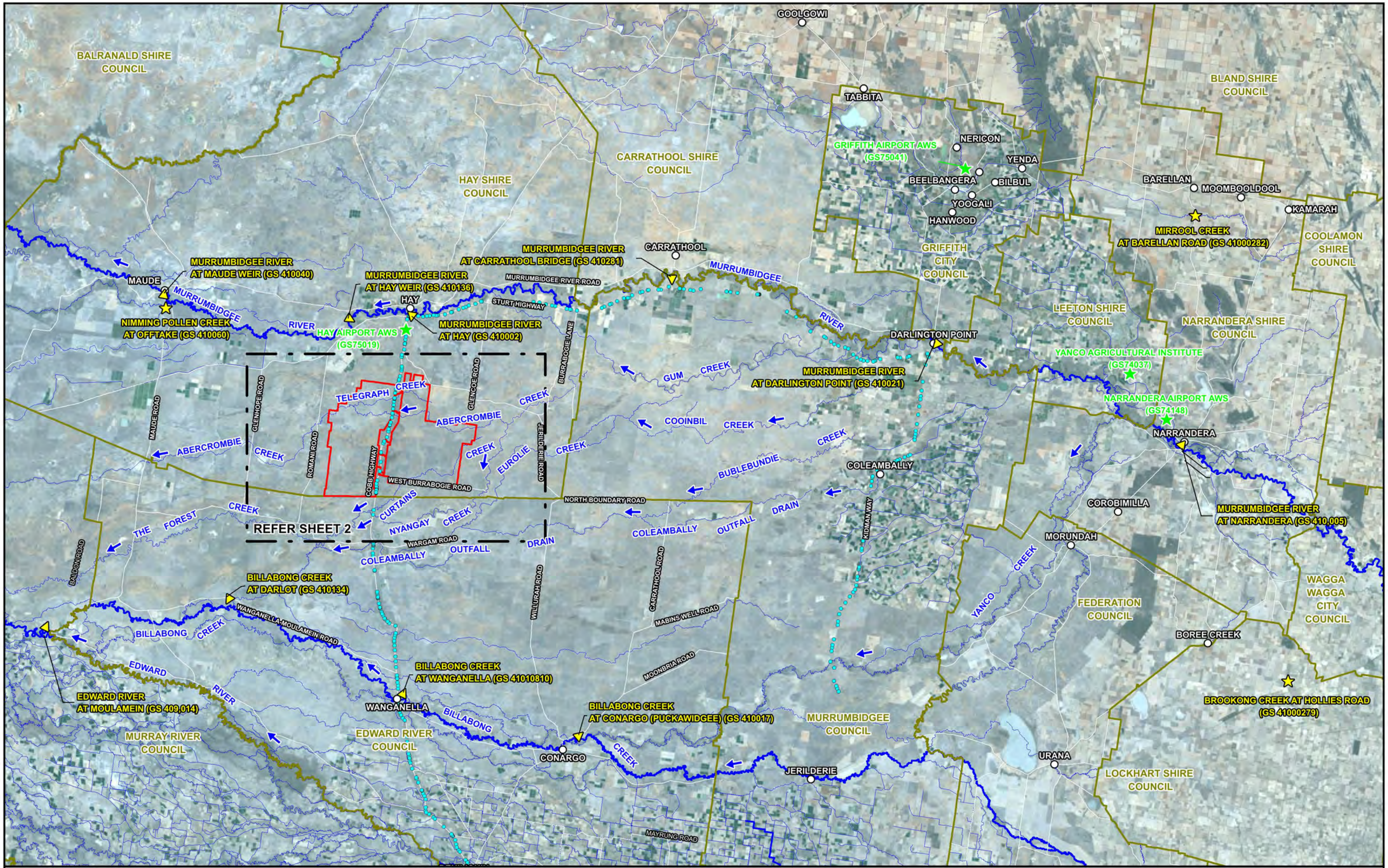
FIGURES



N

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Scale: 1:700,000

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LEGEND

Project Area

LGA Boundary

WaterNSW Stream Gauge

WaterNSW Rain Gauge

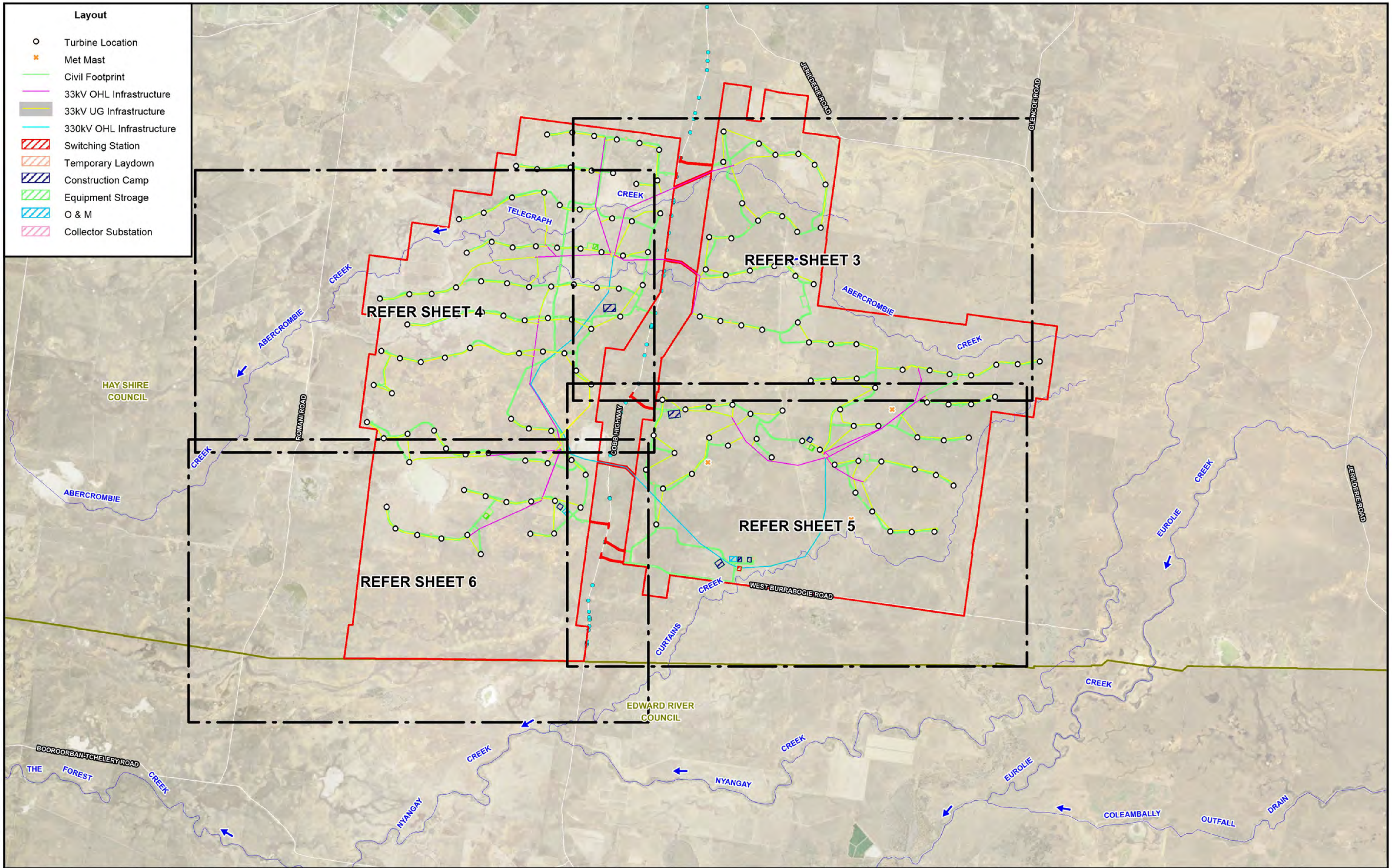
BoM All Weather Station (AWS)

Existing Transverse Drainage Structure Along Cobb Highway

THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure 4.1
(Sheet 1 of 6)

EXISTING DRAINAGE SYSTEM IN THE VICINITY



THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure 4.1
(Sheet 2 of 6)

EXISTING DRAINAGE SYSTEM IN THE VICINITY

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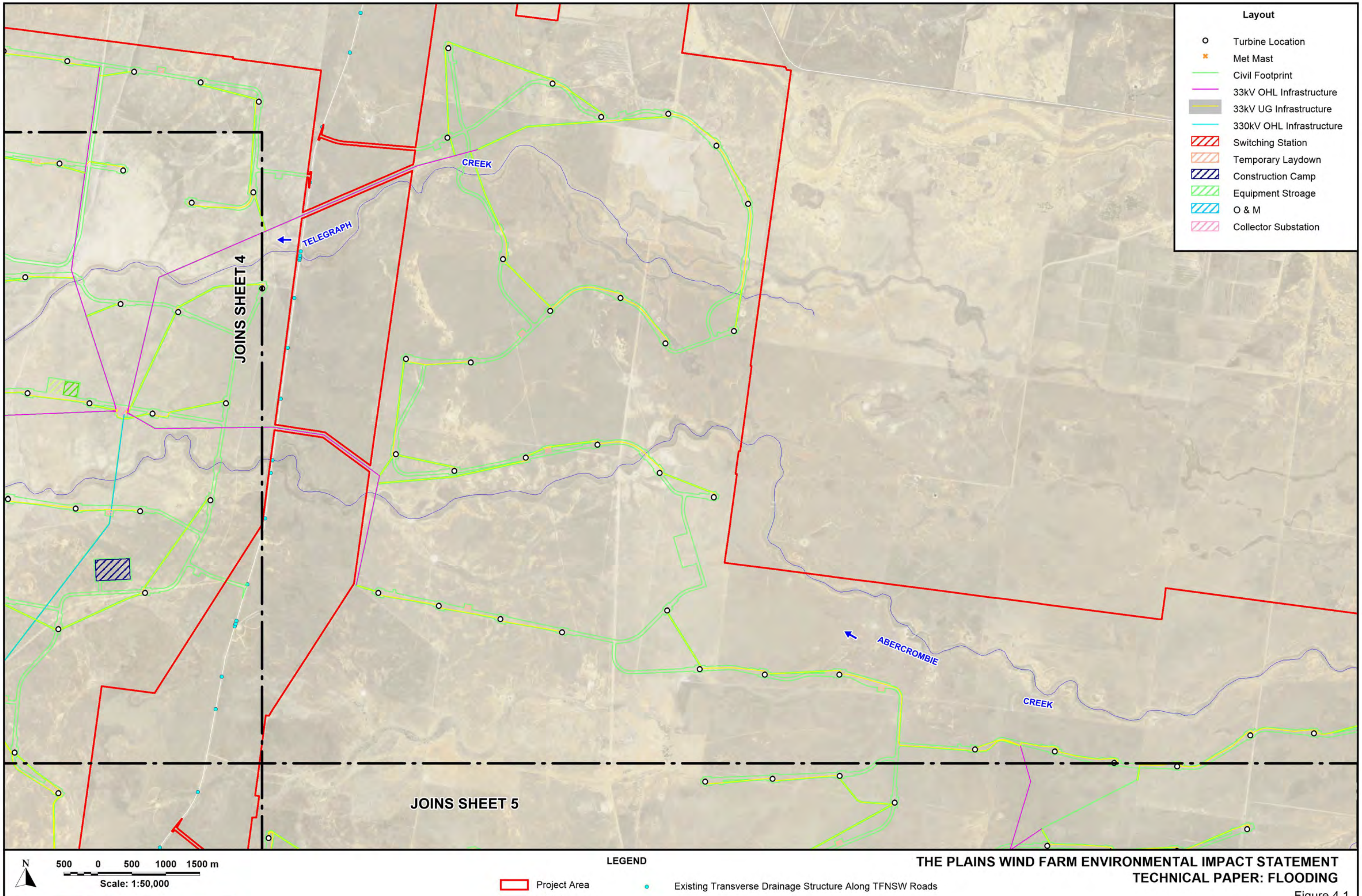

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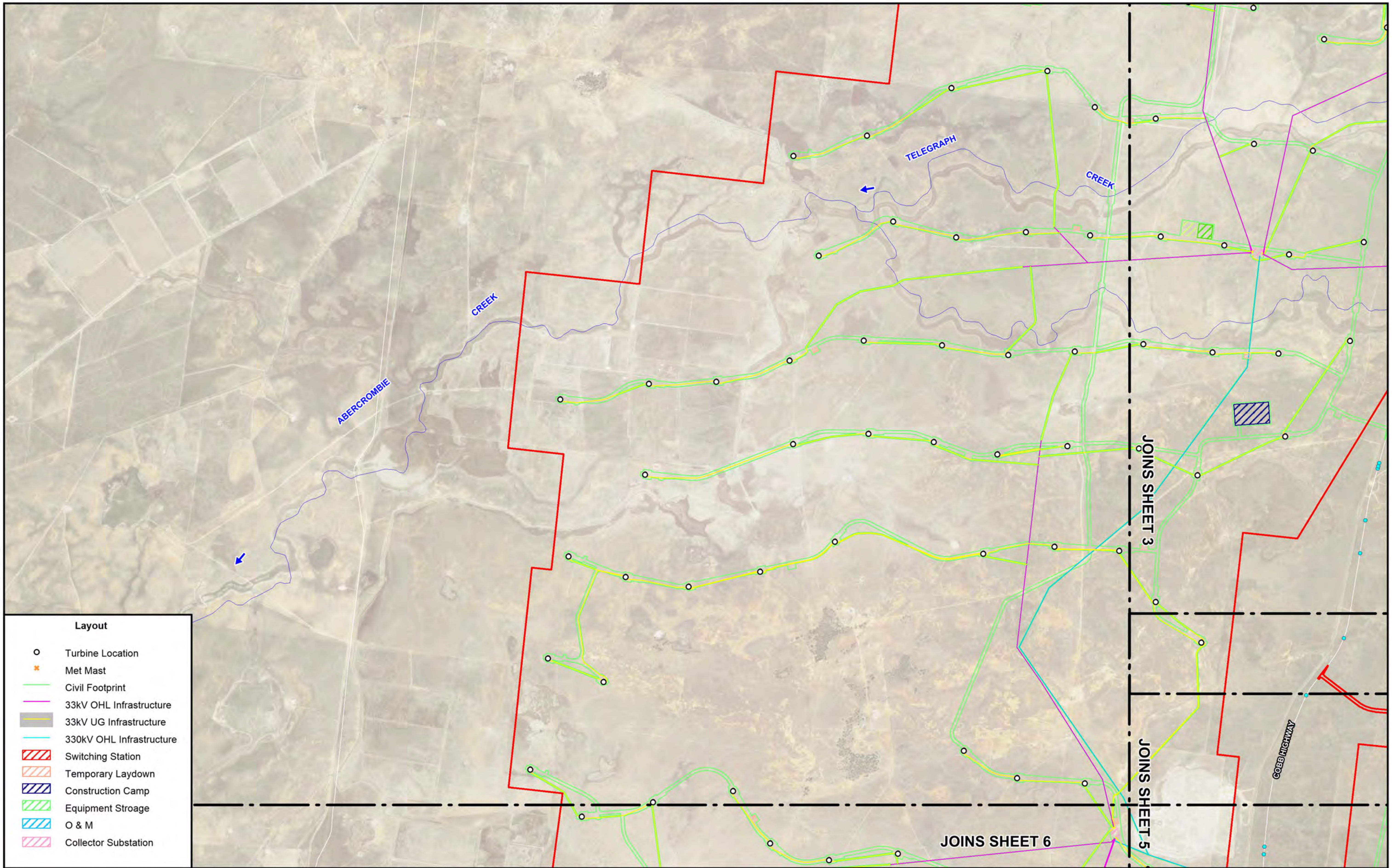
THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure 4.1
(Sheet 3 of 6)

EXISTING DRAINAGE SYSTEM IN THE VICINITY



LEGEND

Project Area

LGA Boundary

Existing Transverse Drainage Structure Along TFNSW Roads

Lyall & Associates

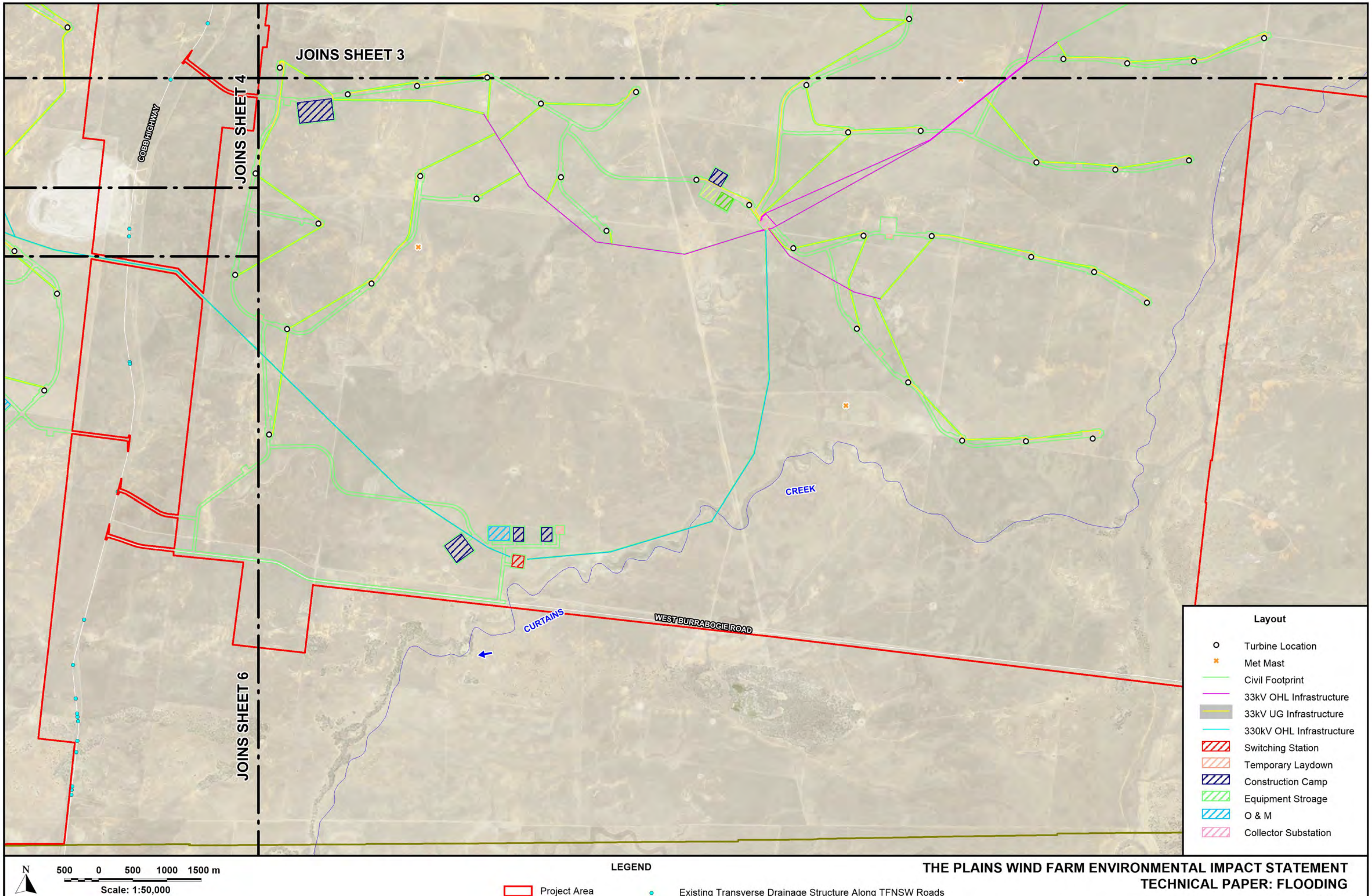
THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT

TECHNICAL PAPER: FLOODING

Figure 4.1

(Sheet 4 of 6)

EXISTING DRAINAGE SYSTEM IN THE VICINITY



LEGEND

Project Area

LGA Boundary

Existing Transverse Drainage Structure Along TFNSW Roads

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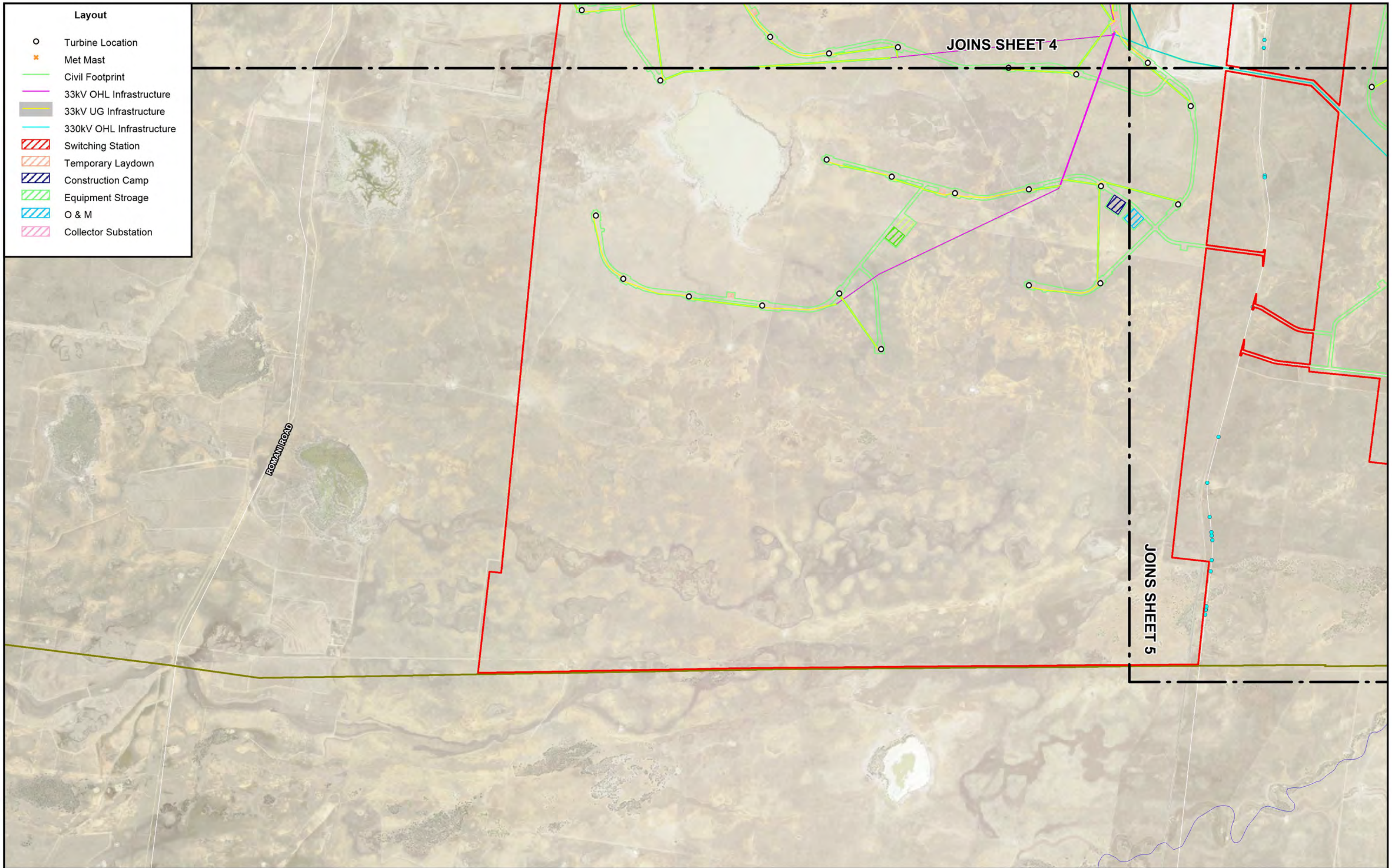
THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure 4.1
(Sheet 5 of 6)

EXISTING DRAINAGE SYSTEM IN THE VICINITY



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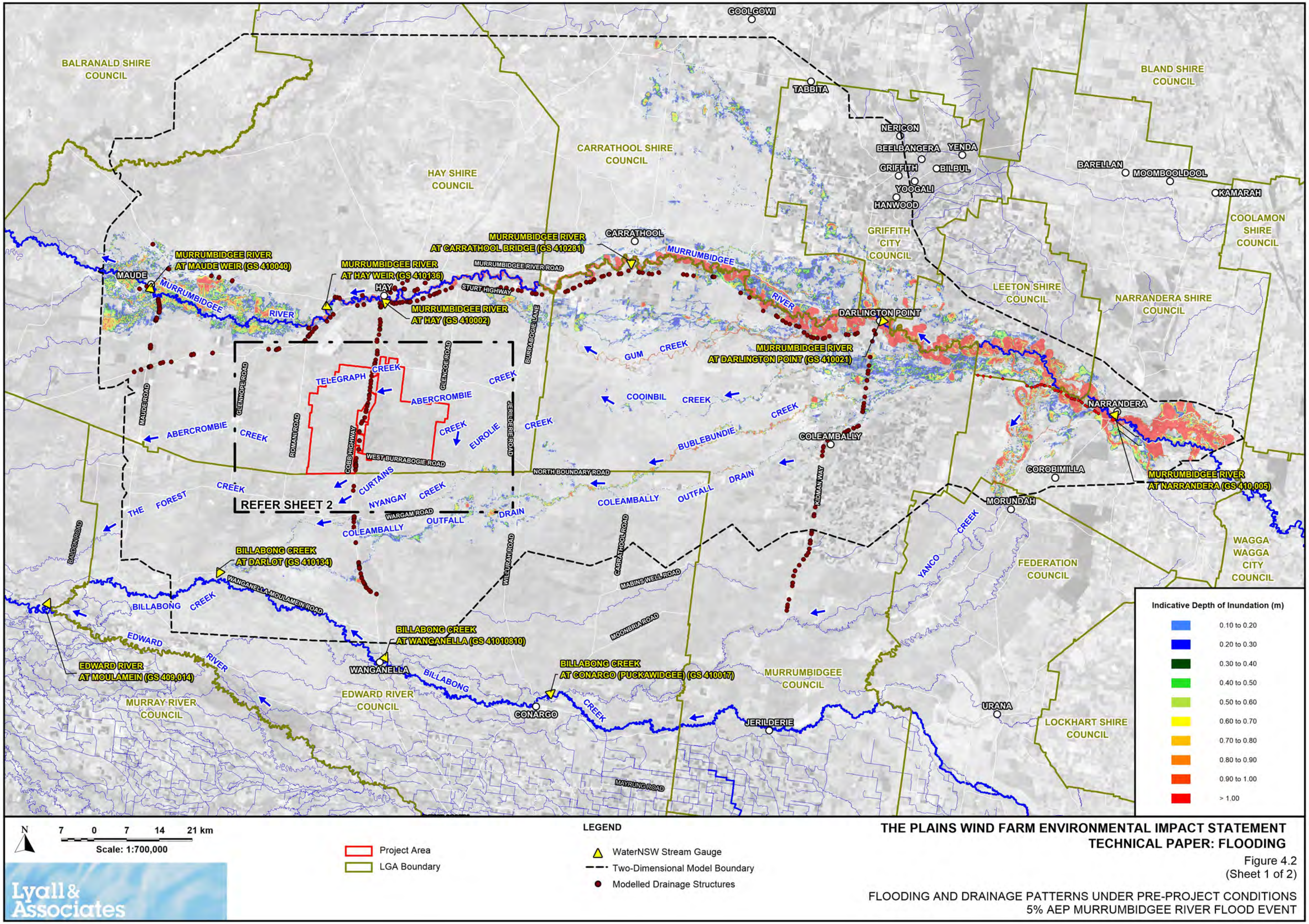
THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure 4.1
(Sheet 6 of 6)

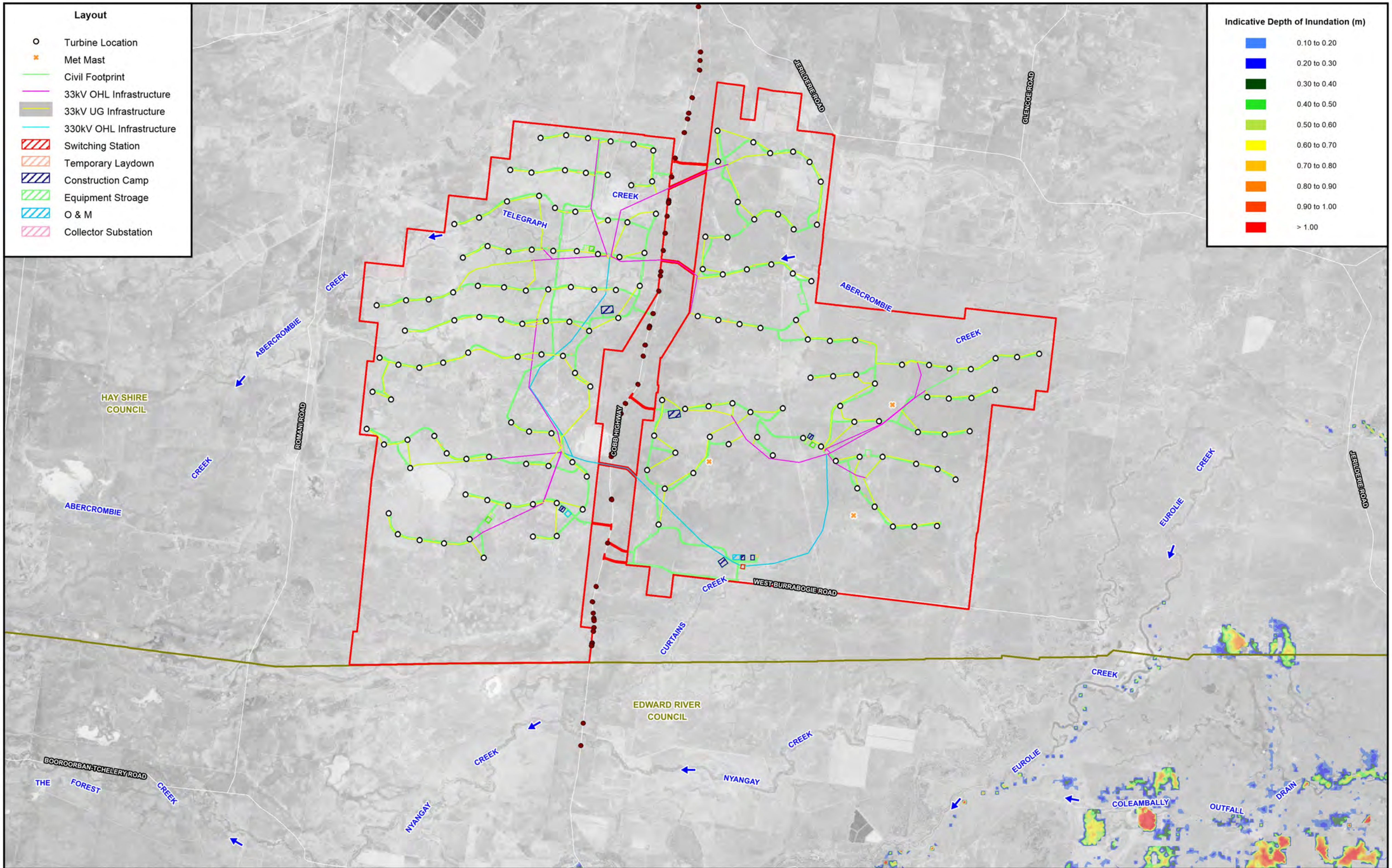
EXISTING DRAINAGE SYSTEM IN THE VICINITY



THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure 4.2
(Sheet 1 of 2)

FLOODING AND DRAINAGE PATTERNS UNDER PRE-PROJECT CONDITIONS
5% AEP MURRUMBIDGEE RIVER FLOOD EVENT



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Scale: 1:150,000

LEGEND

Project Area

LGA Boundary

Modelled Drainage Structures

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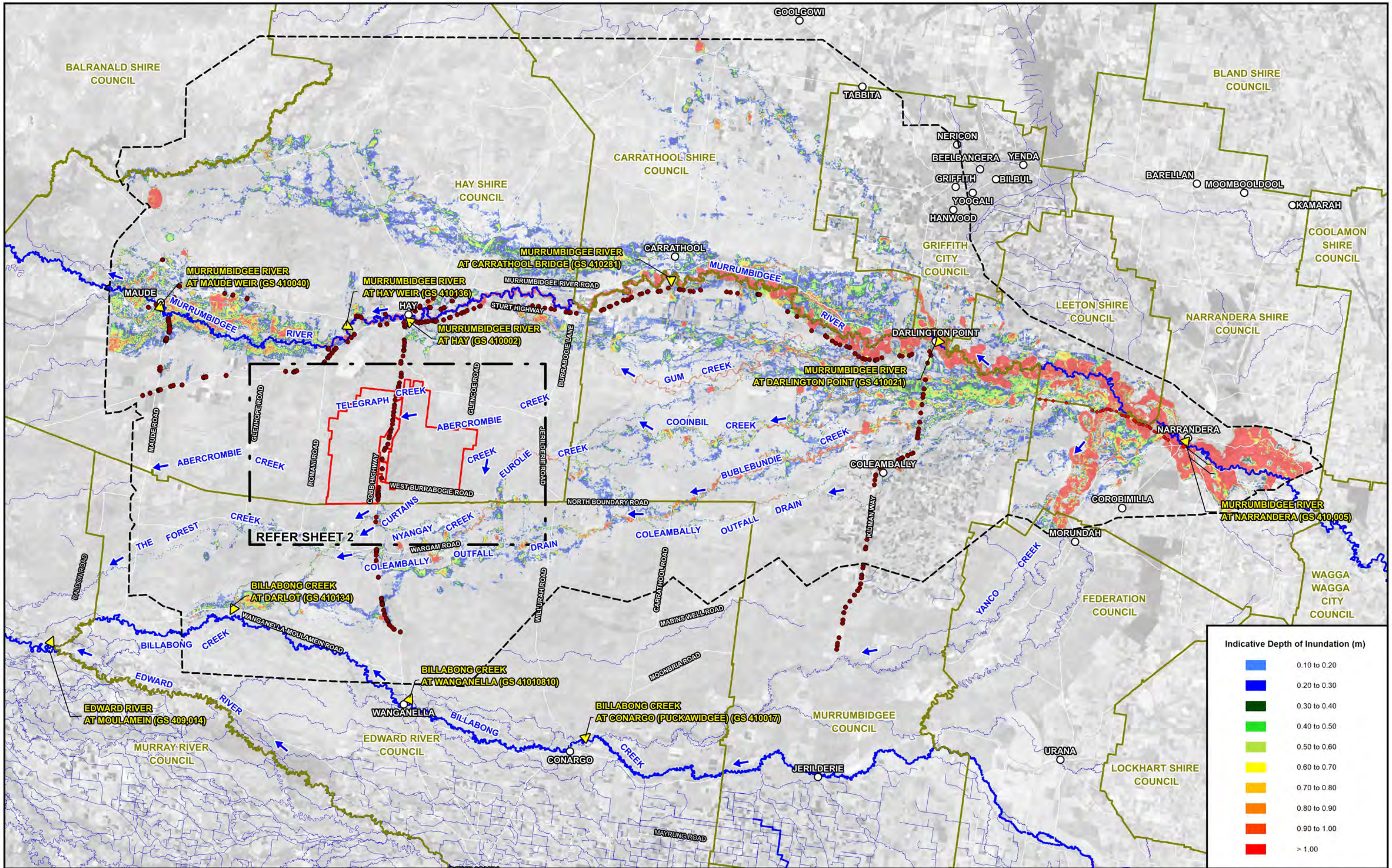
THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure 4.2
(Sheet 2 of 2)

FLOODING AND DRAINAGE PATTERNS UNDER PRE-PROJECT CONDITIONS
5% AEP MURRUMBIDGEE RIVER FLOOD EVENT



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Scale: 1:700,000

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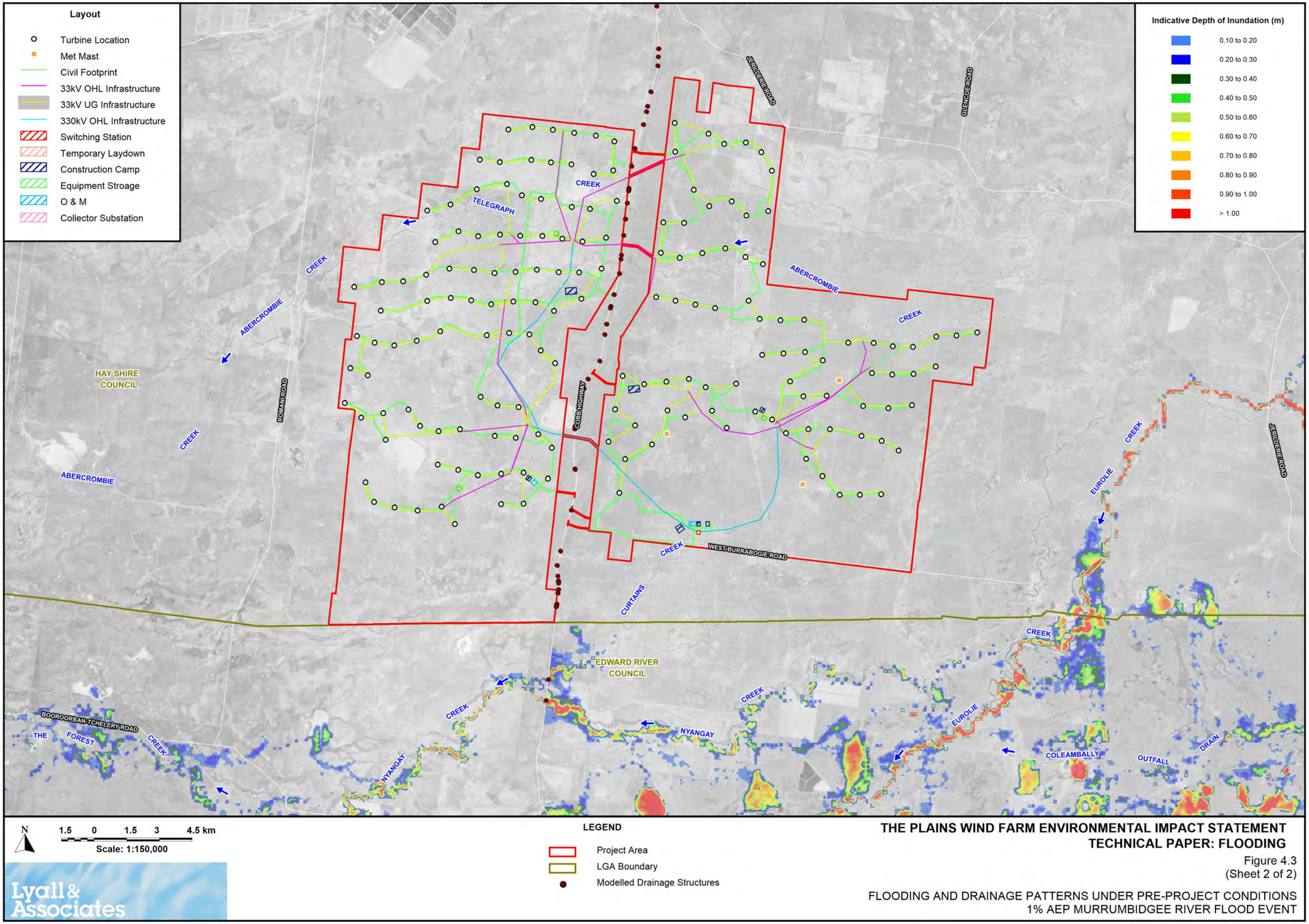
LEGEND

- Project Area
- LGA Boundary
- WaterNSW Stream Gauge
- Two-Dimensional Model Boundary
- Modelled Drainage Structures

THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure 4.3
(Sheet 1 of 2)

FLOODING AND DRAINAGE PATTERNS UNDER PRE-PROJECT CONDITIONS
1% AEP MURRUMBIDGEE RIVER FLOOD EVENT



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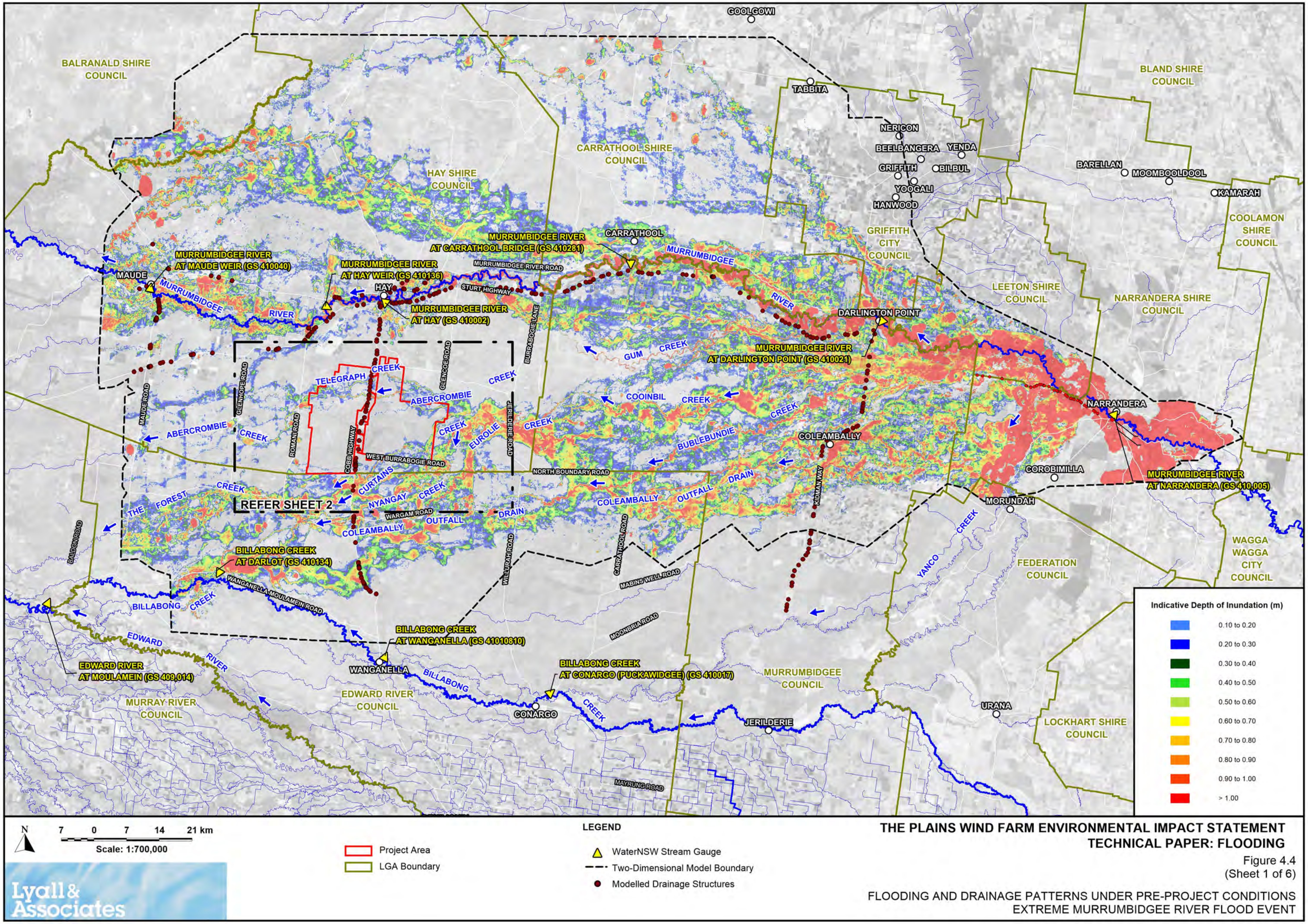
THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure 4.3
(Sheet 2 of 2)

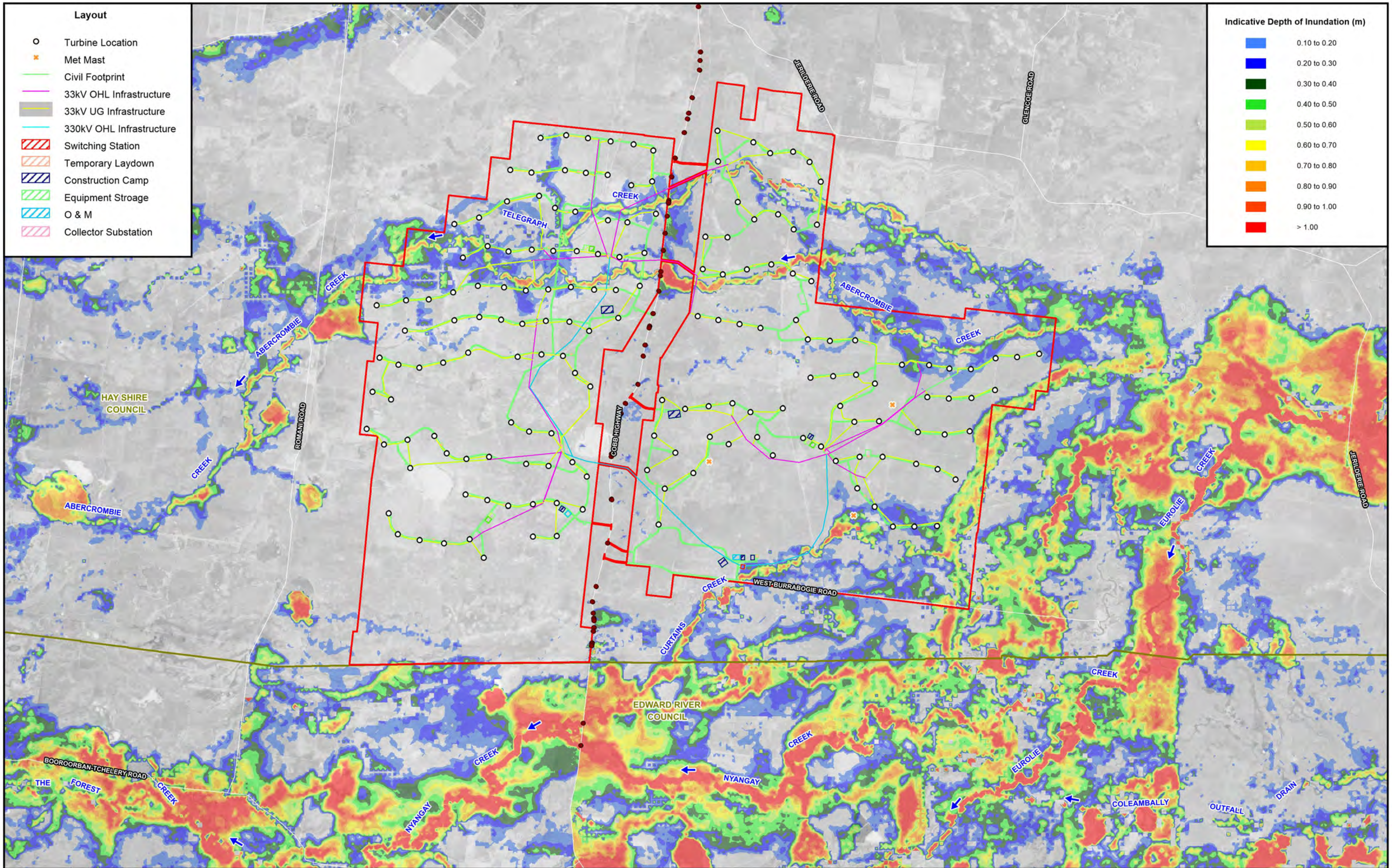
FLOODING AND DRAINAGE PATTERNS UNDER PRE-PROJECT CONDITIONS
1% AEP MURRUMBIDGEE RIVER FLOOD EVENT



THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure 4.4
(Sheet 1 of 6)

FLOODING AND DRAINAGE PATTERNS UNDER PRE-PROJECT CONDITIONS
EXTREME MURRUMBIDGEE RIVER FLOOD EVENT



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Scale: 1:150,000

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LEGEND

Project Area

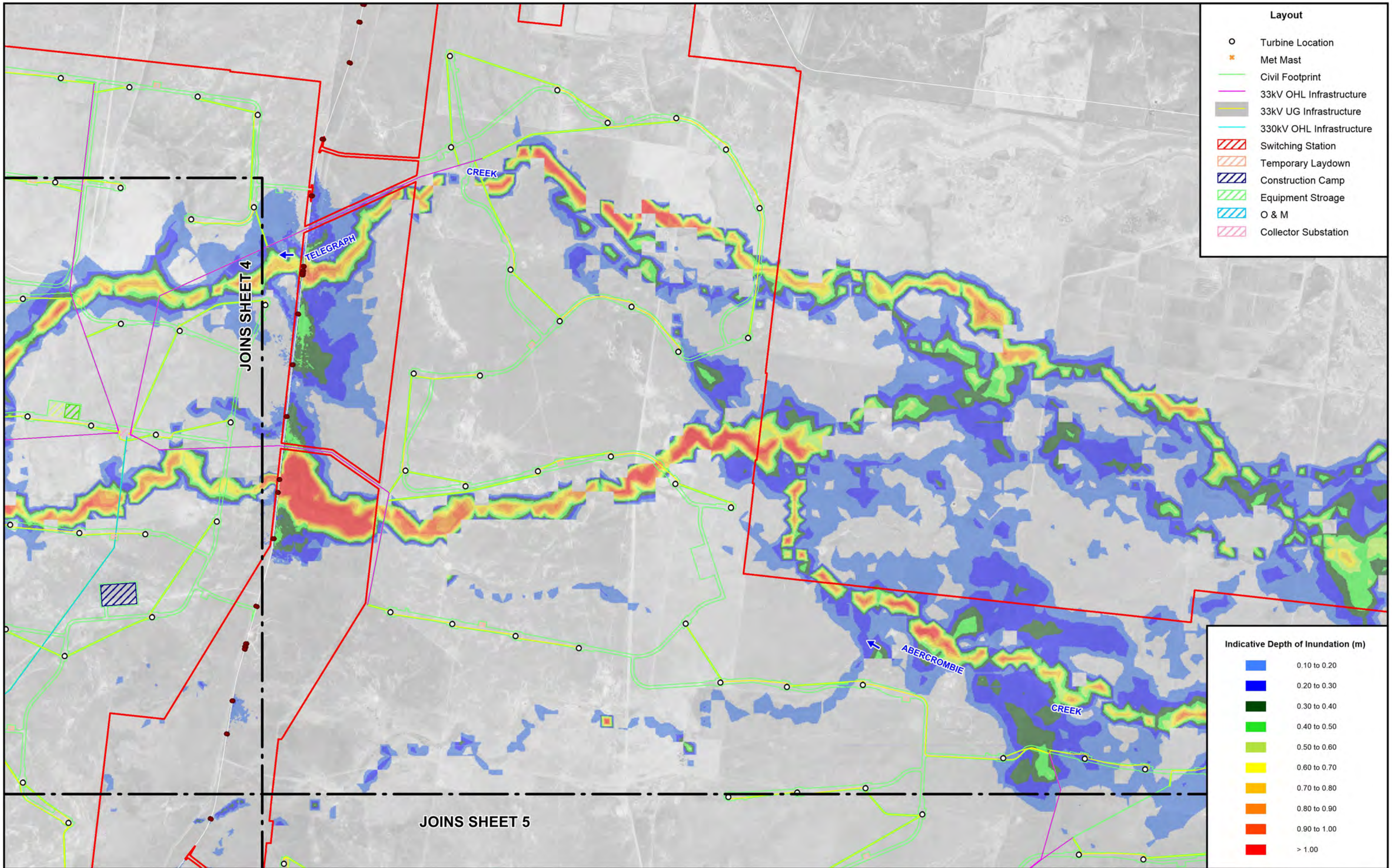
LGA Boundary

Modelled Drainage Structures

THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure 4.4
(Sheet 2 of 6)

FLOODING AND DRAINAGE PATTERNS UNDER PRE-PROJECT CONDITIONS
EXTREME MURRUMBIDGEE RIVER FLOOD EVENT



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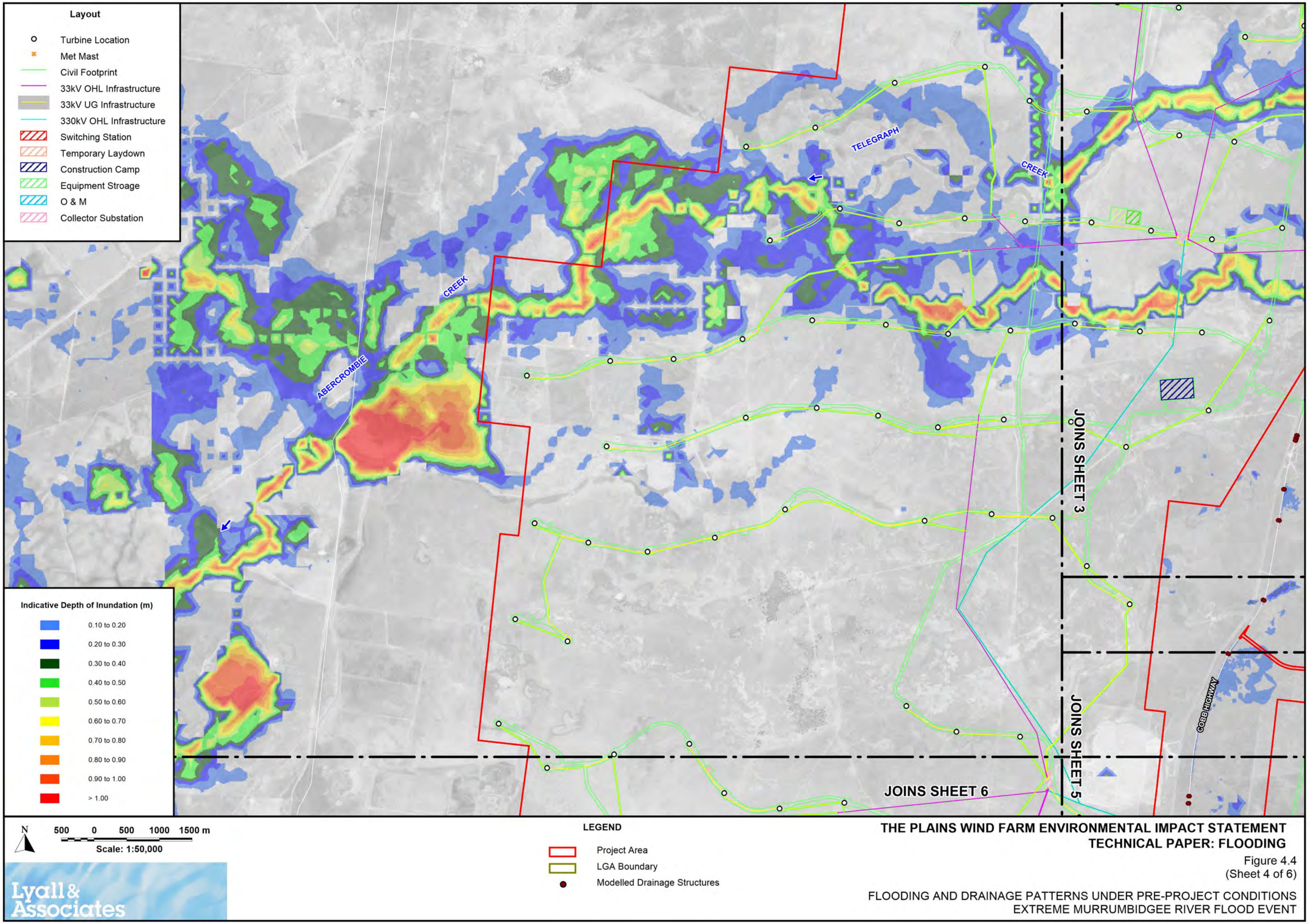
THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure 4.4
(Sheet 3 of 6)

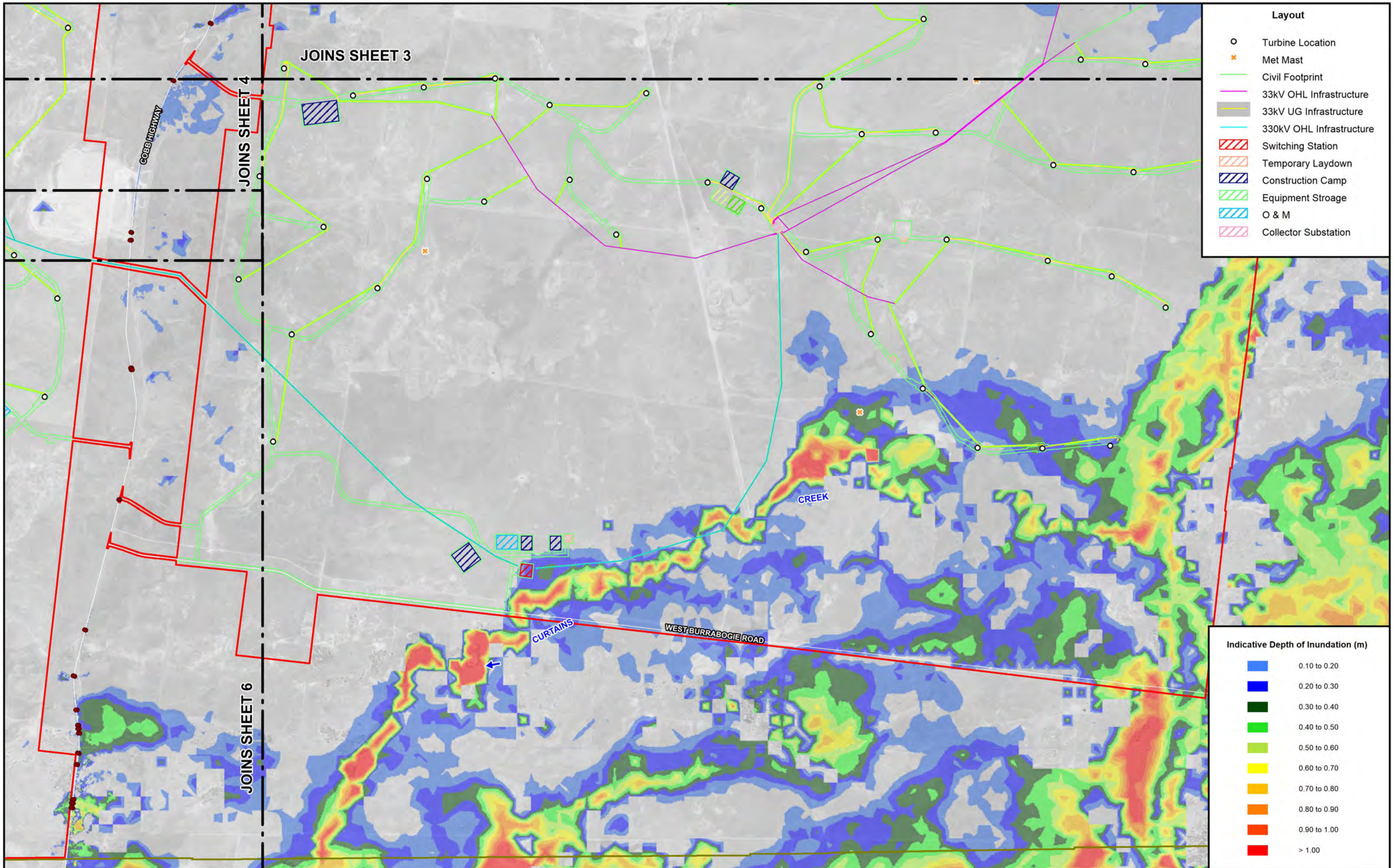
FLOODING AND DRAINAGE PATTERNS UNDER PRE-PROJECT CONDITIONS
EXTREME MURRUMBIDGEE RIVER FLOOD EVENT



THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure 4.4
(Sheet 4 of 6)

FLOODING AND DRAINAGE PATTERNS UNDER PRE-PROJECT CONDITIONS
EXTREME MURRUMBIDGEE RIVER FLOOD EVENT



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Scale: 1:50,000

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LEGEND

Project Area

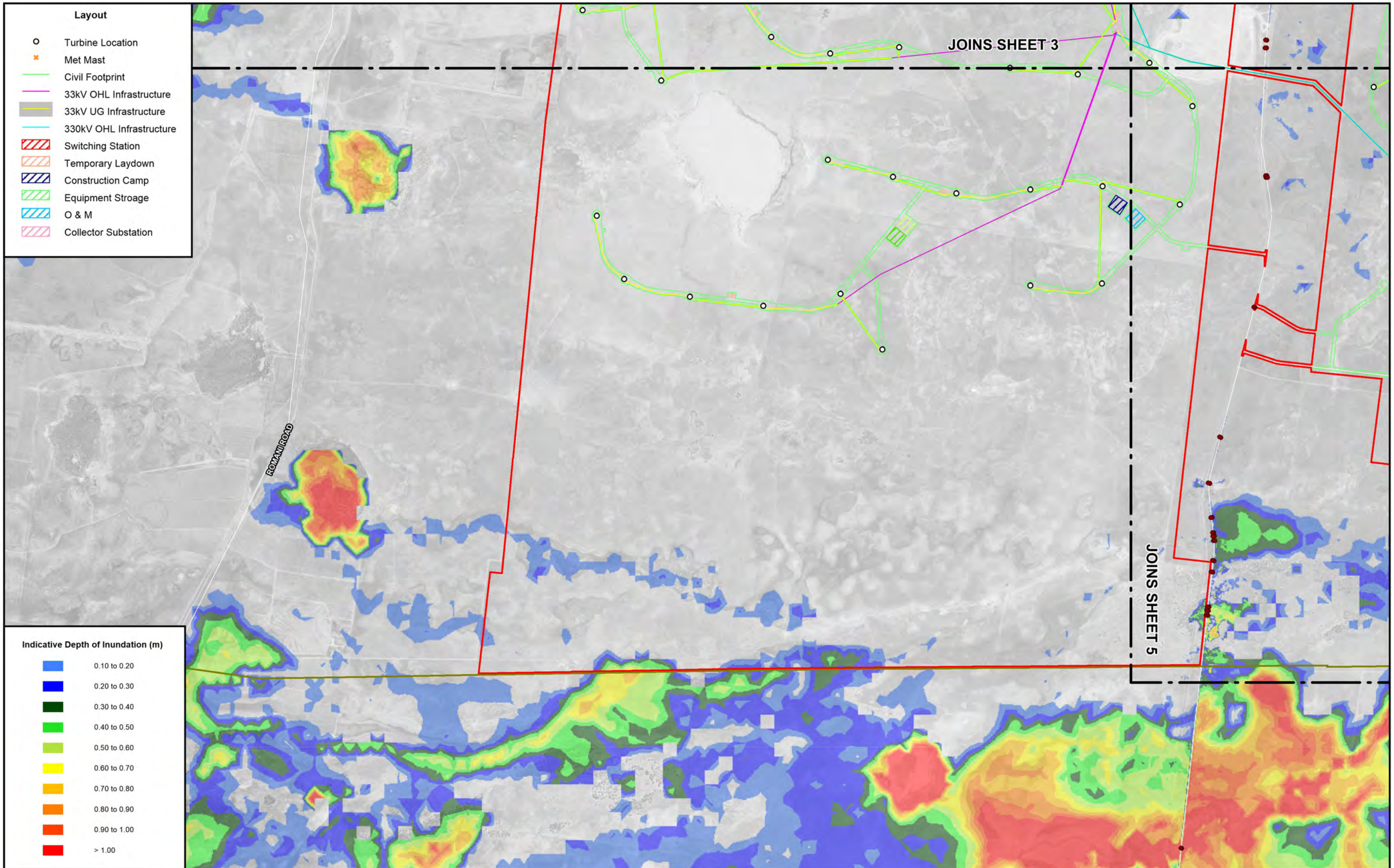
LGA Boundary

Modelled Drainage Structures

THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure 4.4
(Sheet 5 of 6)

FLOODING AND DRAINAGE PATTERNS UNDER PRE-PROJECT CONDITIONS
EXTREME MURRUMBIDGEE RIVER FLOOD EVENT



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Scale: 1:50,000

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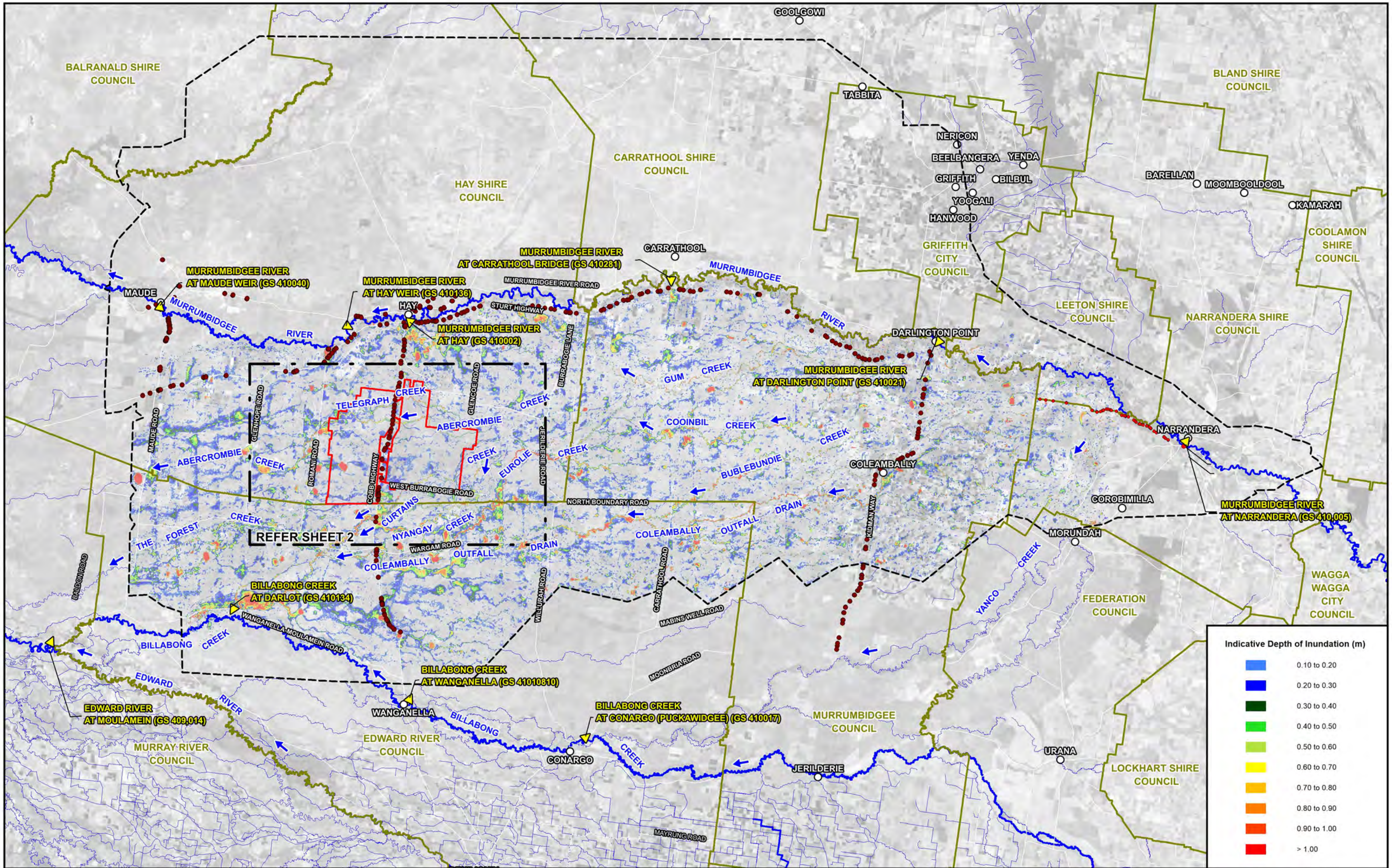
LEGEND
Project Area
LGA Boundary
Modelled Drainage Structures

THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure 4.4
(Sheet 6 of 6)

FLOODING AND DRAINAGE PATTERNS UNDER PRE-PROJECT CONDITIONS
EXTREME MURRUMBIDGEE RIVER FLOOD EVENT



N

7 0 7 14 21 km

Scale: 1:700,000

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LEGEND

- Project Area
- LGA Boundary
- WaterNSW Stream Gauge
- Two-Dimensional Model Boundary
- Modelled Drainage Structures

THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure 4.5
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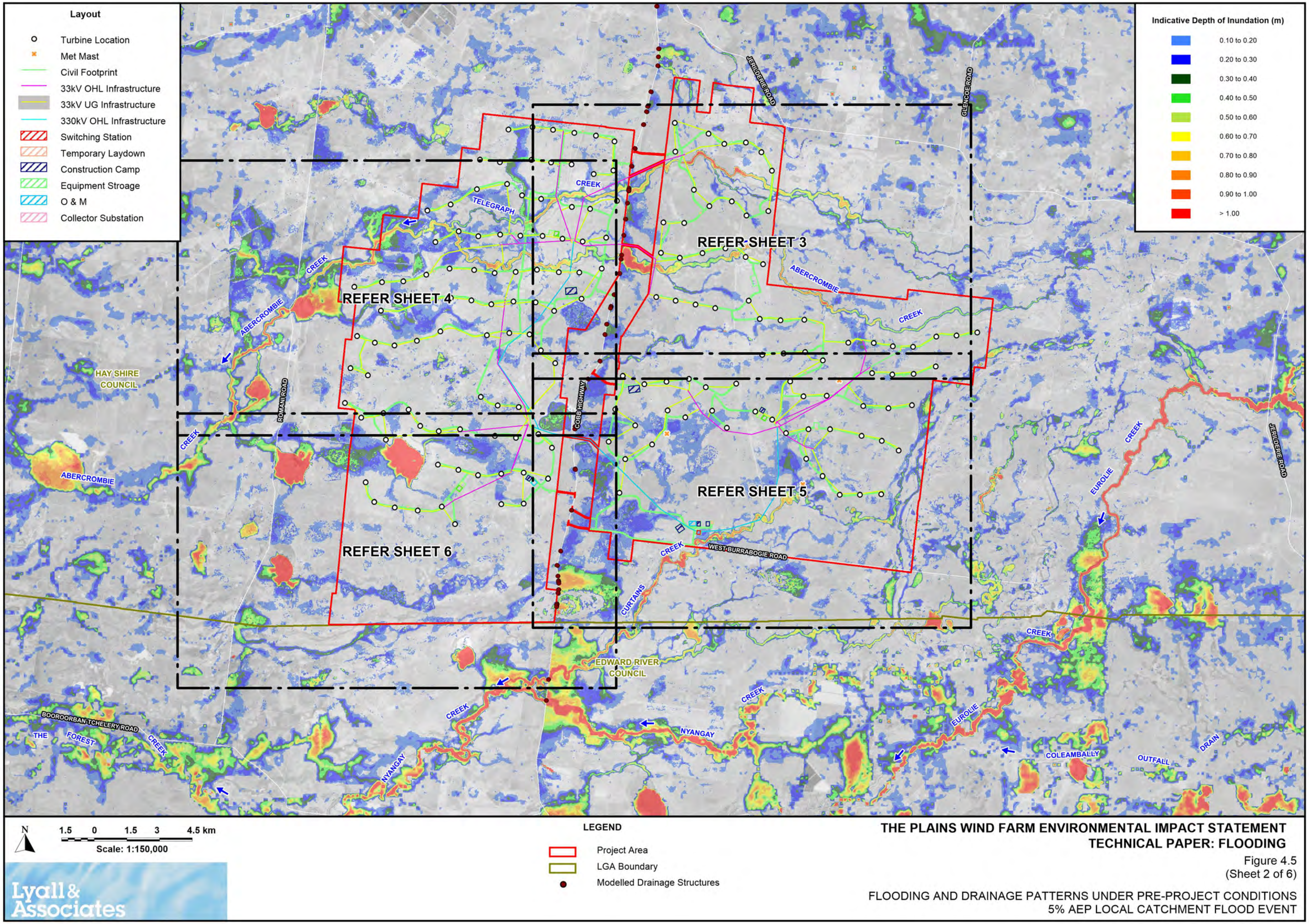
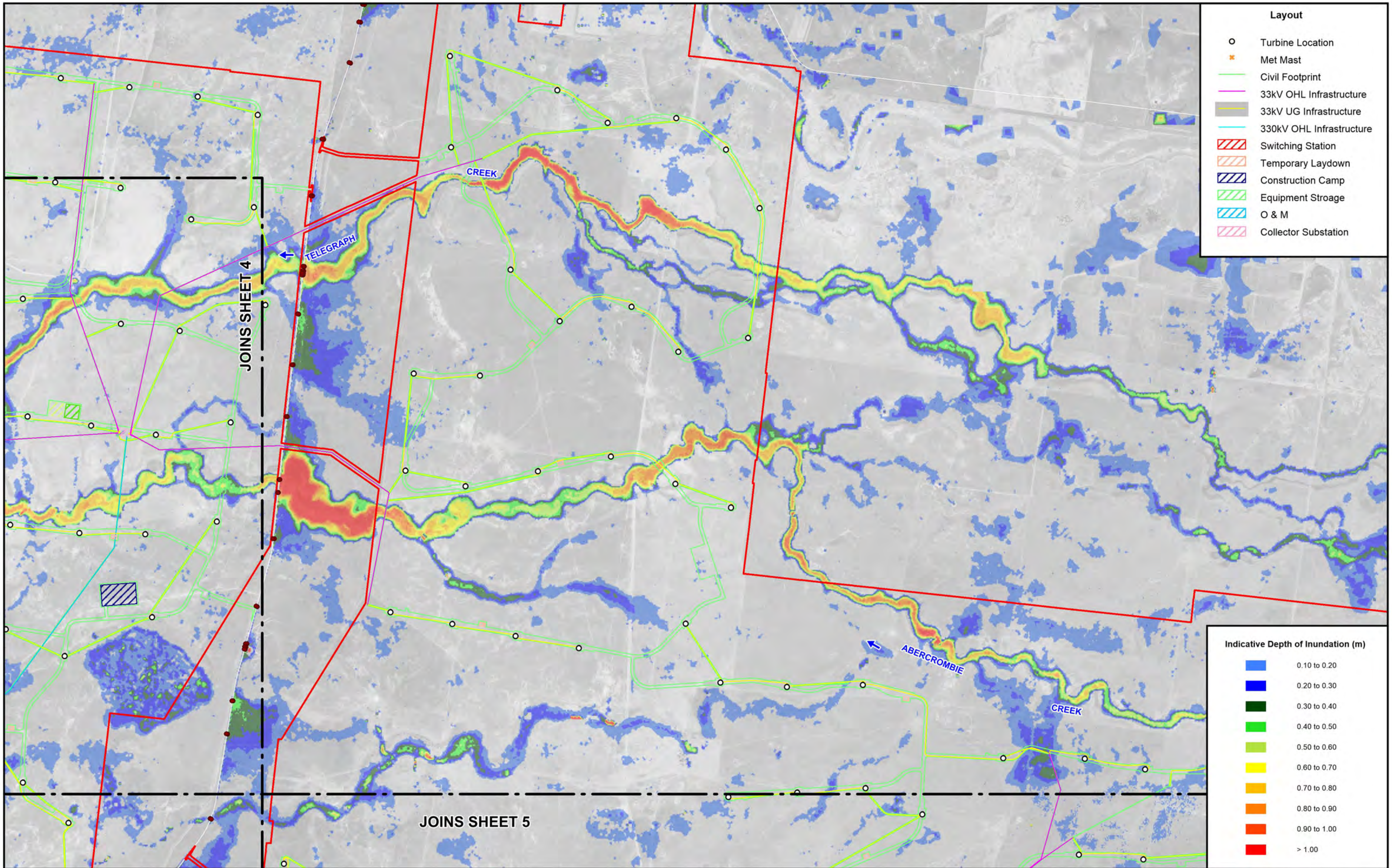
FLOODING AND DRAINAGE PATTERNS UNDER PRE-PROJECT CONDITIONS
5% AEP LOCAL CATCHMENT FLOOD EVENT



THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure 4.5
(Sheet 2 of 6)

FLOODING AND DRAINAGE PATTERNS UNDER PRE-PROJECT CONDITIONS
5% AEP LOCAL CATCHMENT FLOOD EVENT



N
500 0 500 1000 1500 m
Scale: 1:50,000

Lyall & Associates

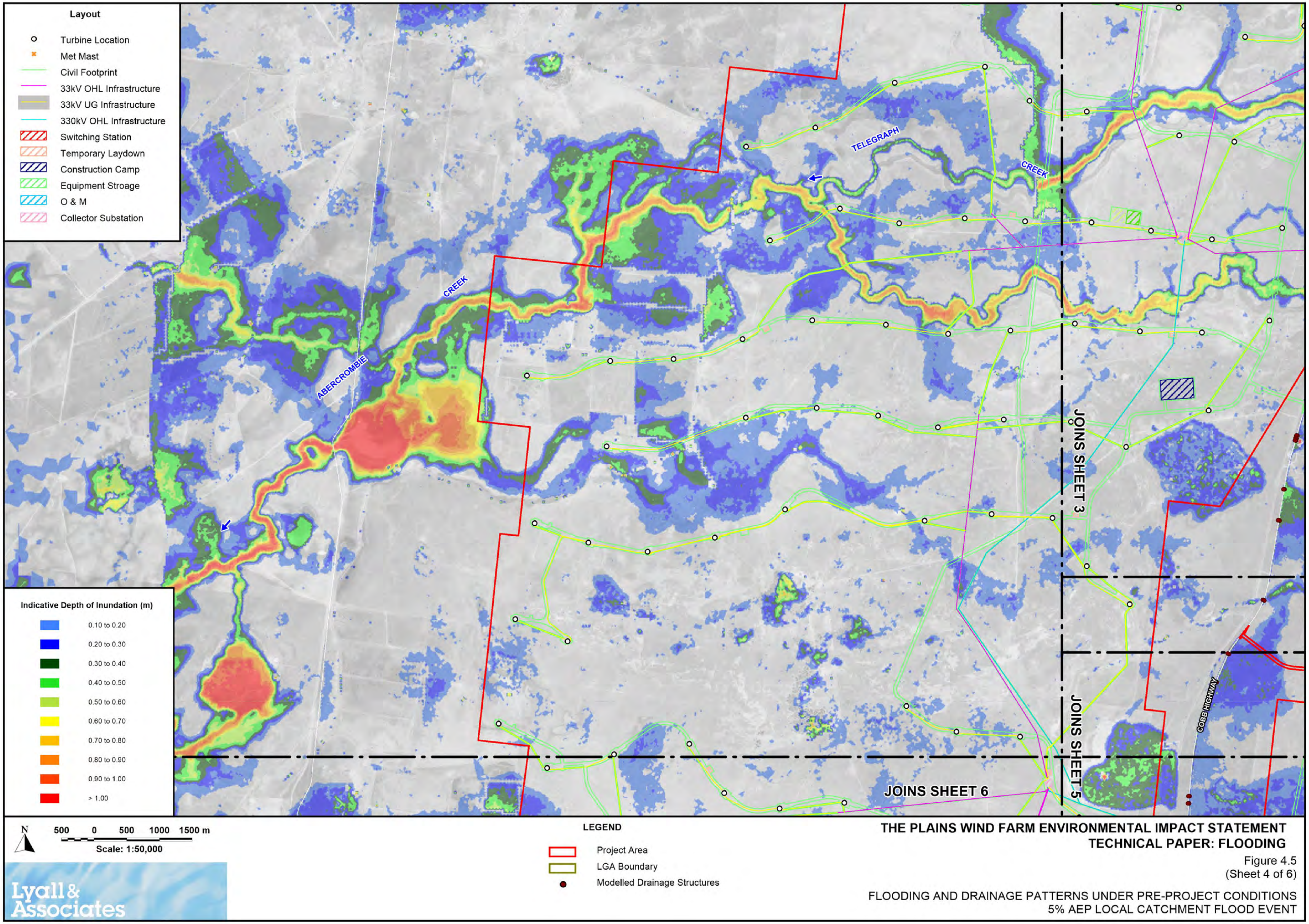
LEGEND

- Project Area
- LGA Boundary
- Modelled Drainage Structures

THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure 4.5
(Sheet 3 of 6)

FLOODING AND DRAINAGE PATTERNS UNDER PRE-PROJECT CONDITIONS
5% AEP LOCAL CATCHMENT FLOOD EVENT

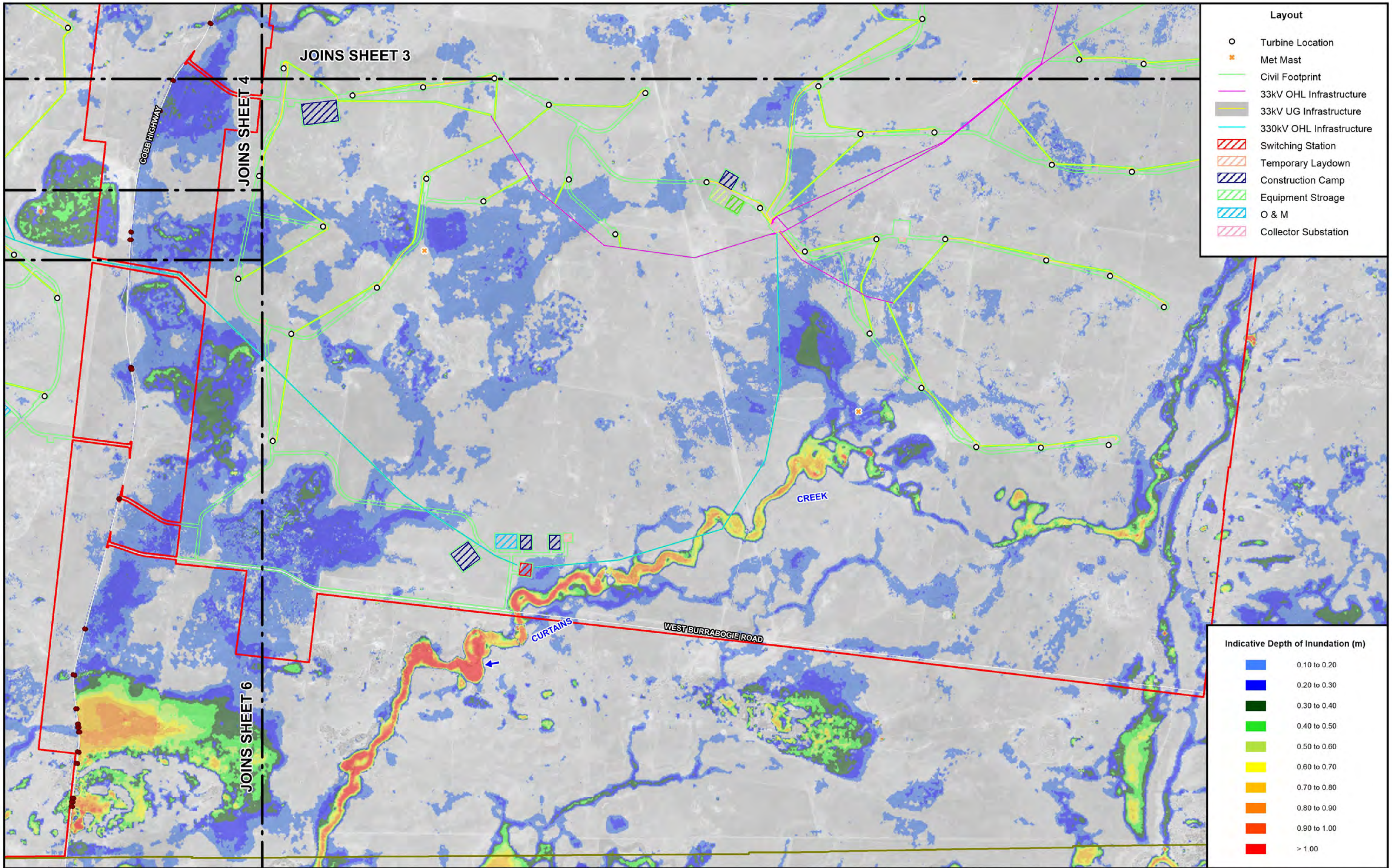


Lyall & Associates

THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure 4.5
(Sheet 4 of 6)

FLOODING AND DRAINAGE PATTERNS UNDER PRE-PROJECT CONDITIONS
5% AEP LOCAL CATCHMENT FLOOD EVENT



LEGEND

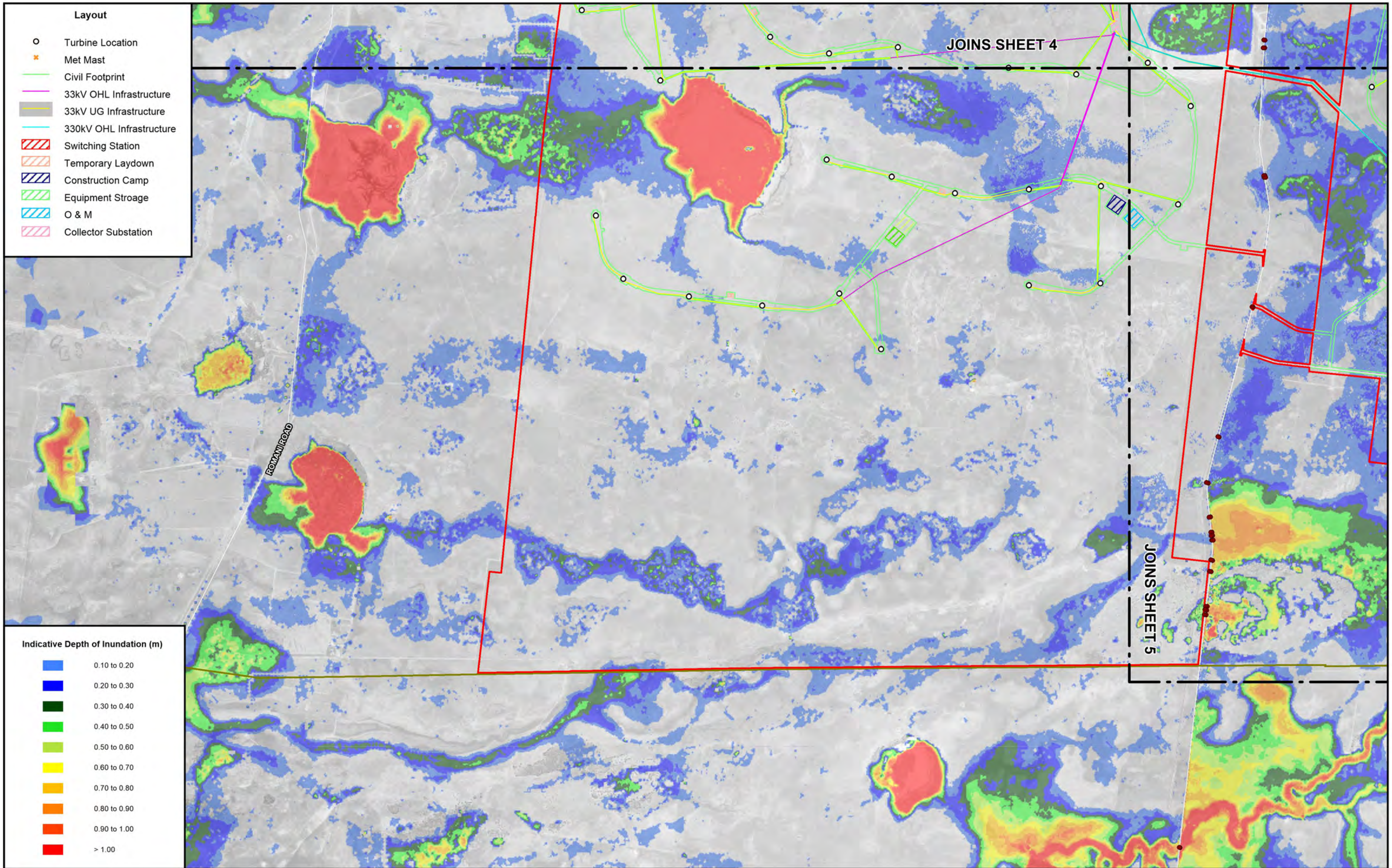
- Project Area
- LGA Boundary
- Modelled Drainage Structures

Lyall & Associates

THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure 4.5
(Sheet 5 of 6)

FLOODING AND DRAINAGE PATTERNS UNDER PRE-PROJECT CONDITIONS
5% AEP LOCAL CATCHMENT FLOOD EVENT



N
500 0 500 1000 1500 m
Scale: 1:50,000

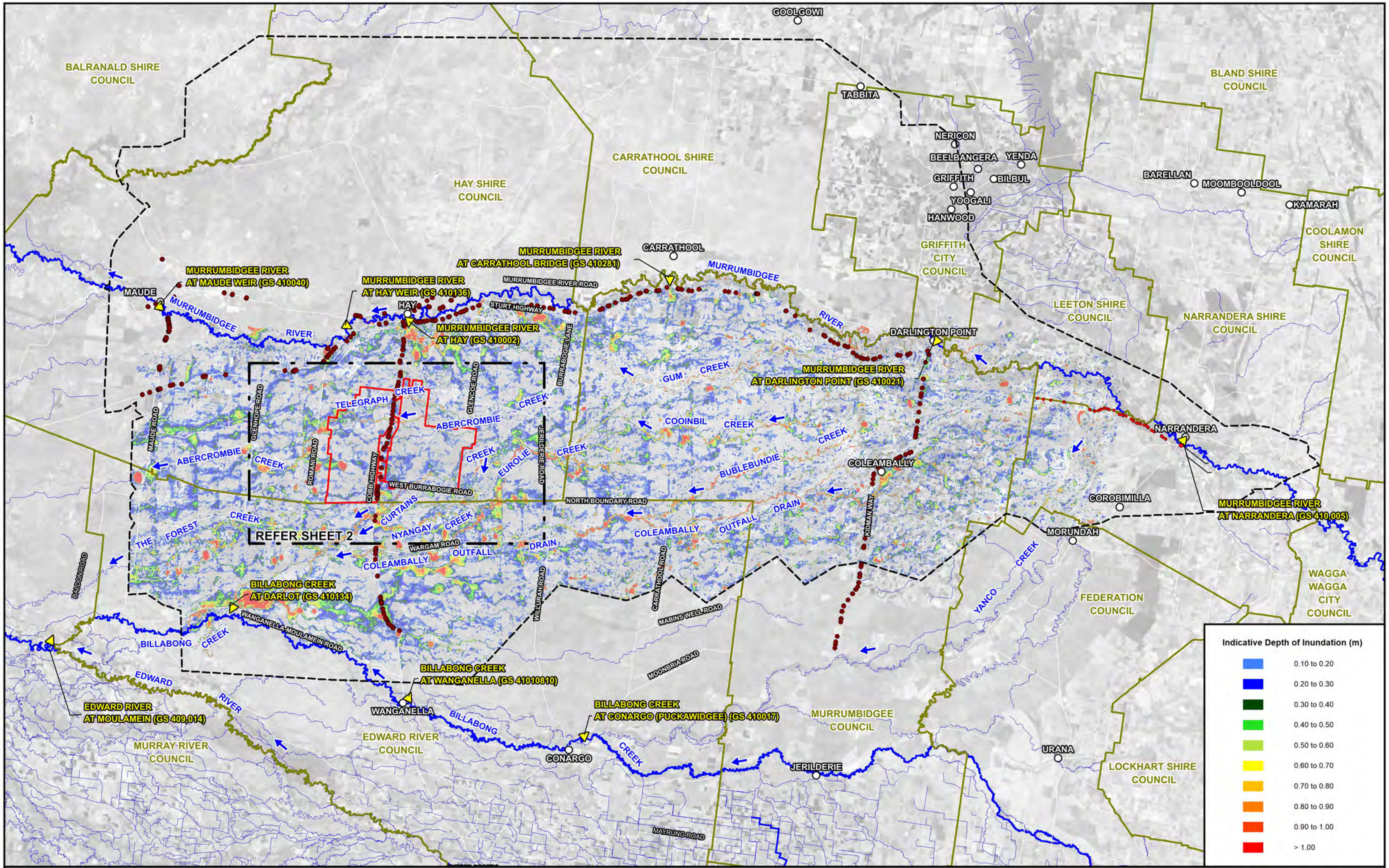
Lyall & Associates

LEGEND
Project Area
LGA Boundary
Modelled Drainage Structures

THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure 4.5
(Sheet 6 of 6)

FLOODING AND DRAINAGE PATTERNS UNDER PRE-PROJECT CONDITIONS
5% AEP LOCAL CATCHMENT FLOOD EVENT



N

7 0 7 14 21 km

Scale: 1:700,000

Lyall & Associates

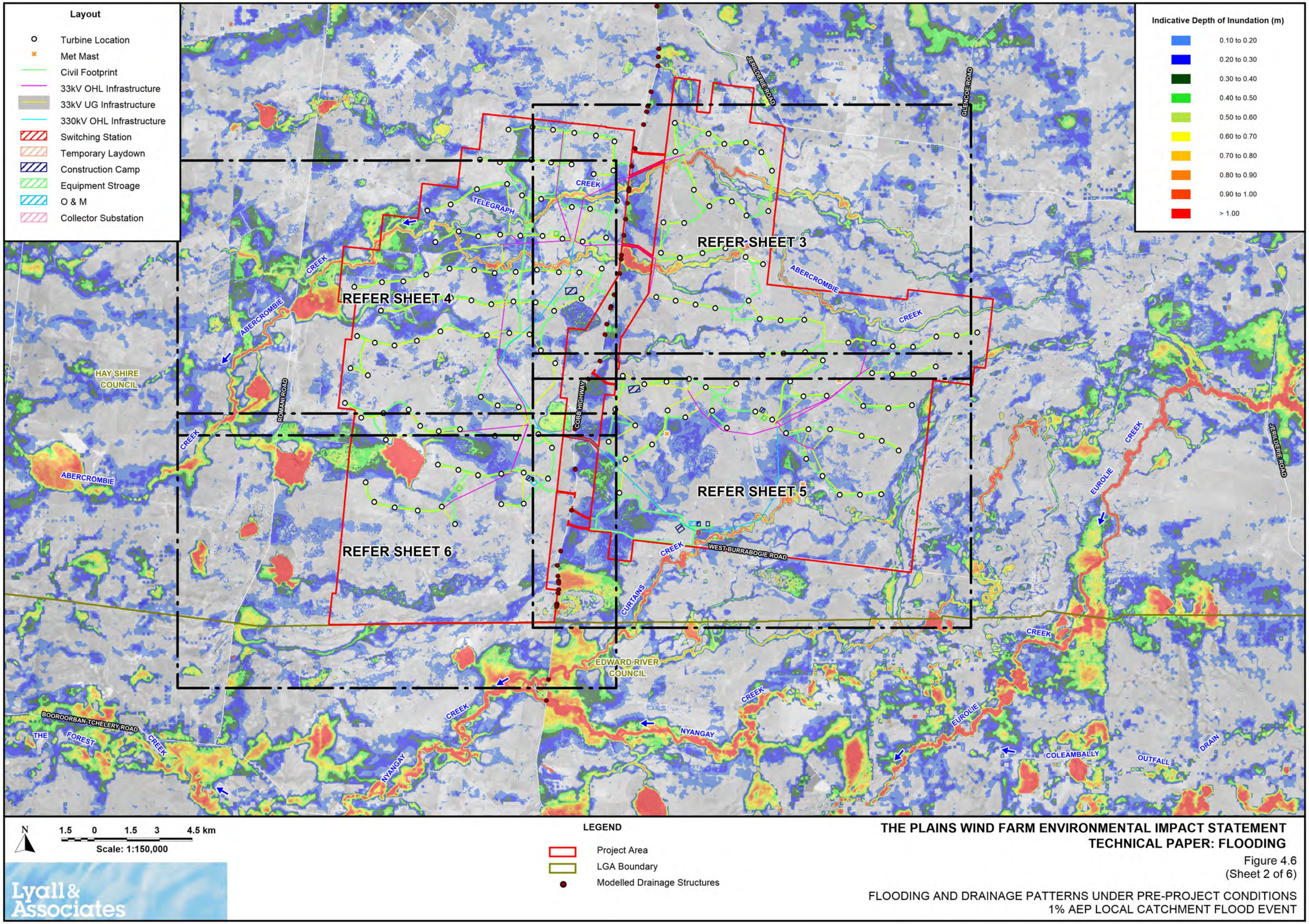
LEGEND

- Project Area
- LGA Boundary
- WaterNSW Stream Gauge
- Two-Dimensional Model Boundary
- Modelled Drainage Structures

THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure 4.6
(Sheet 1 of 6)

FLOODING AND DRAINAGE PATTERNS UNDER PRE-PROJECT CONDITIONS
1% AEP LOCAL CATCHMENT FLOOD EVENT



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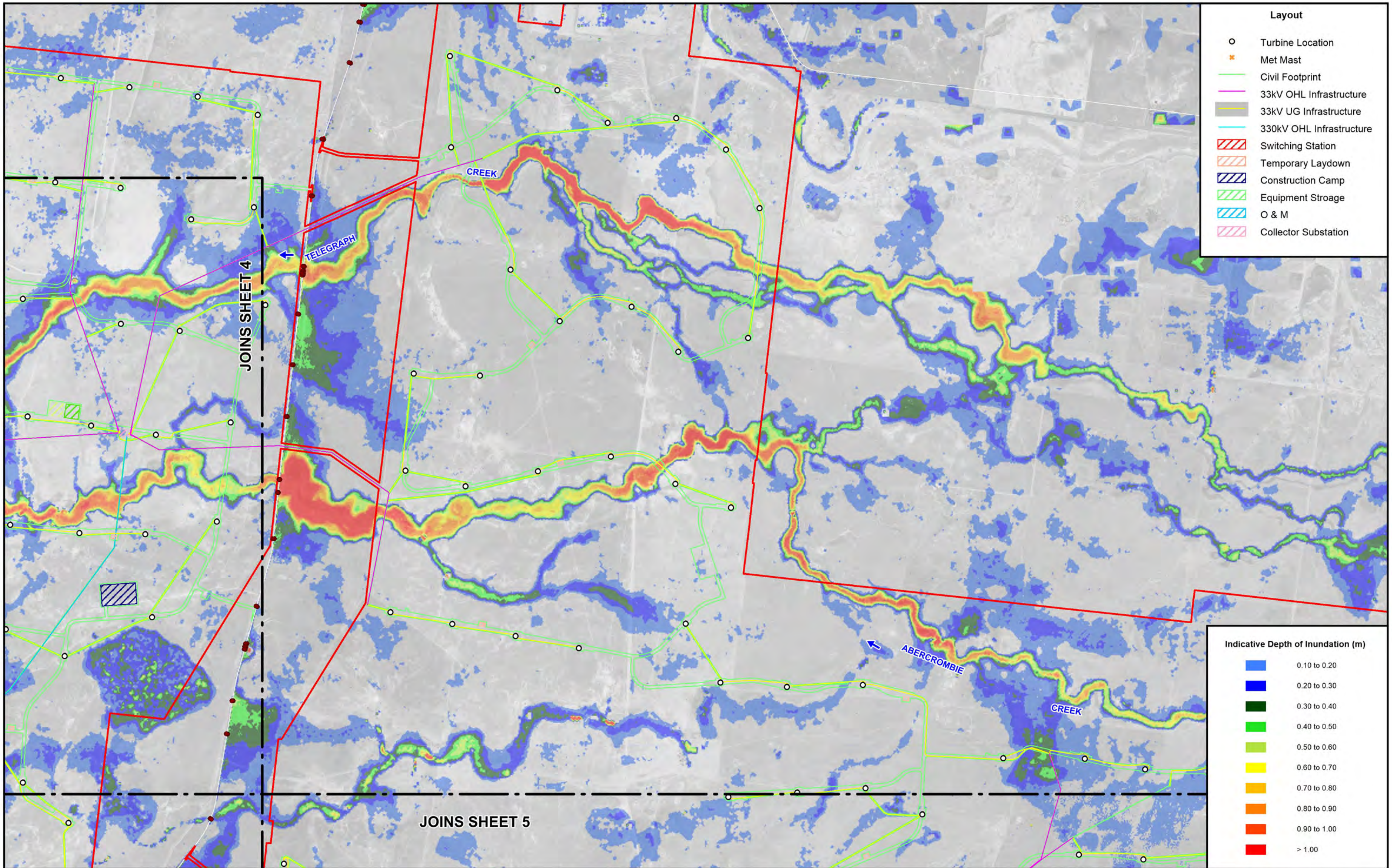
THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure 4.6
(Sheet 2 of 6)

FLOODING AND DRAINAGE PATTERNS UNDER PRE-PROJECT CONDITIONS
1% AEP LOCAL CATCHMENT FLOOD EVENT



N
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Scale: 1:50,000

Lyall & Associates

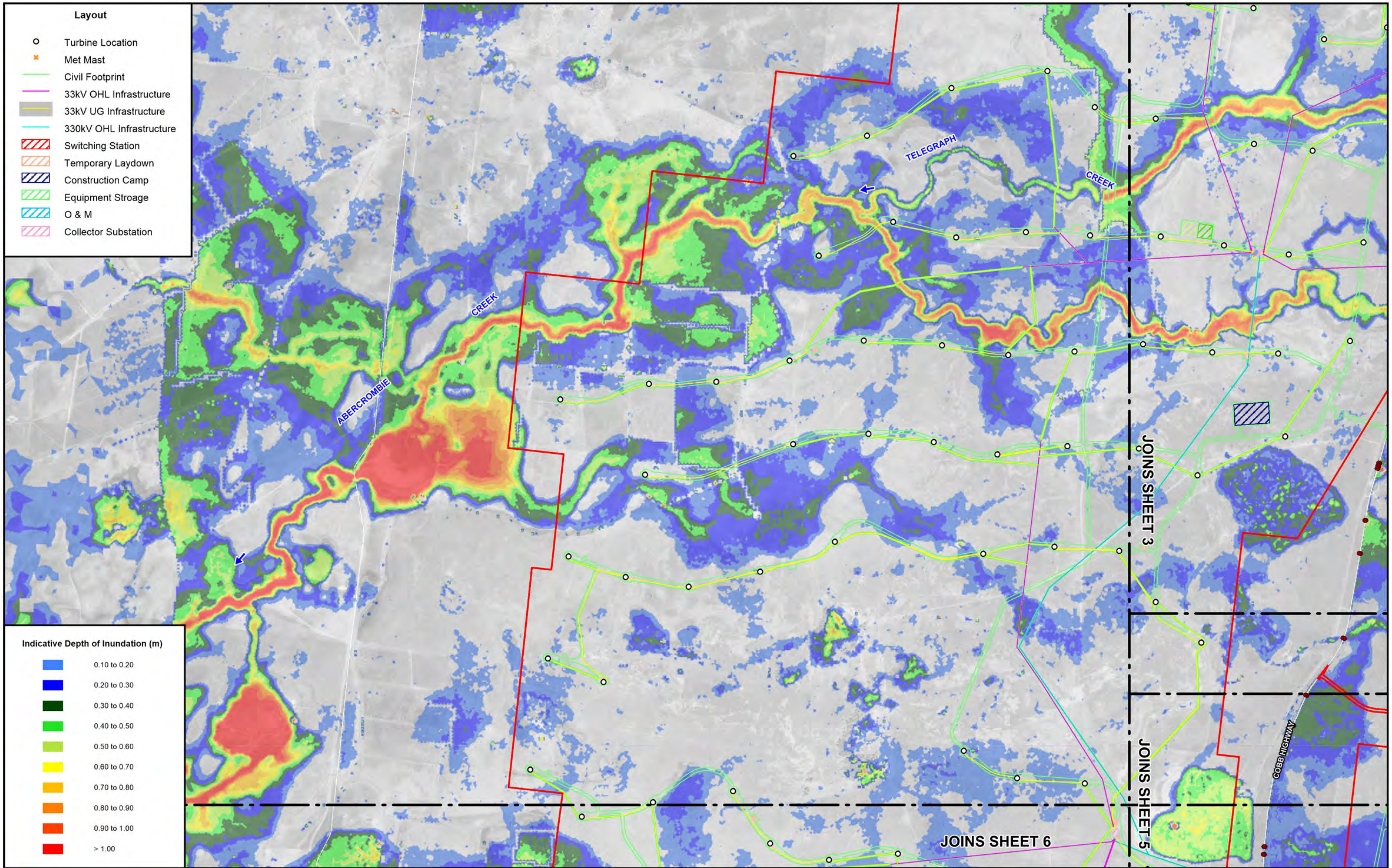
LEGEND

Project Area
LGA Boundary
Modelled Drainage Structures

THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure 4.6
(Sheet 3 of 6)

FLOODING AND DRAINAGE PATTERNS UNDER PRE-PROJECT CONDITIONS
1% AEP LOCAL CATCHMENT FLOOD EVENT



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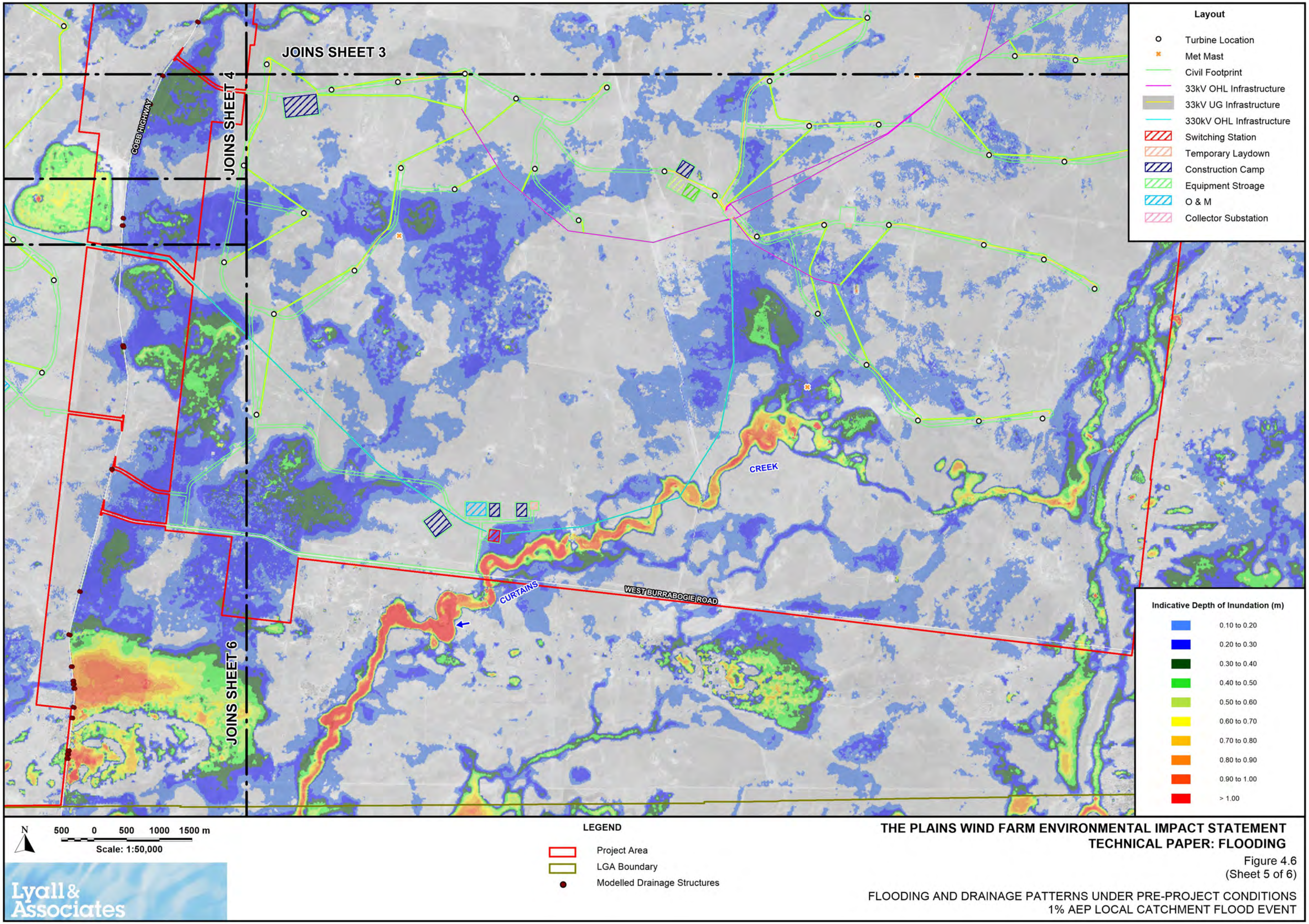
THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure 4.6
(Sheet 4 of 6)

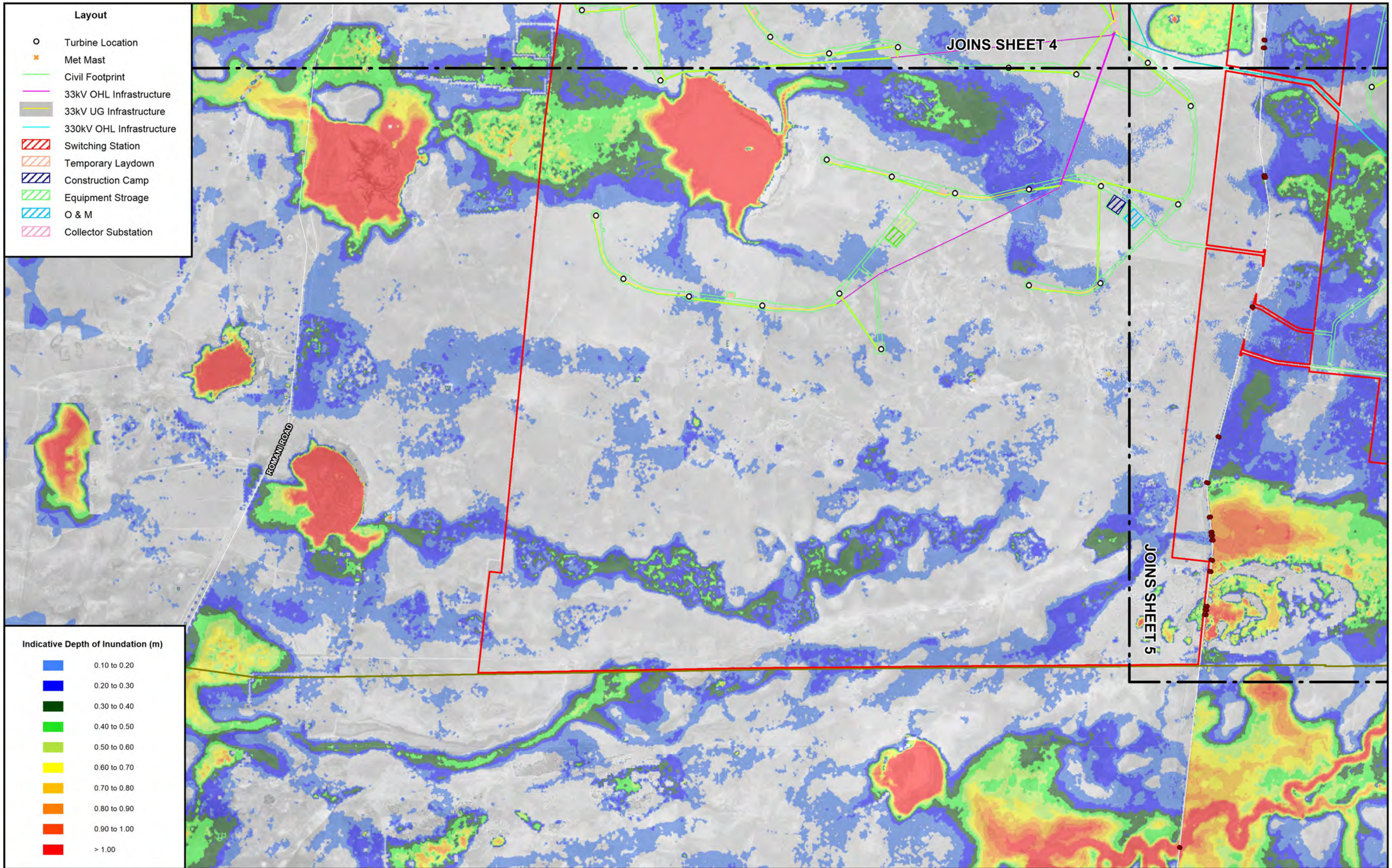
FLOODING AND DRAINAGE PATTERNS UNDER PRE-PROJECT CONDITIONS
1% AEP LOCAL CATCHMENT FLOOD EVENT



THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure 4.6
(Sheet 5 of 6)

FLOODING AND DRAINAGE PATTERNS UNDER PRE-PROJECT CONDITIONS
1% AEP LOCAL CATCHMENT FLOOD EVENT



N

500 0 500 1000 1500 m

Scale: 1:50,000

Lyall & Associates

LEGEND

Project Area

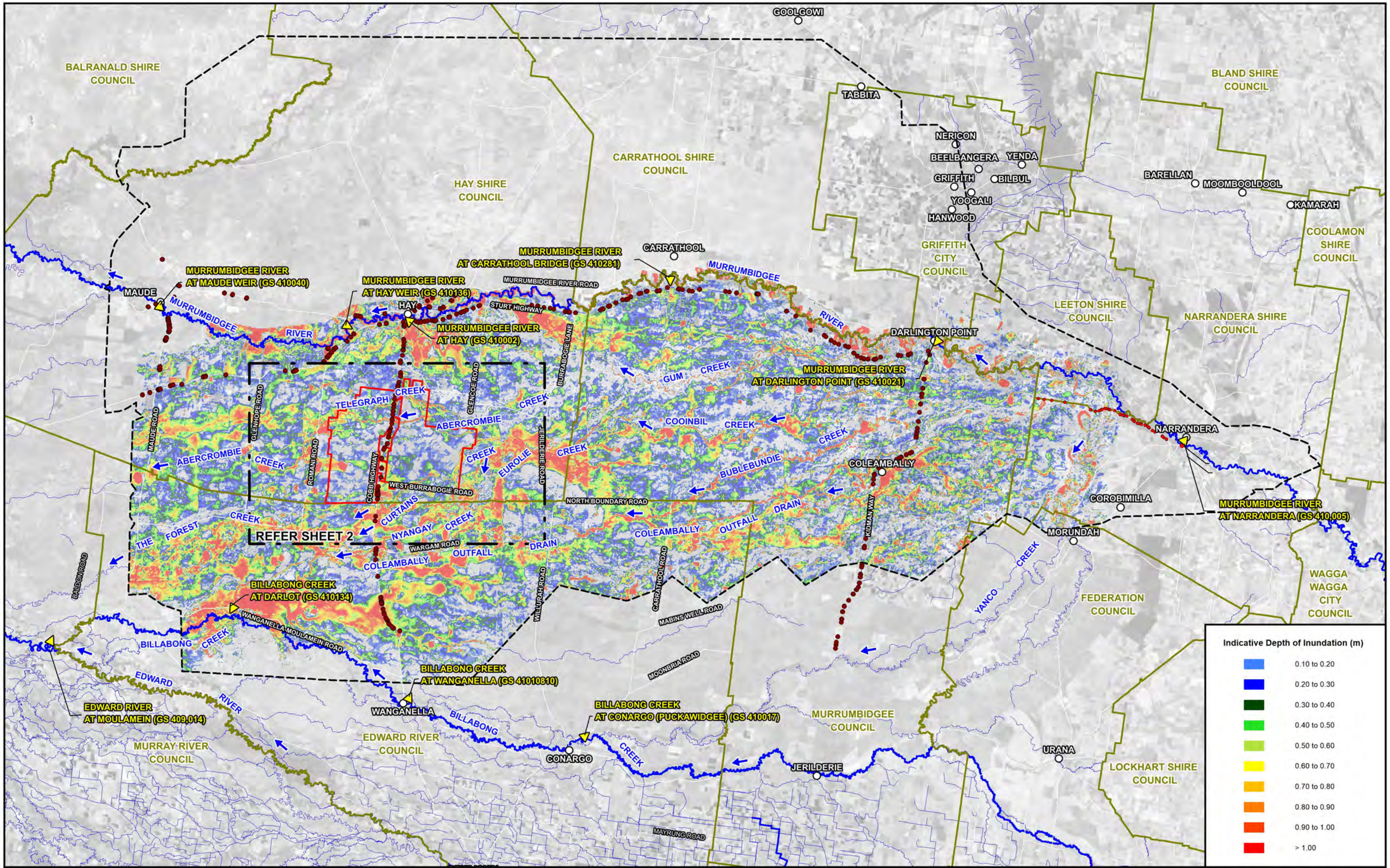
LGA Boundary

Modelled Drainage Structures

THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure 4.6
(Sheet 6 of 6)

FLOODING AND DRAINAGE PATTERNS UNDER PRE-PROJECT CONDITIONS
1% AEP LOCAL CATCHMENT FLOOD EVENT



N

7 0 7 14 21 km

Scale: 1:700,000

Project Area

LGA Boundary

LEGEND

WaterNSW Stream Gauge

Two-Dimensional Model Boundary

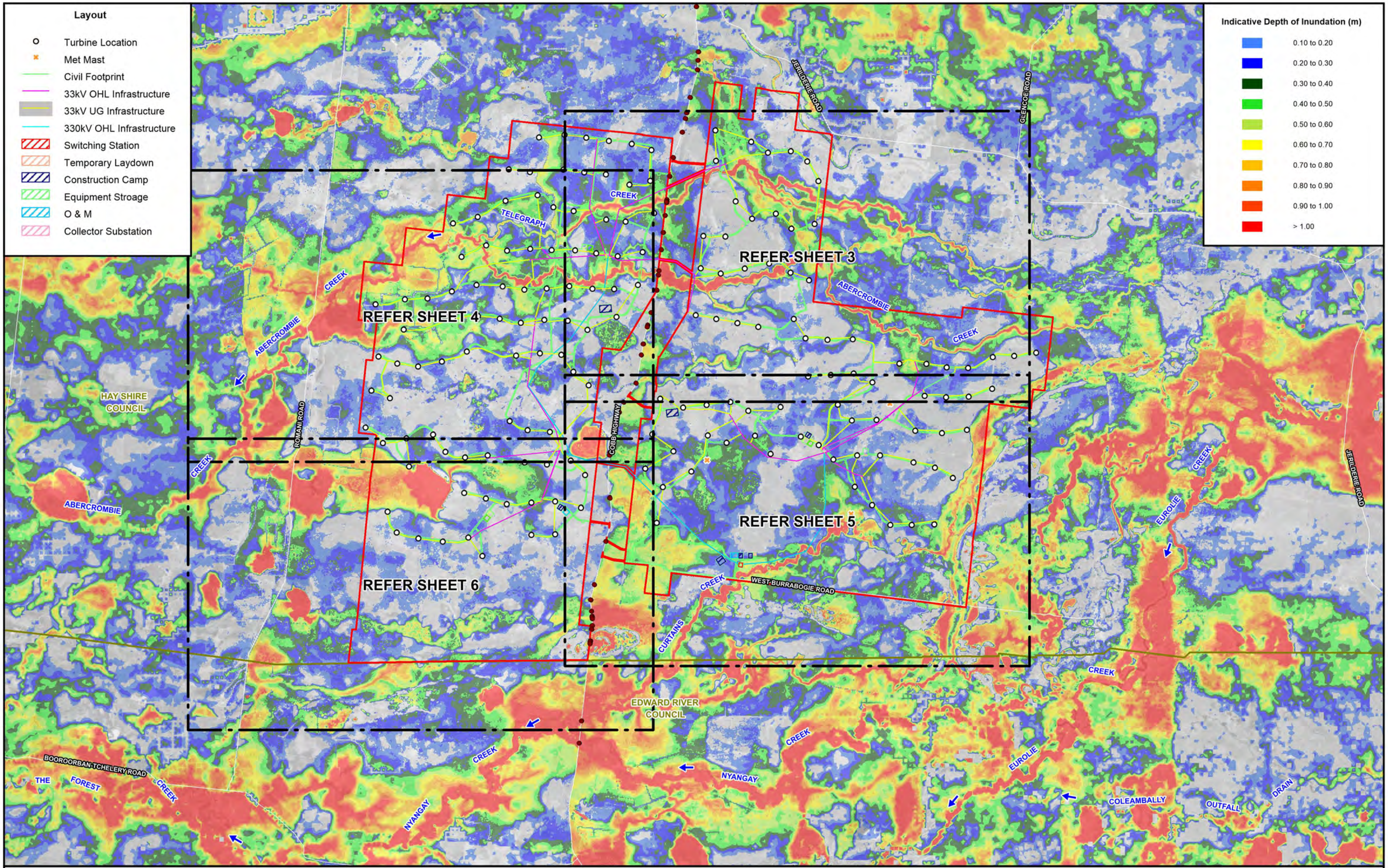
Modelled Drainage Structures

Lyall & Associates

THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure 4.7
(Sheet 1 of 6)

FLOODING AND DRAINAGE PATTERNS UNDER PRE-PROJECT CONDITIONS
PMF LOCAL CATCHMENT FLOOD EVENT



N

1.5 0 1.5 3 4.5 km

Scale: 1:150,000

LEGEND

Project Area

LGA Boundary

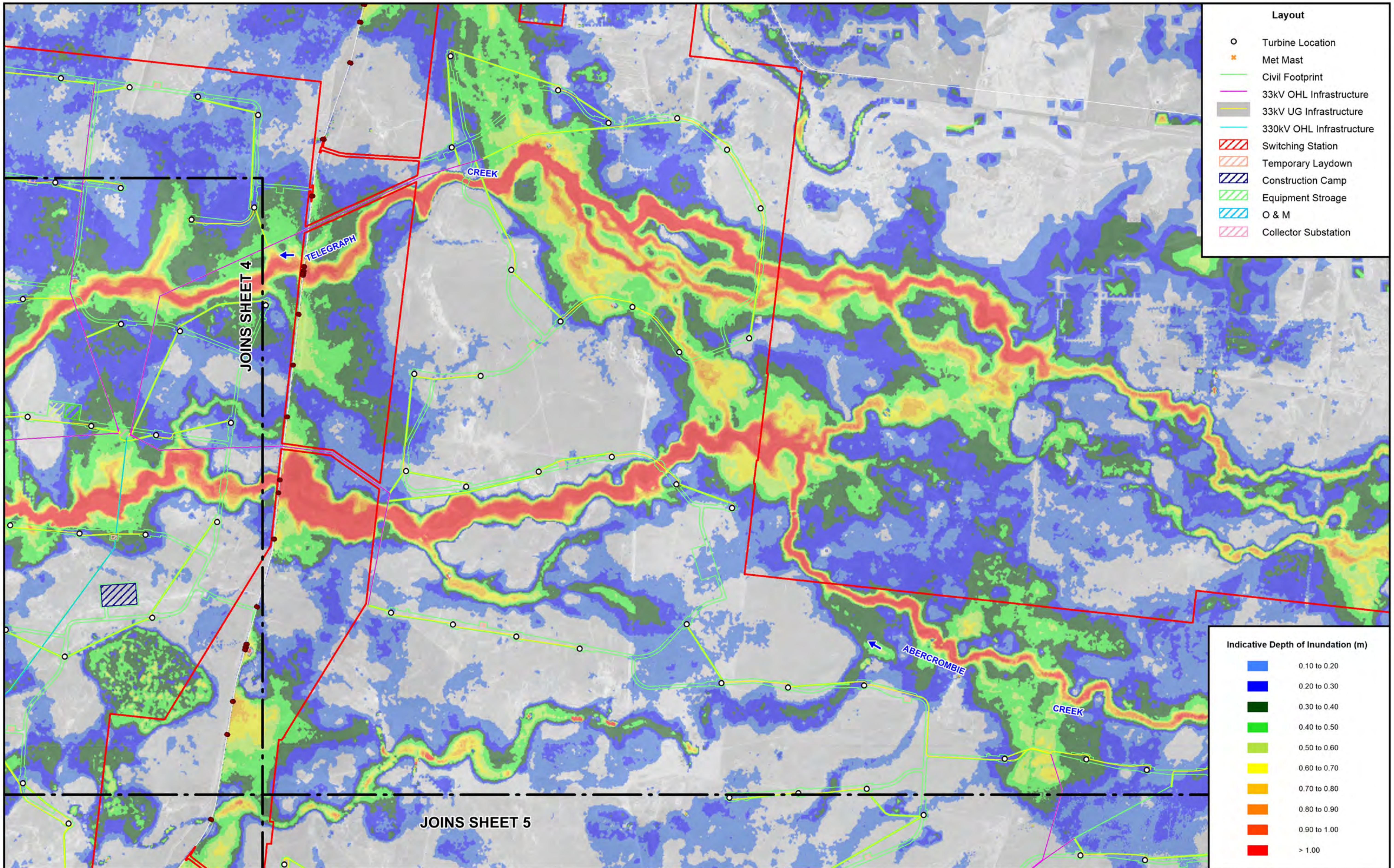
Modelled Drainage Structures

Lyall & Associates

THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure 4.7
(Sheet 2 of 6)

FLOODING AND DRAINAGE PATTERNS UNDER PRE-PROJECT CONDITIONS
PMF LOCAL CATCHMENT FLOOD EVENT



N
500 0 500 1000 1500 m
Scale: 1:50,000

Lyall & Associates

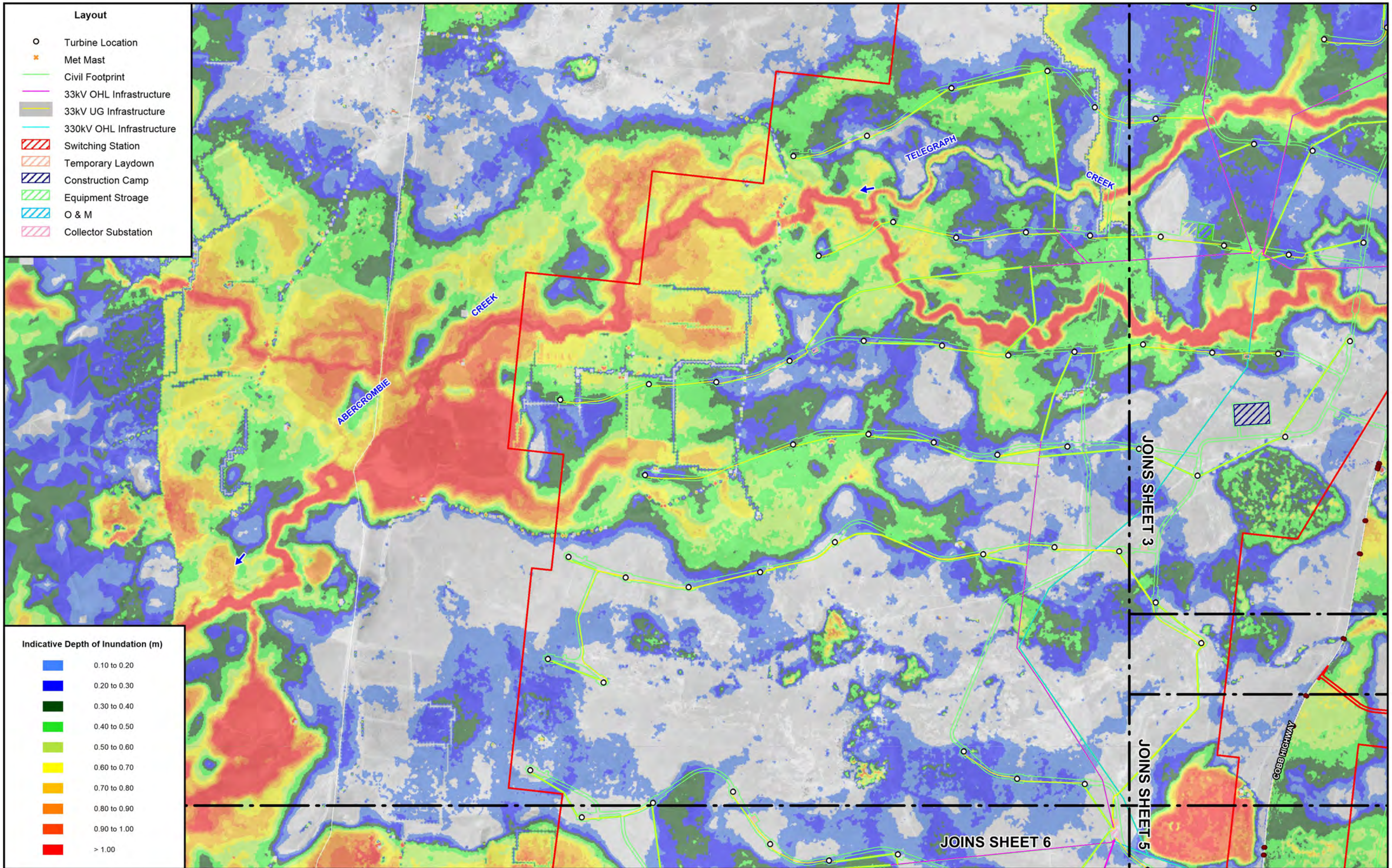
LEGEND

- Project Area
- LGA Boundary
- Modelled Drainage Structures

THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure 4.7
(Sheet 3 of 6)

FLOODING AND DRAINAGE PATTERNS UNDER PRE-PROJECT CONDITIONS
PMF LOCAL CATCHMENT FLOOD EVENT



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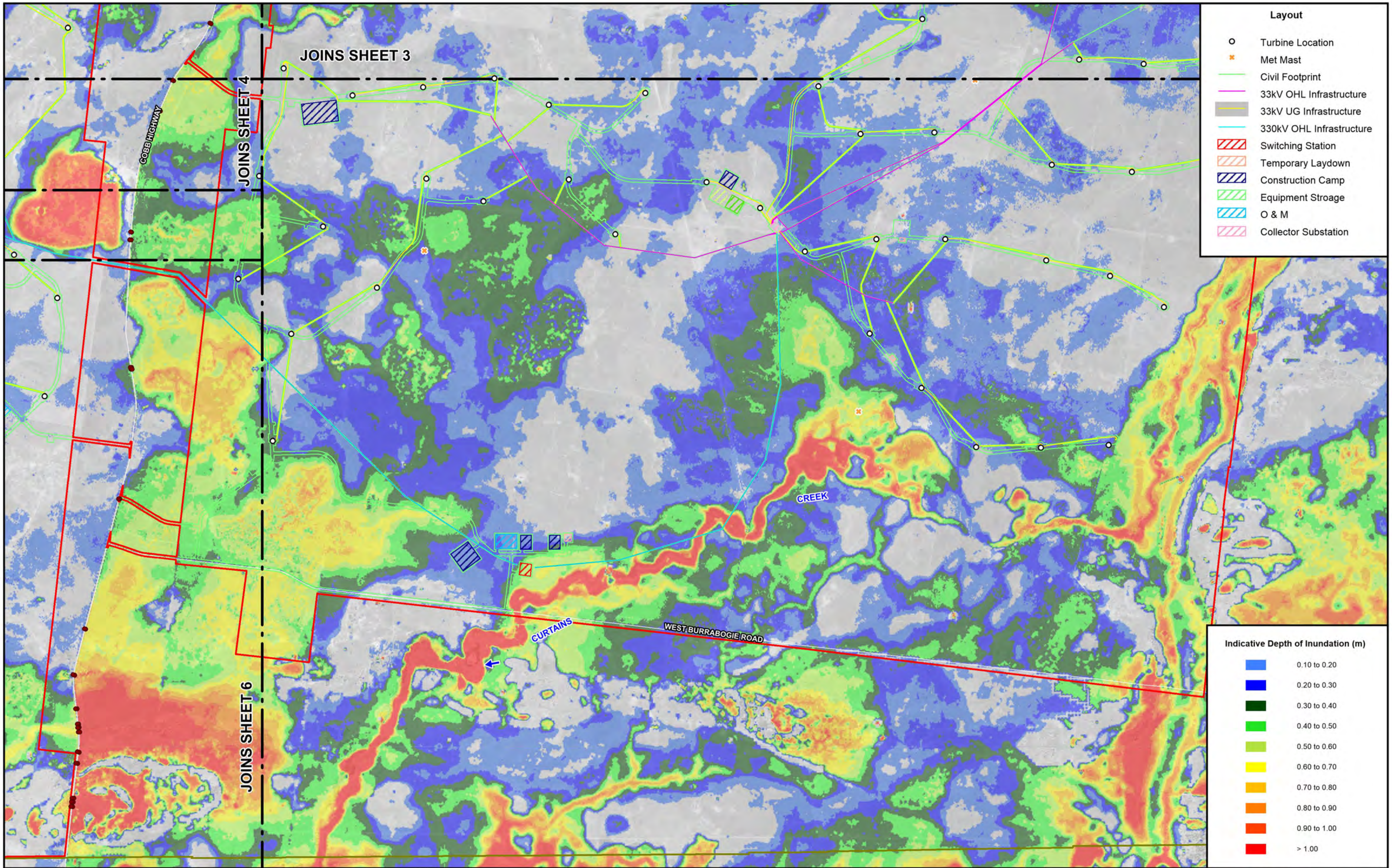
THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure 4.7
(Sheet 4 of 6)

FLOODING AND DRAINAGE PATTERNS UNDER PRE-PROJECT CONDITIONS
PMF LOCAL CATCHMENT FLOOD EVENT



LEGEND

Project Area

LGA Boundary

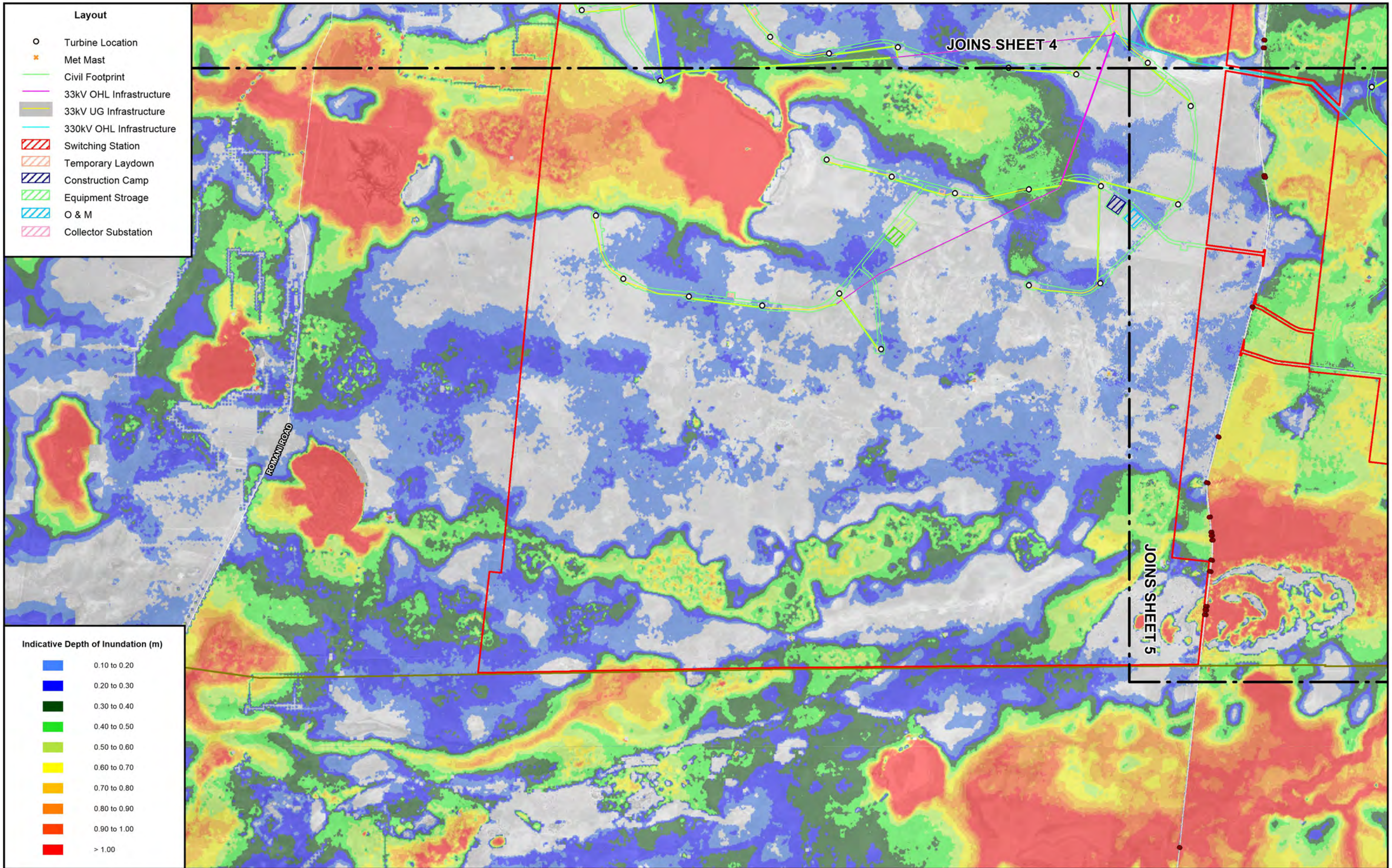
Modelled Drainage Structures

Lyall & Associates

THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure 4.7
(Sheet 5 of 6)

FLOODING AND DRAINAGE PATTERNS UNDER PRE-PROJECT CONDITIONS
PMF LOCAL CATCHMENT FLOOD EVENT



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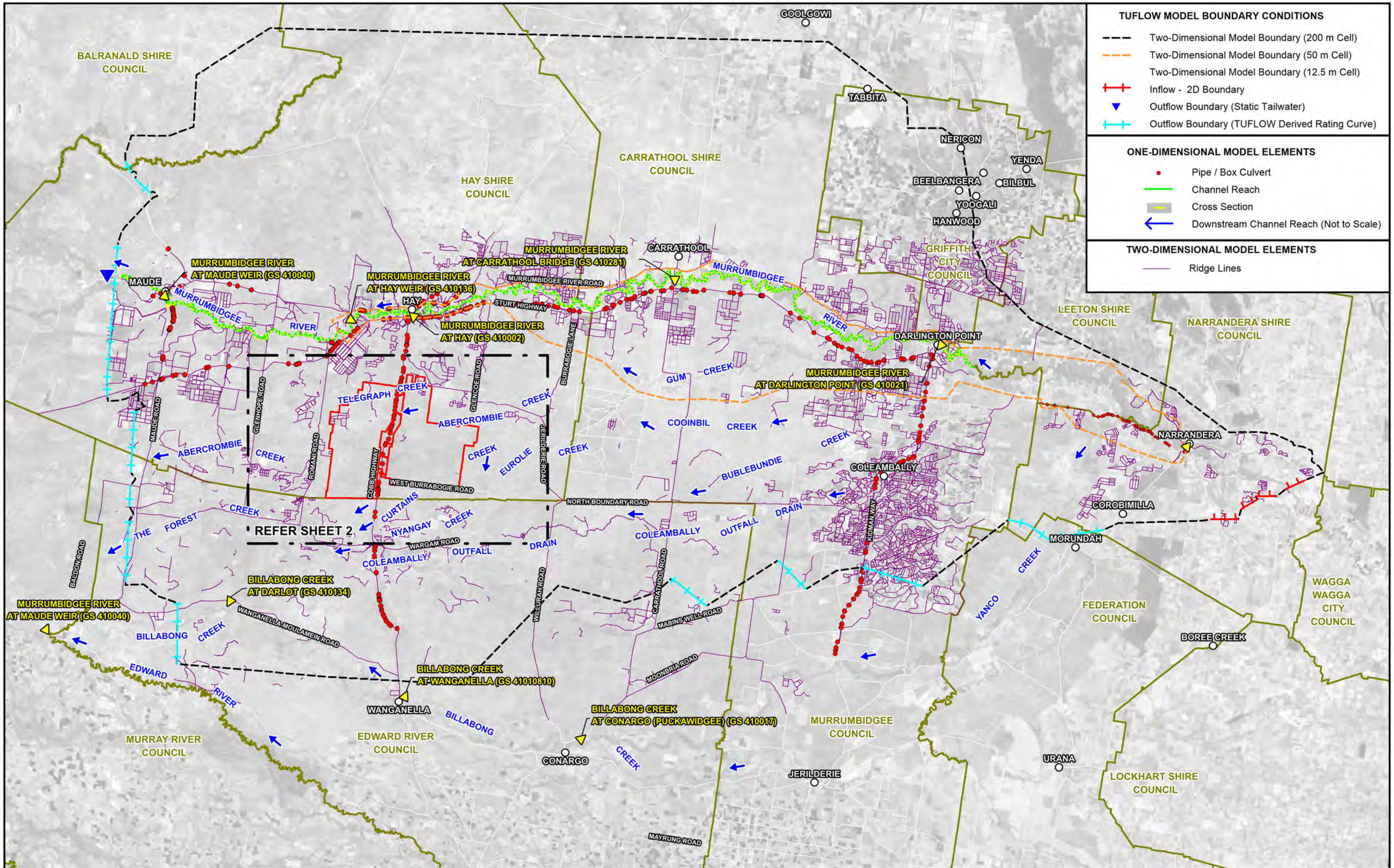
THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure 4.7
(Sheet 6 of 6)

FLOODING AND DRAINAGE PATTERNS UNDER PRE-PROJECT CONDITIONS
PMF LOCAL CATCHMENT FLOOD EVENT

APPENDIX A
FIGURES SHOWING THE LAYOUT OF HYDRAULIC MODELS



N

7 0 7 14 21 km

Scale: 1:700,000

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LEGEND

Project Area

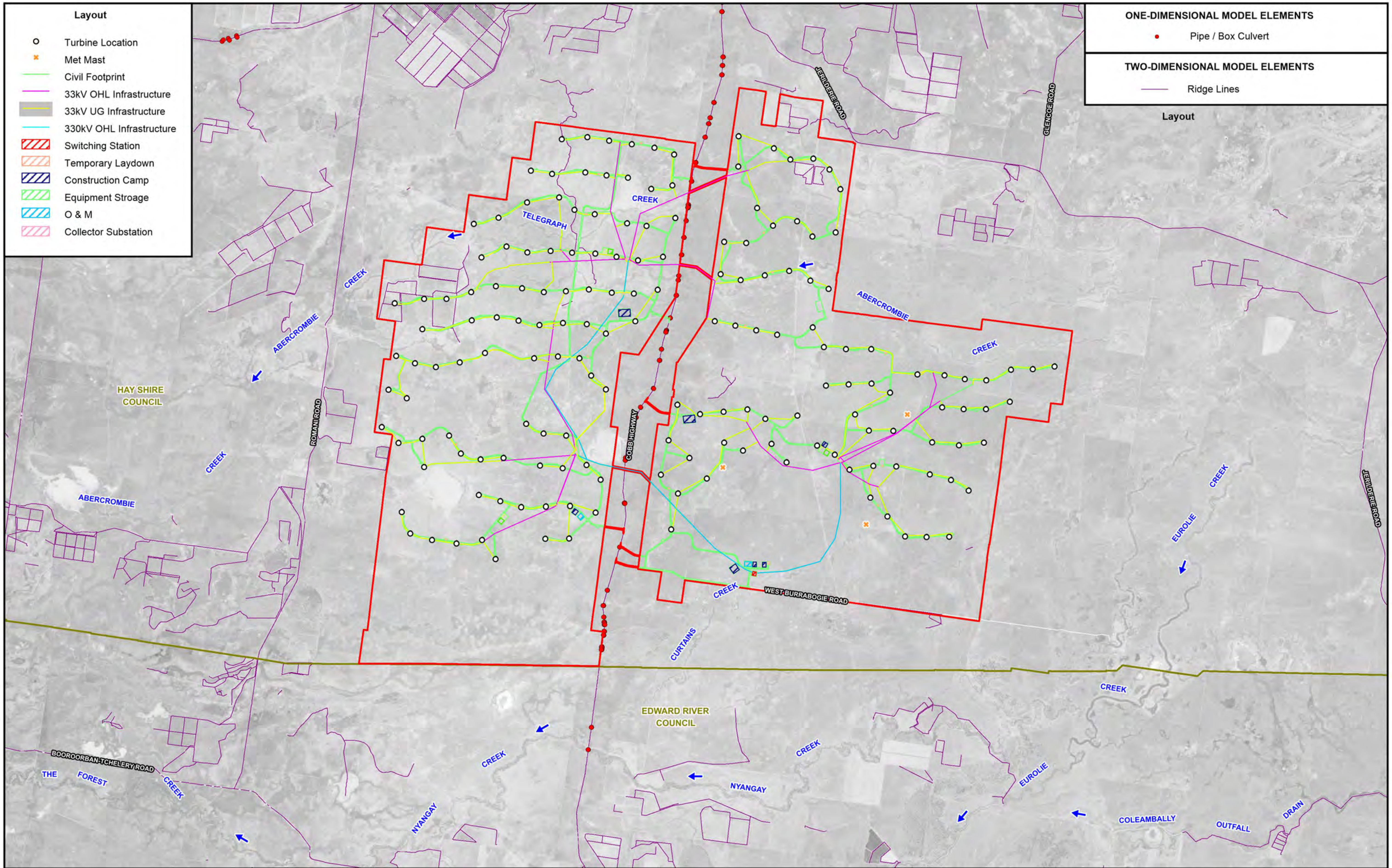
LGA Boundary

WaterNSW Stream Gauge

THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure A1
(Sheet 1 of 2)

MURRUMBIDGEE RIVER TUFLOW MODEL LAYOUT



N

7 0 7 14 21 km

Scale: 1:150,000

Lyall & Associates

LEGEND

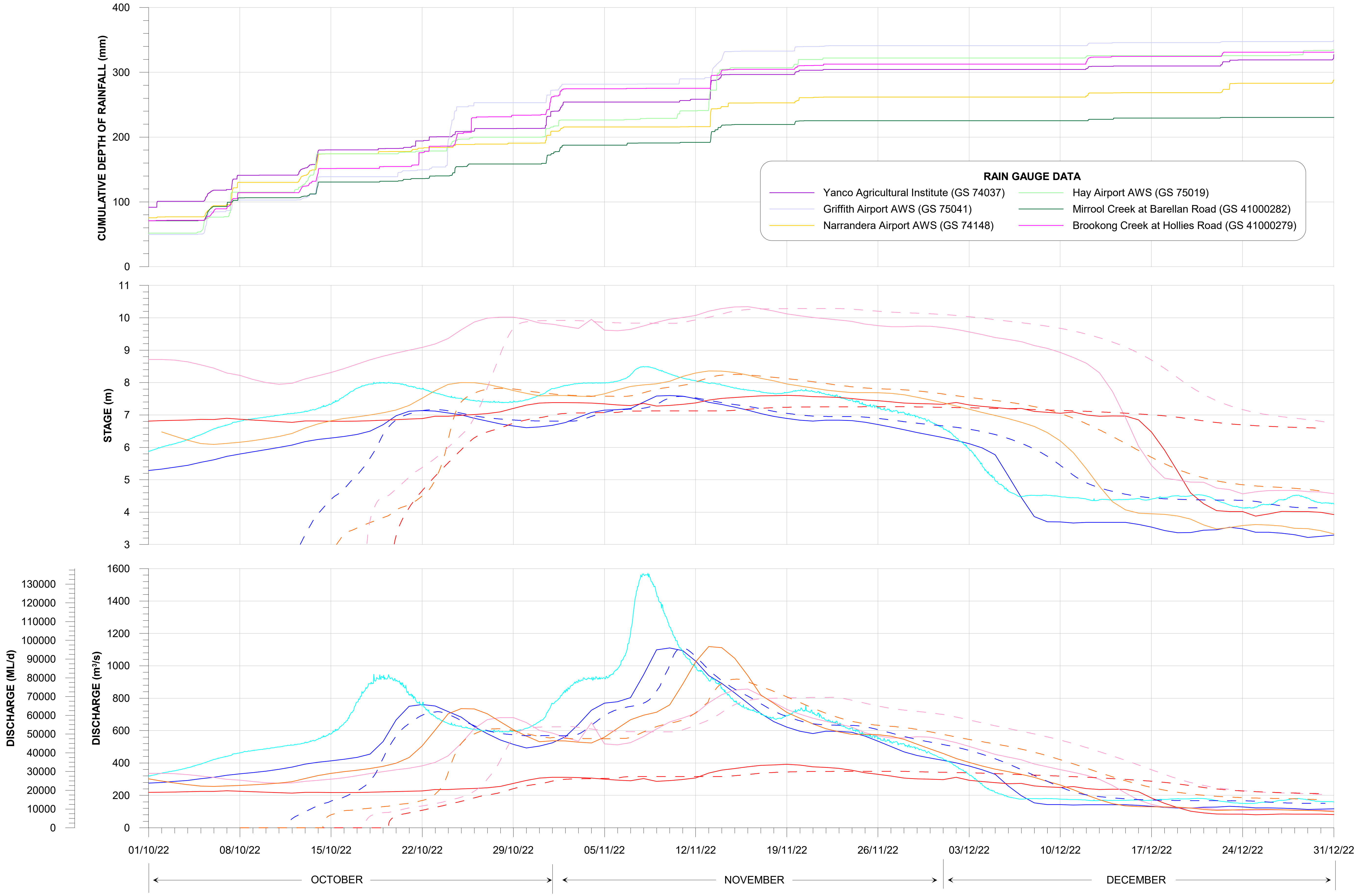
Project Area

LGA Boundary

THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure A1
(Sheet 2 of 2)

MURRUMBIDGEE RIVER TUFLOW MODEL LAYOUT



STREAM GAUGE DATA

Modelled	Recorded	
		Murrumbidgee River At Narrandera (GS 410005)
		Murrumbidgee River At Darlington Point (GS 410221)
		Murrumbidgee River At Carrathool Bridge (GS 41000281)
		Murrumbidgee River At Hay Weir (GS 410136)
		Murrumbidgee River At Maude Weir (GS 410040)

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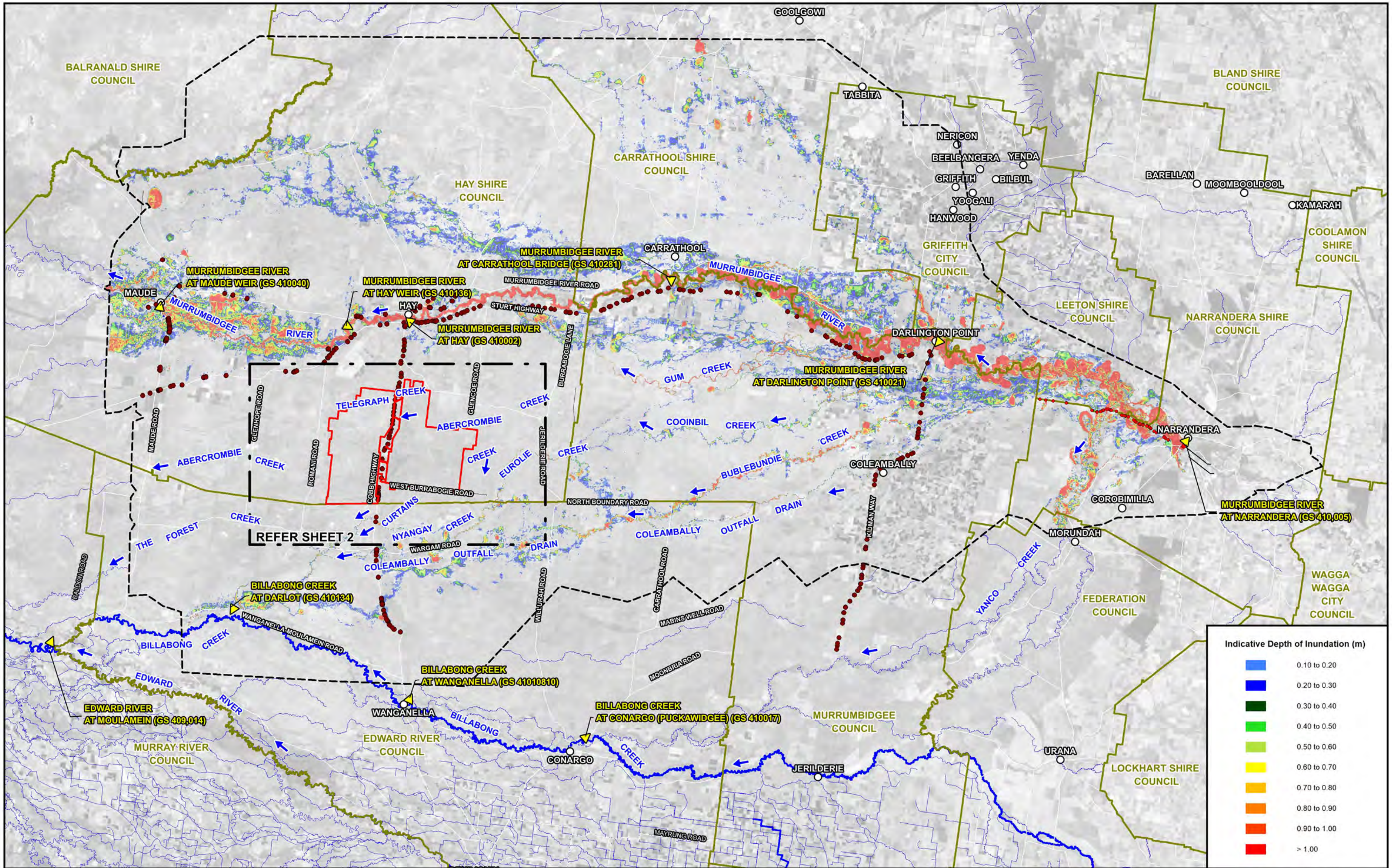
NOTE

Time zero on calendar day axis = 0000 hours on 1 September 2022.

THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure A2

STREAM AND RAIN GAUGE DATA
OCTOBER - DECEMBER 2022



N

7 0 7 14 21 km

Scale: 1:700,000

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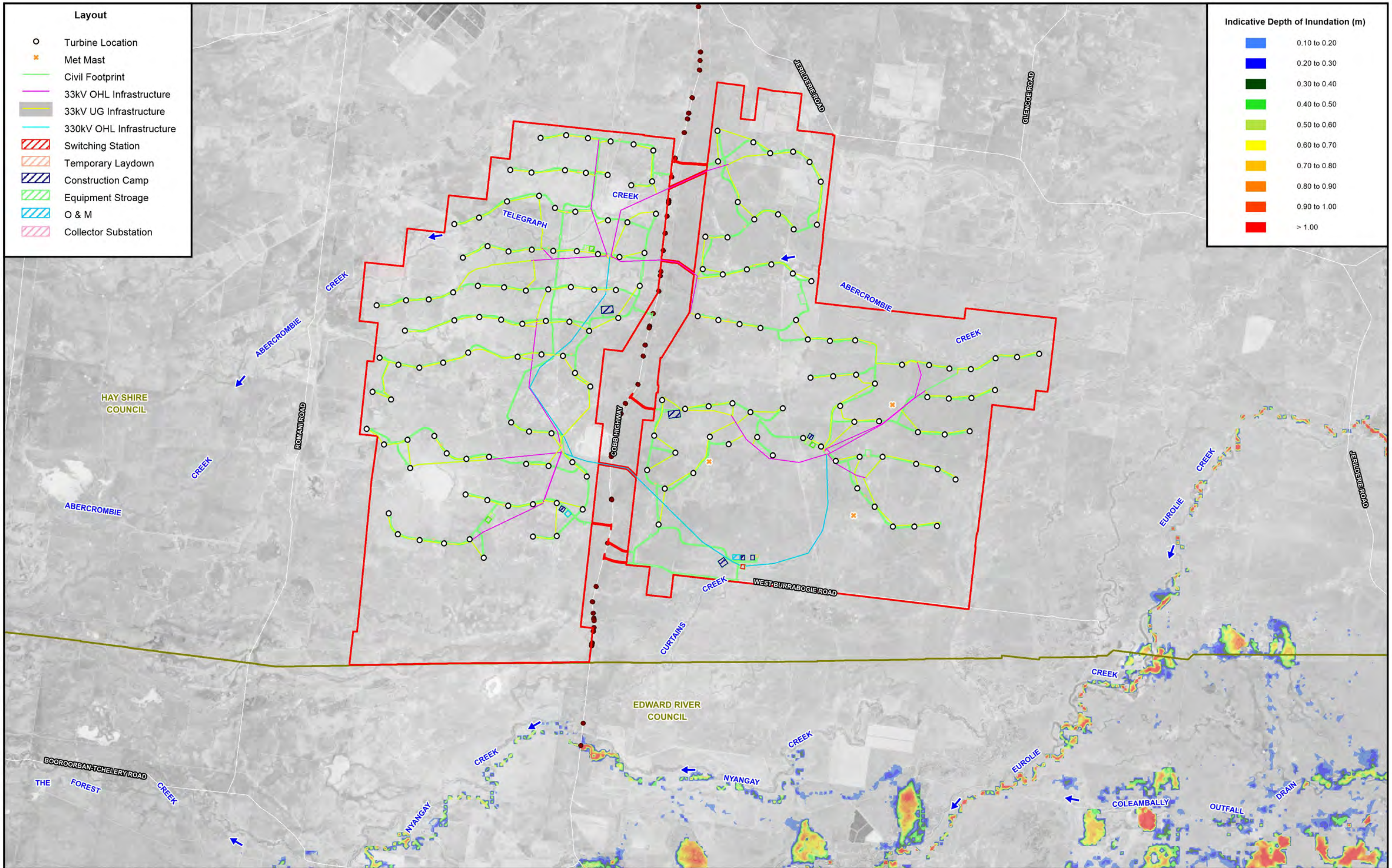
LEGEND

- Project Area
- LGA Boundary
- WaterNSW Stream Gauge
- Two-Dimensional Model Boundary
- Modelled Drainage Structures

THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure A3
(Sheet 1 of 2)

MURRUMBIDGEE RIVER TUFLOW MODEL RESULTS
OCTOBER-DECEMBER 2022 FLOOD EVENT



N

1.5 0 1.5 3 4.5 km

Scale: 1:150,000

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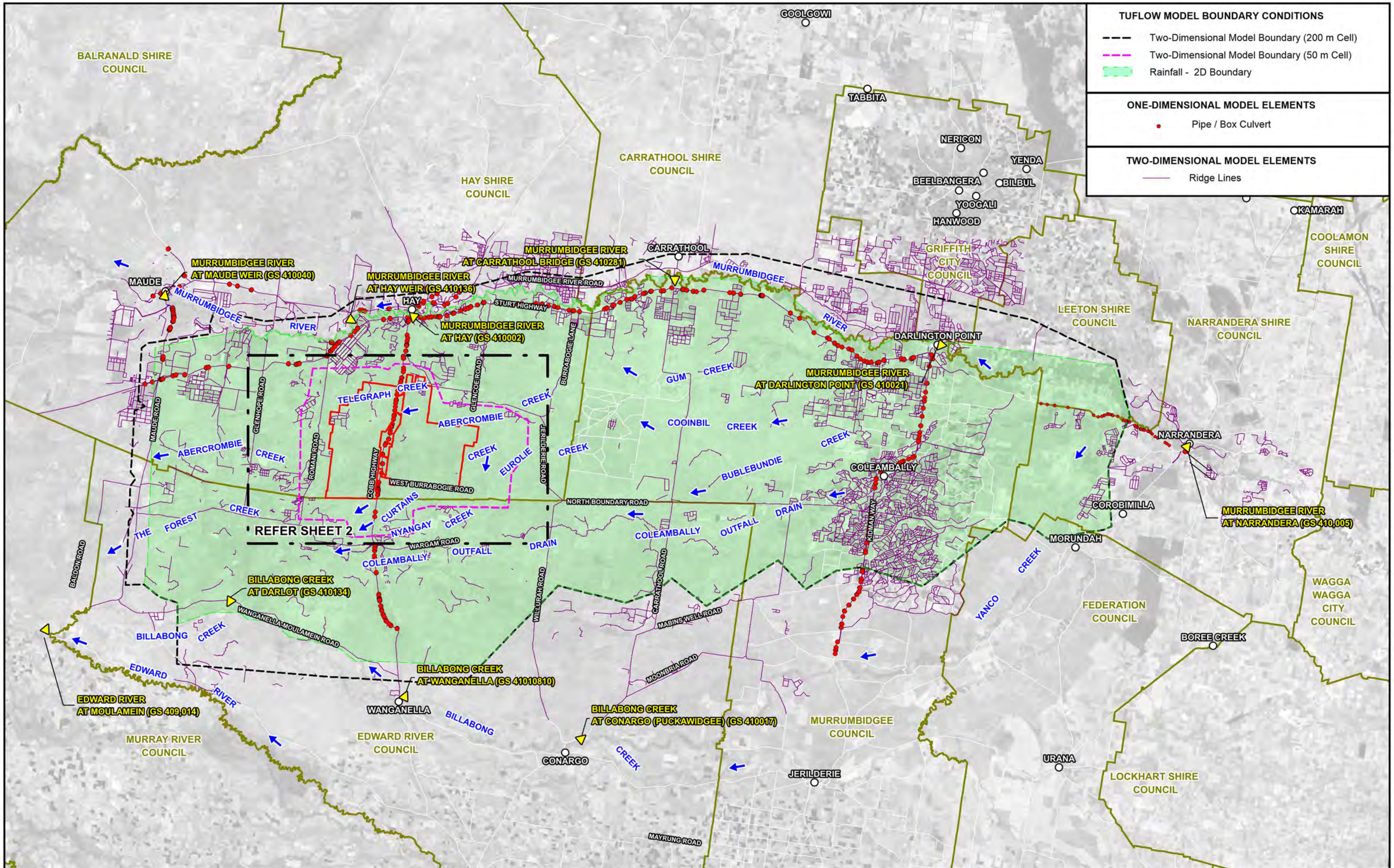
LEGEND

- Project Area
- LGA Boundary
- Modelled Drainage Structures

THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure A3
(Sheet 2 of 2)

MURRUMBIDGEE RIVER TUFLOW MODEL RESULTS
OCTOBER-DECEMBER 2022 FLOOD EVENT



N

7 0 7 14 21 km

Scale: 1:700,000

LEGEND

Project Area

LGA Boundary

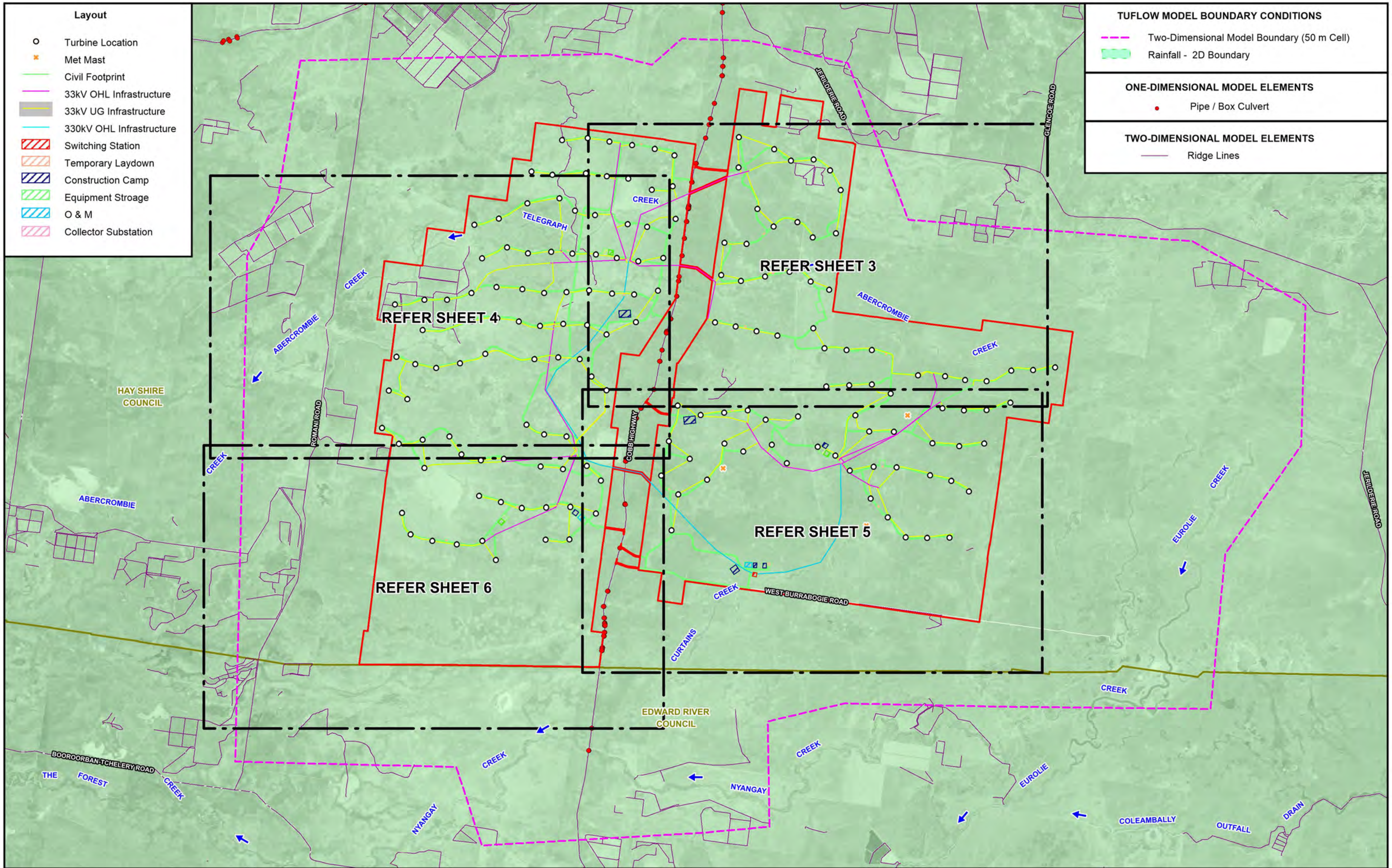
WaterNSW Stream Gauge

Lyall & Associates

THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure A4
(Sheet 1 of 6)

LOCAL CATCHMENT TUFLOW MODEL LAYOUT



N

7 0 7 14 21 km

Scale: 1:150,000

LEGEND

Project Area

LGA Boundary

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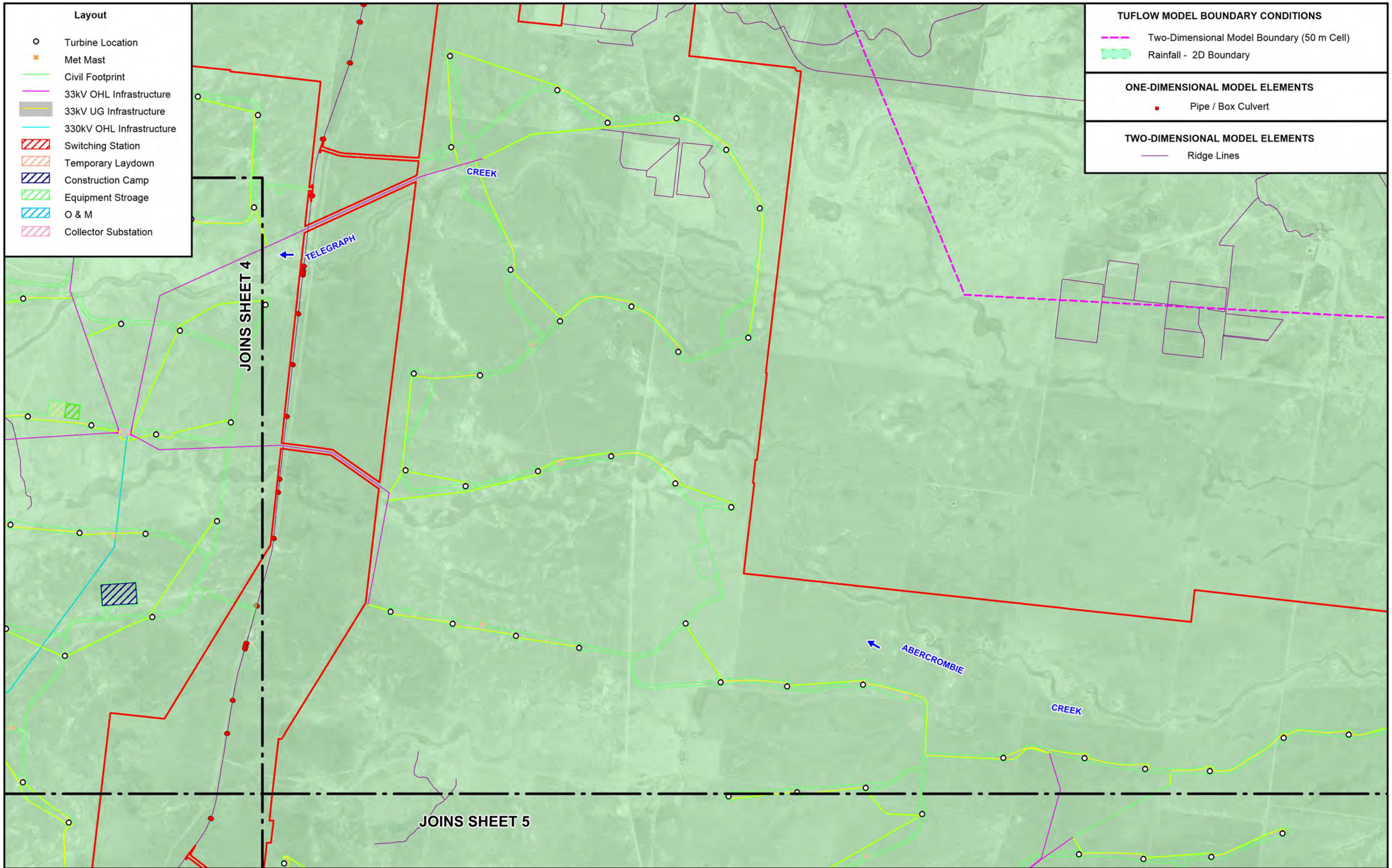
THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure A4
(Sheet 2 of 6)

LOCAL CATCHMENT TUFLOW MODEL LAYOUT



N

7 0 7 14 21 km

Scale: 1:150,000

Lyall & Associates

LEGEND

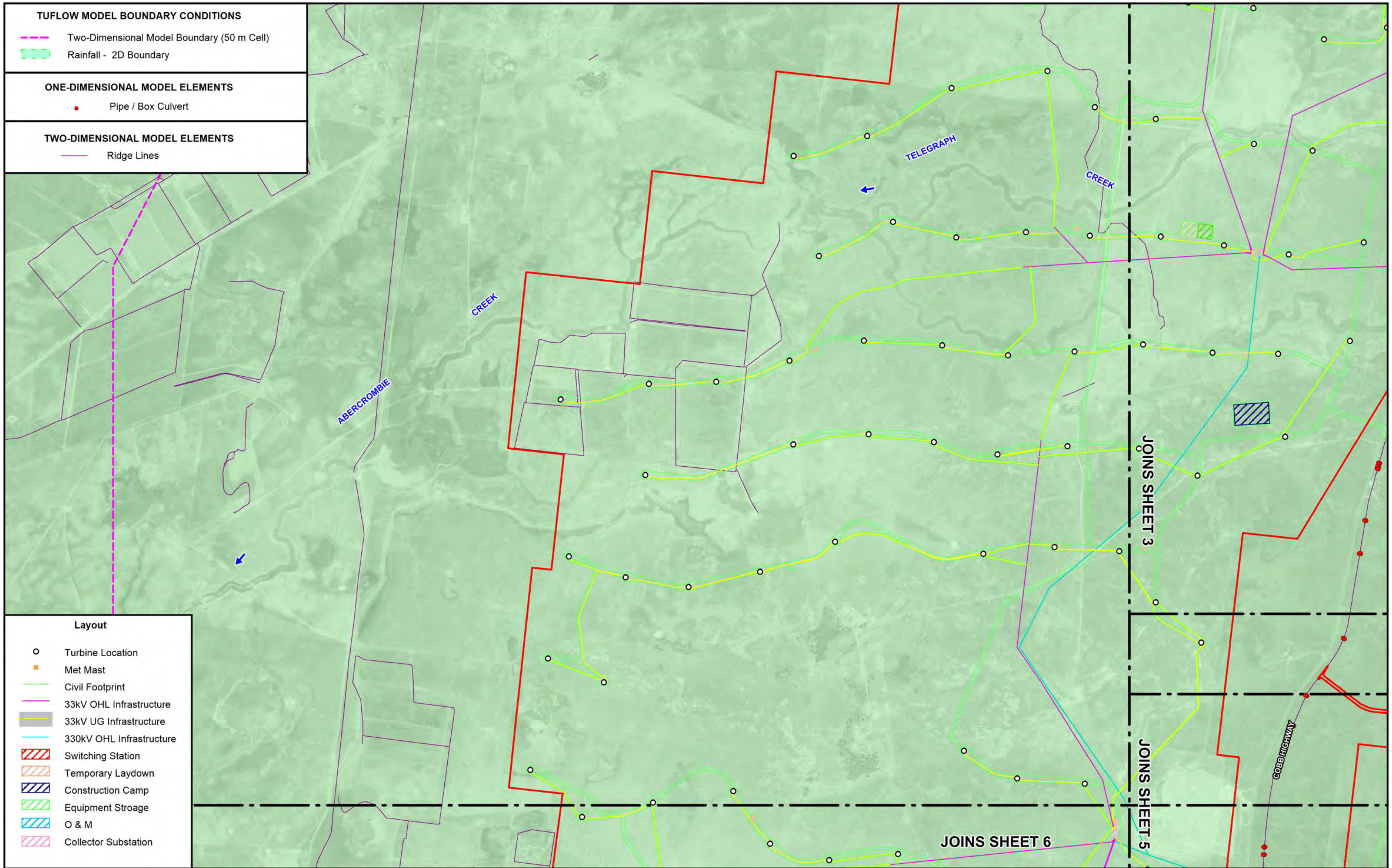
Project Area

LGA Boundary

THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure A4
(Sheet 3 of 6)

LOCAL CATCHMENT TUFLOW MODEL LAYOUT



N

7 0 7 14 21 km

Scale: 1:150,000

Lyall & Associates

LEGEND

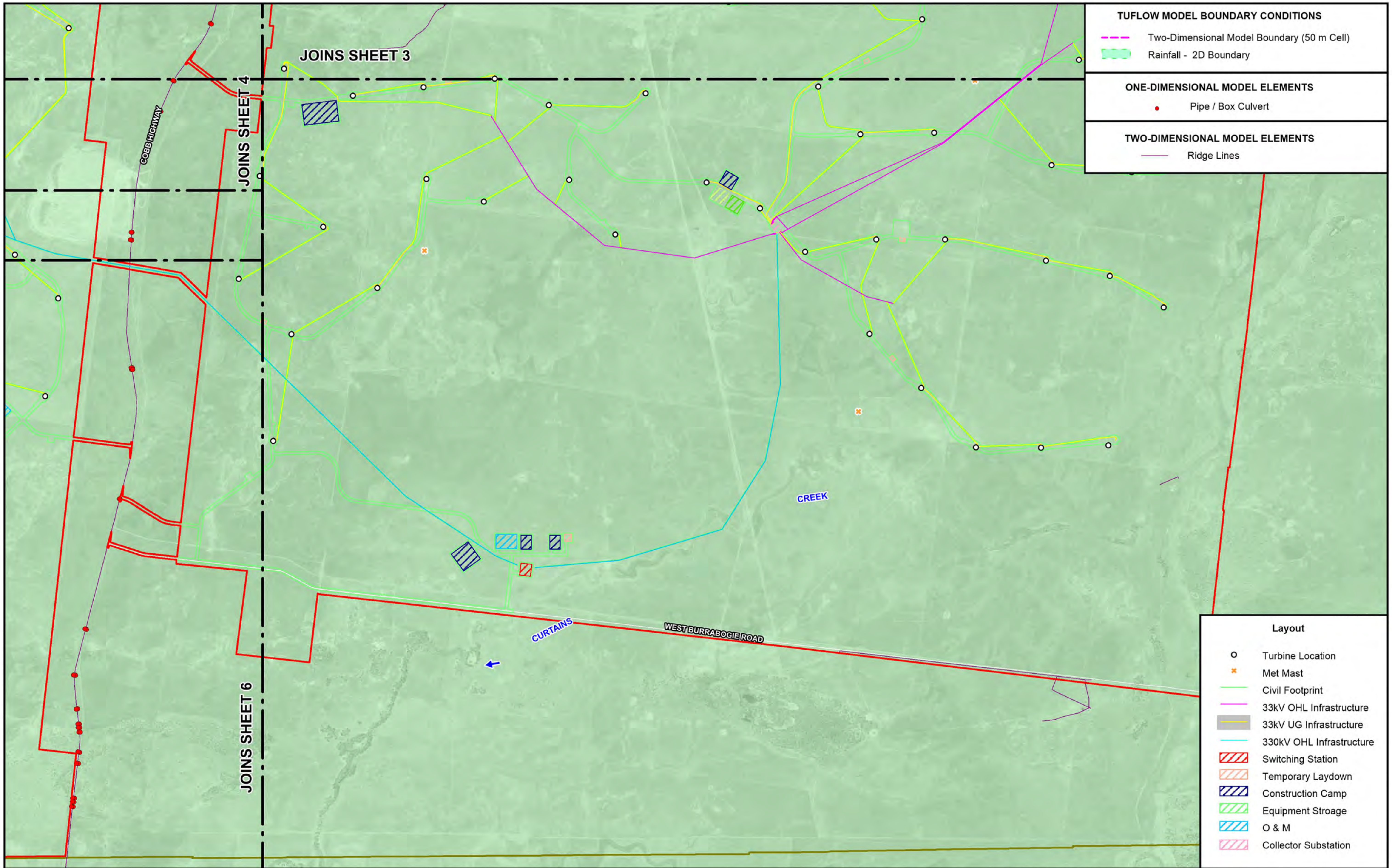
Project Area

LGA Boundary

THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure A4
(Sheet 4 of 6)

LOCAL CATCHMENT TUFLOW MODEL LAYOUT



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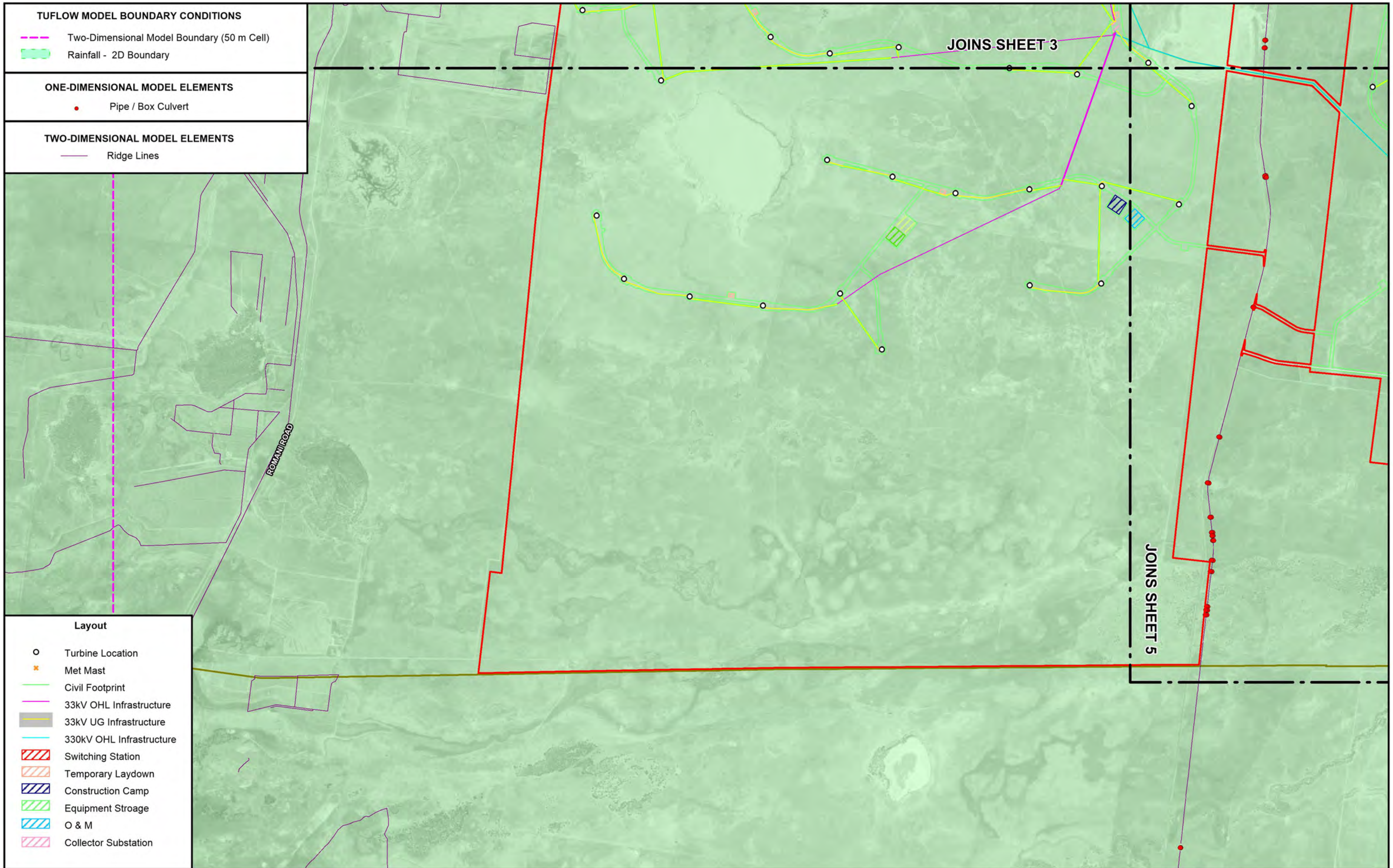
THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure A4
(Sheet 5 of 6)

LOCAL CATCHMENT TUFLOW MODEL LAYOUT



N

7 0 7 14 21 km

Scale: 1:150,000

Lyall & Associates

LEGEND

Project Area

LGA Boundary

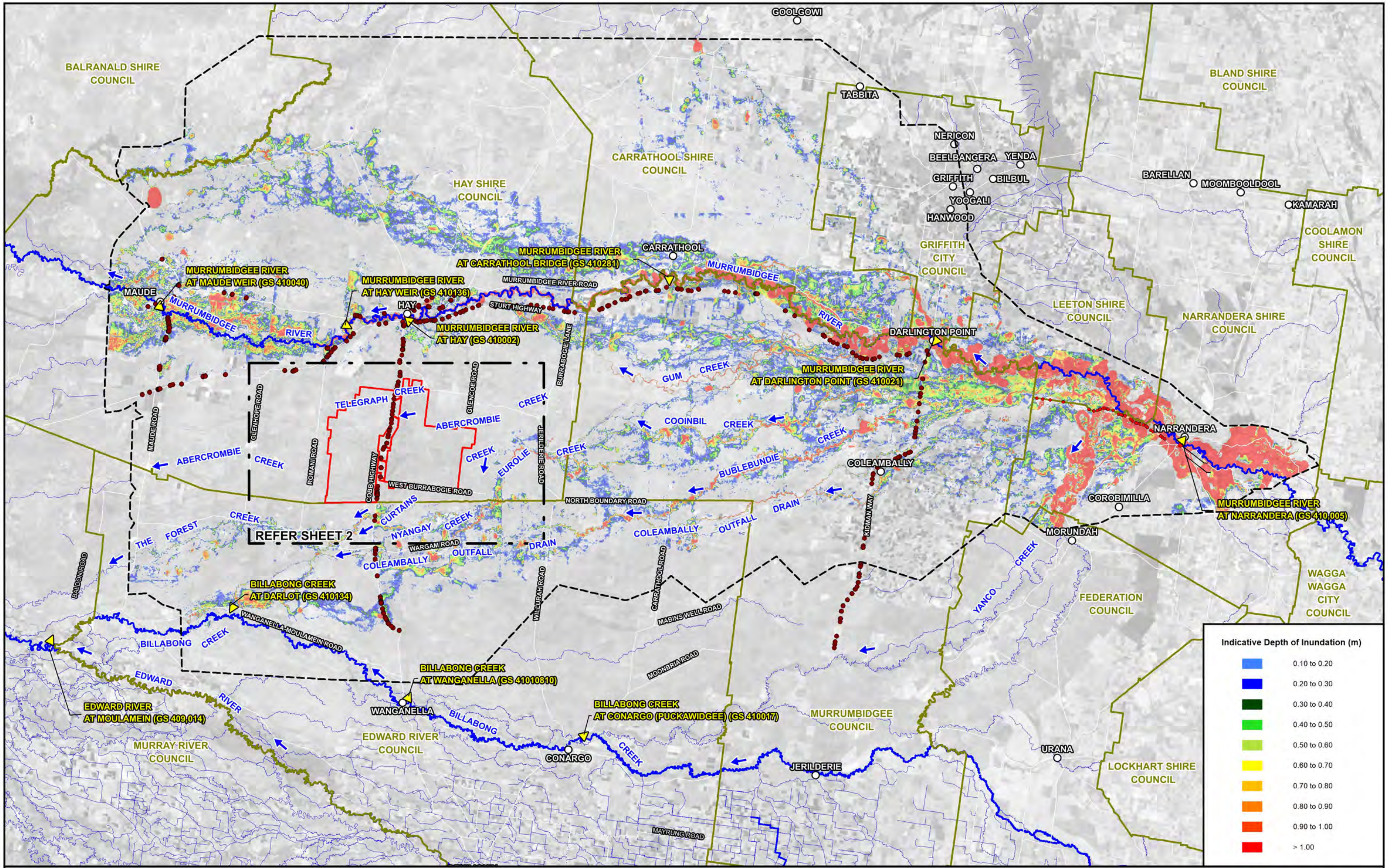
THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure A4
(Sheet 6 of 6)

LOCAL CATCHMENT TUFLOW MODEL LAYOUT

APPENDIX B

FIGURES SHOWING THE INDICATIVE EXTENT AND DEPTH OF INUNDATION UNDER PRE-PROJECT CONDITIONS ACROSS THE PROJECT DURING A 0.5% AND 0.2% AEP MURRUMBIDGEE RIVER FLOOD EVENT



N

7 0 7 14 21 km

Scale: 1:700,000

Lyall & Associates

LEGEND

Project Area

LGA Boundary

WaterNSW Stream Gauge

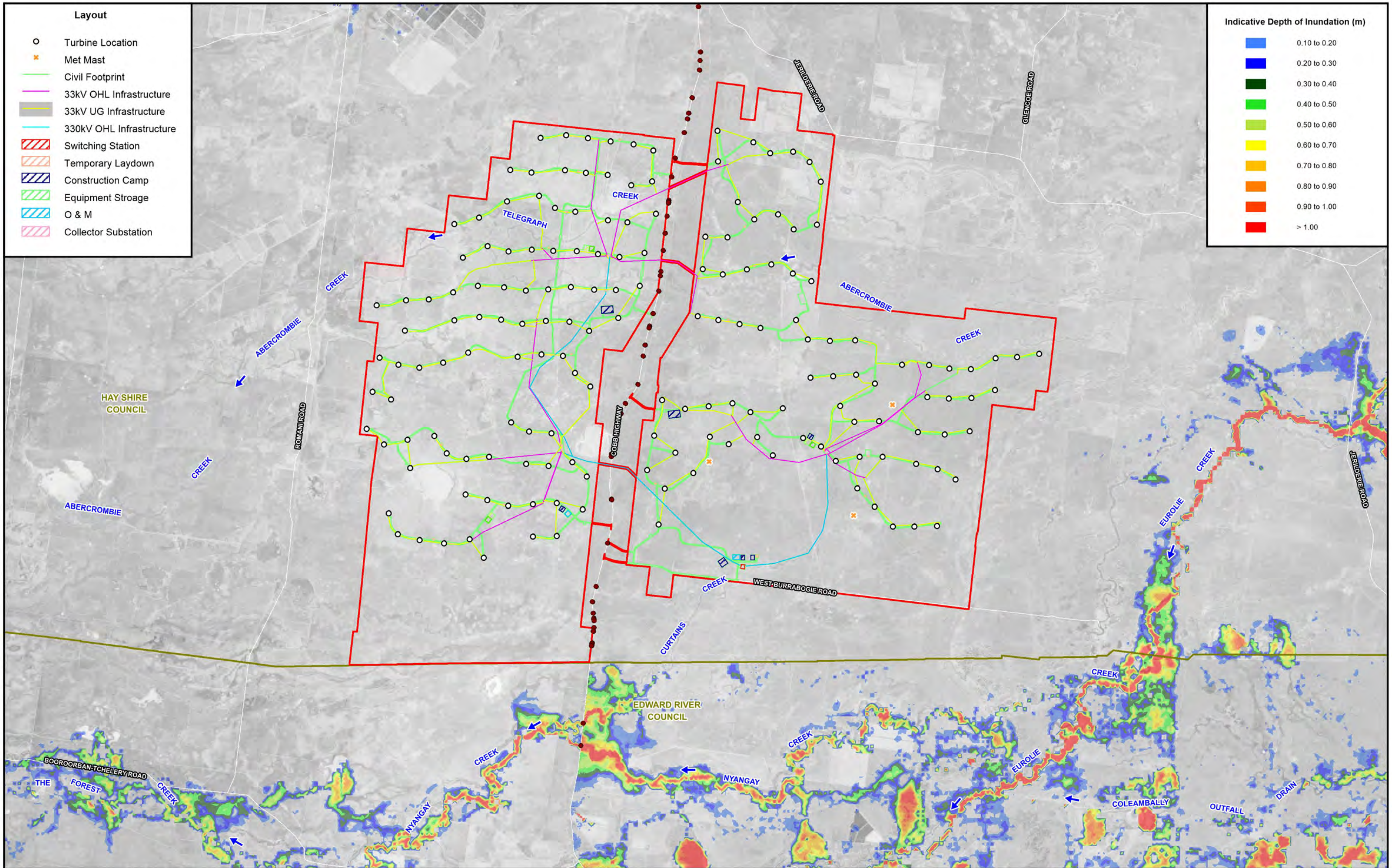
Two-Dimensional Model Boundary

Modelled Drainage Structures

THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure B1
(Sheet 1 of 2)

FLOODING AND DRAINAGE PATTERNS UNDER PRE-PROJECT CONDITIONS
0.5% AEP MURRUMBIDGEE RIVER FLOOD EVENT



N
1.5 0 1.5 3 4.5 km
Scale: 1:150,000

Lyall & Associates

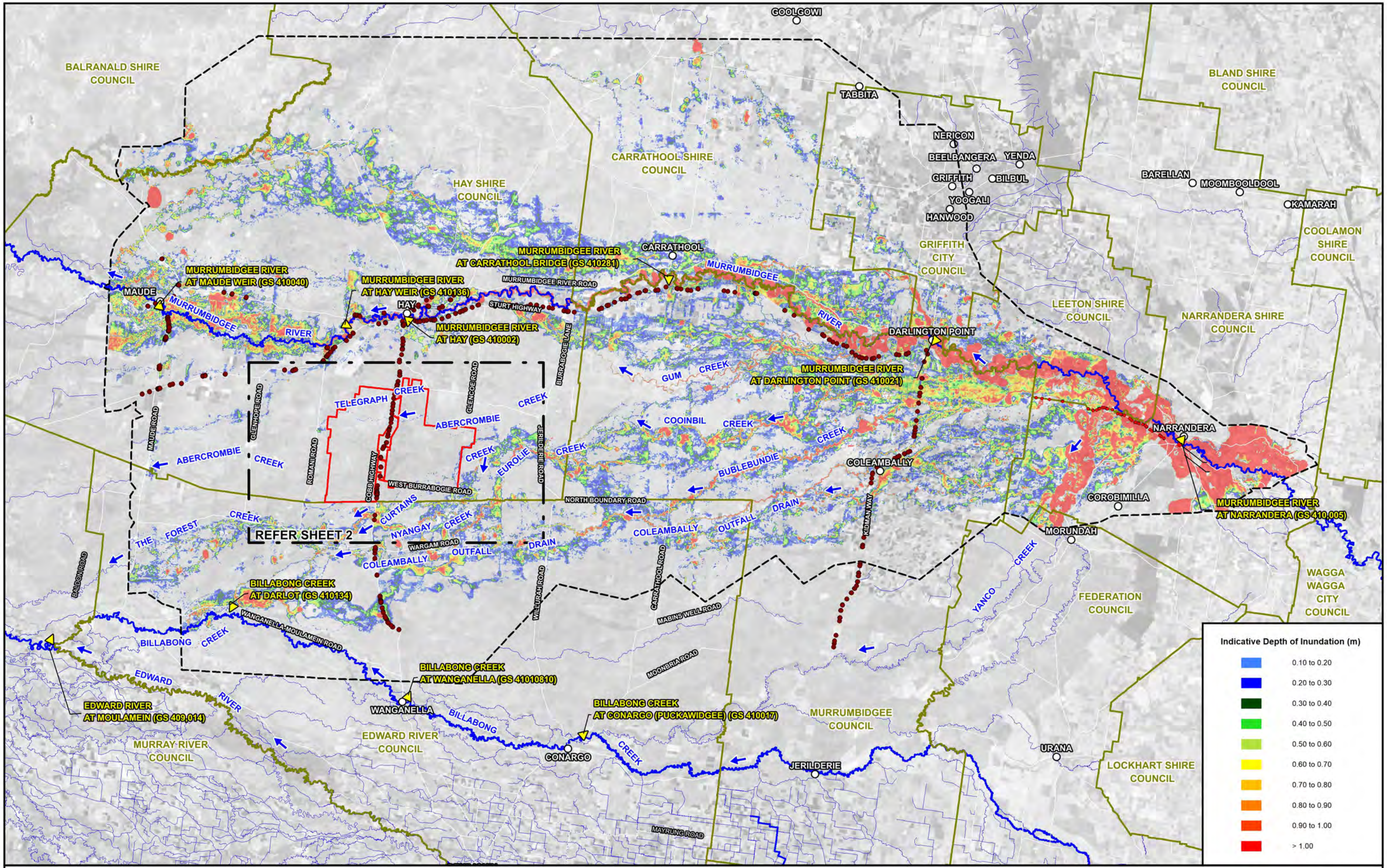
LEGEND

- Project Area
- LGA Boundary
- Modelled Drainage Structures

THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure B1
(Sheet 2 of 2)

FLOODING AND DRAINAGE PATTERNS UNDER PRE-PROJECT CONDITIONS
0.5% AEP MURRUMBIDGEE RIVER FLOOD EVENT



N
7 0 7 14 21 km
Scale: 1:700,000

Lyall & Associates

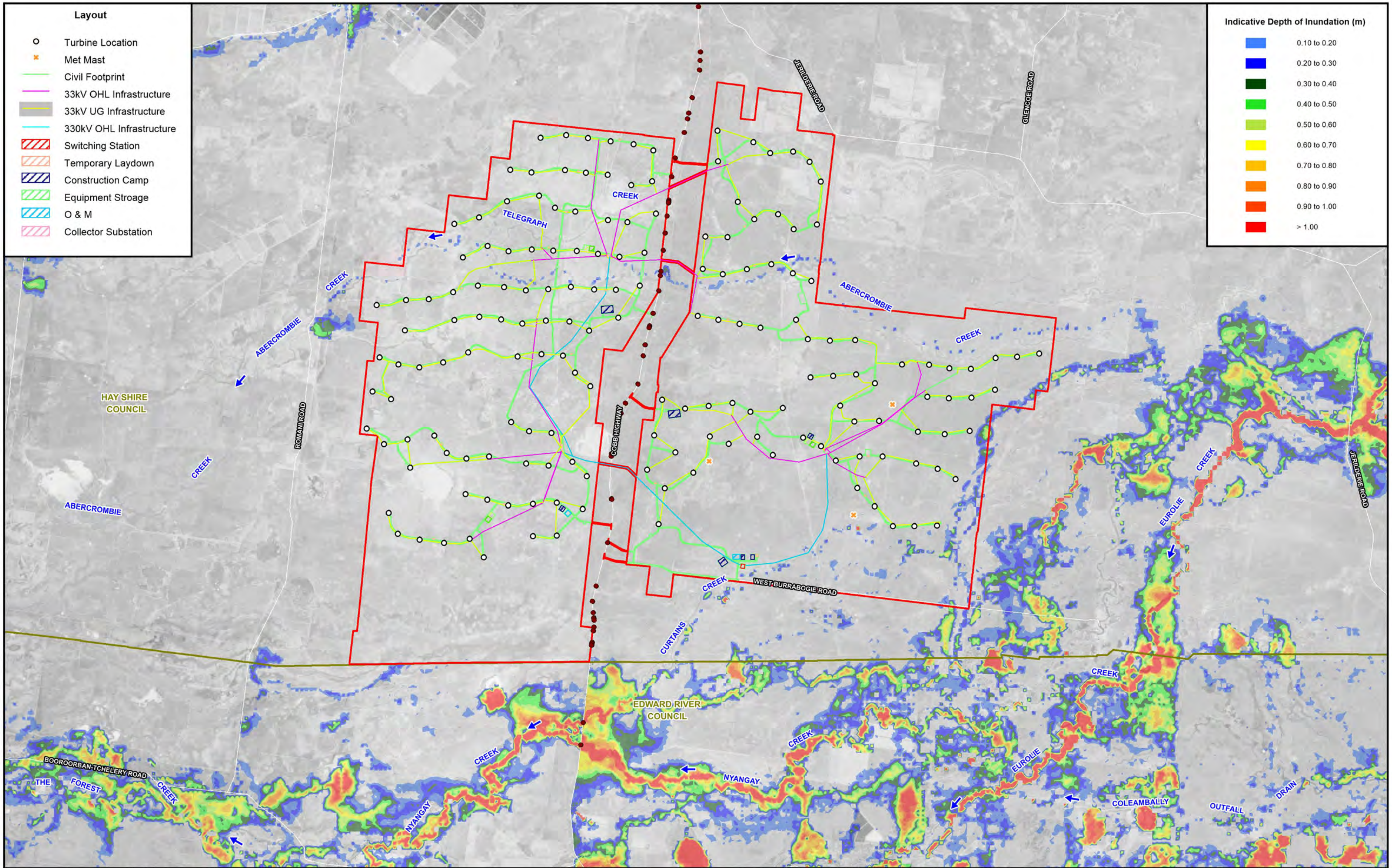
LEGEND

Project Area
LGA Boundary
WaterNSW Stream Gauge
Two-Dimensional Model Boundary
Modelled Drainage Structures

THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure B2
(Sheet 1 of 2)

FLOODING AND DRAINAGE PATTERNS UNDER PRE-PROJECT CONDITIONS
0.2% AEP MURRUMBIDGEE RIVER FLOOD EVENT



N
1.5 0 1.5 3 4.5 km
Scale: 1:150,000

LEGEND
Project Area
LGA Boundary
Modelled Drainage Structures

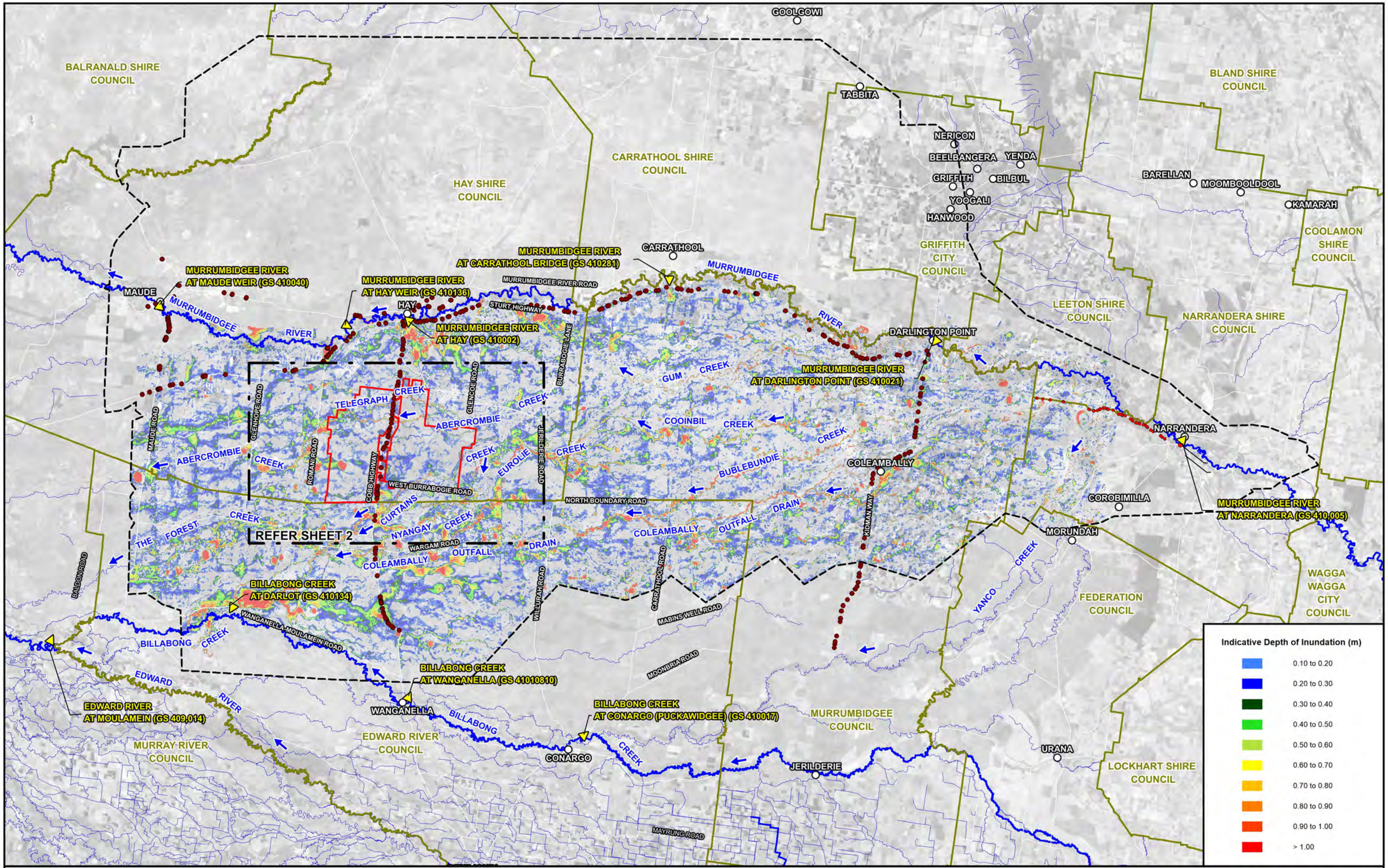
Lyall & Associates

THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure B2
(Sheet 2 of 2)

FLOODING AND DRAINAGE PATTERNS UNDER PRE-PROJECT CONDITIONS
0.2% AEP MURRUMBIDGEE RIVER FLOOD EVENT

APPENDIX C
FIGURES SHOWING THE INDICATIVE EXTENT AND DEPTH OF INUNDATION UNDER PRE-PROJECT CONDITIONS ACROSS THE PROJECT DURING A 0.5% AND 0.2% AEP LOCAL CATCHMENT FLOOD EVENT



N

7 0 7 14 21 km

Scale: 1:700,000

LEGEND

Project Area

LGA Boundary

WaterNSW Stream Gauge

Two-Dimensional Model Boundary

Modelled Drainage Structures

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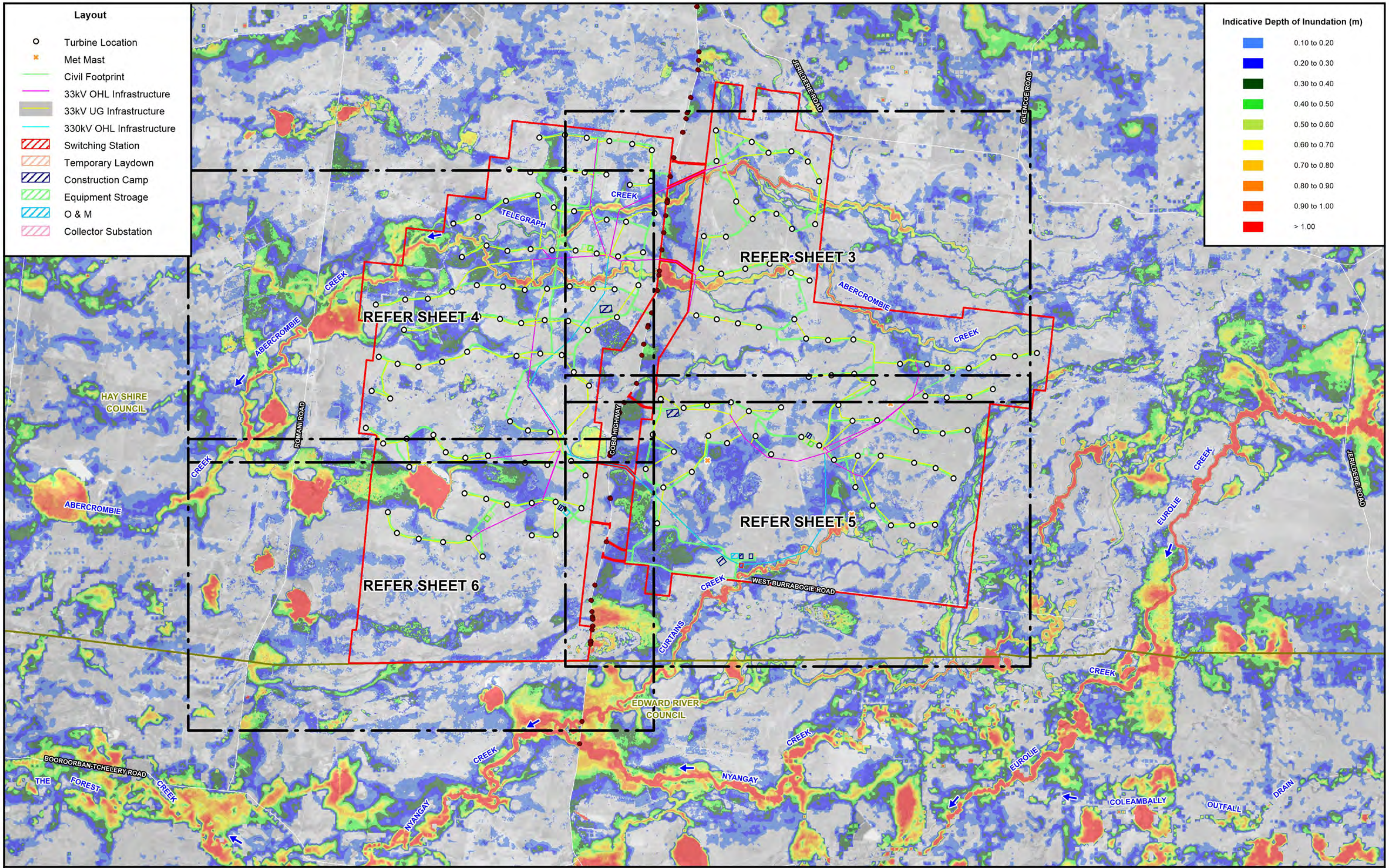
THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure C1
(Sheet 1 of 6)

FLOODING AND DRAINAGE PATTERNS UNDER PRE-PROJECT CONDITIONS
0.5% AEP LOCAL CATCHMENT FLOOD EVENT



LEGEND

- Project Area
- LGA Boundary
- Modelled Drainage Structures

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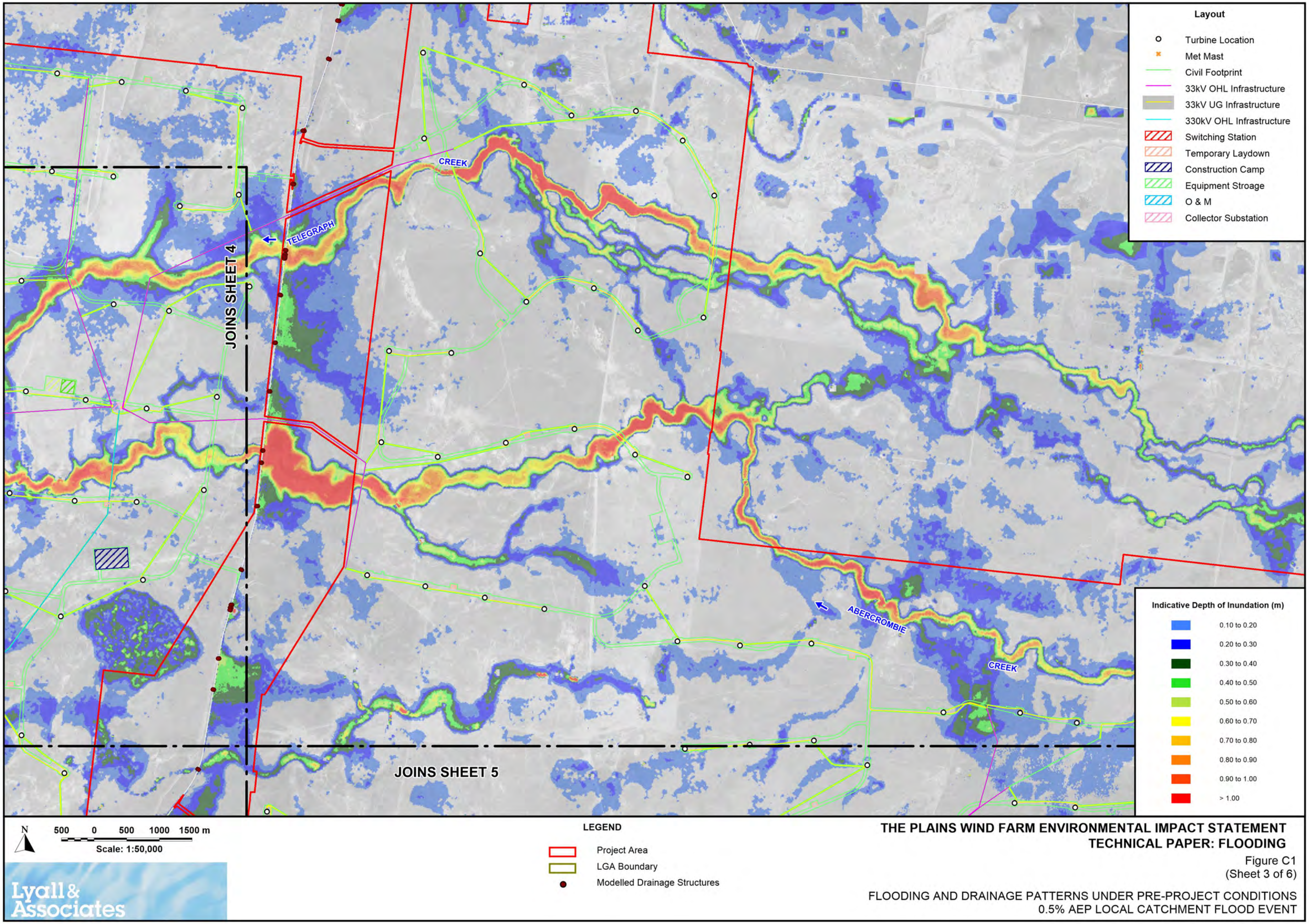
THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure C1
(Sheet 2 of 6)

FLOODING AND DRAINAGE PATTERNS UNDER PRE-PROJECT CONDITIONS
0.5% AEP LOCAL CATCHMENT FLOOD EVENT



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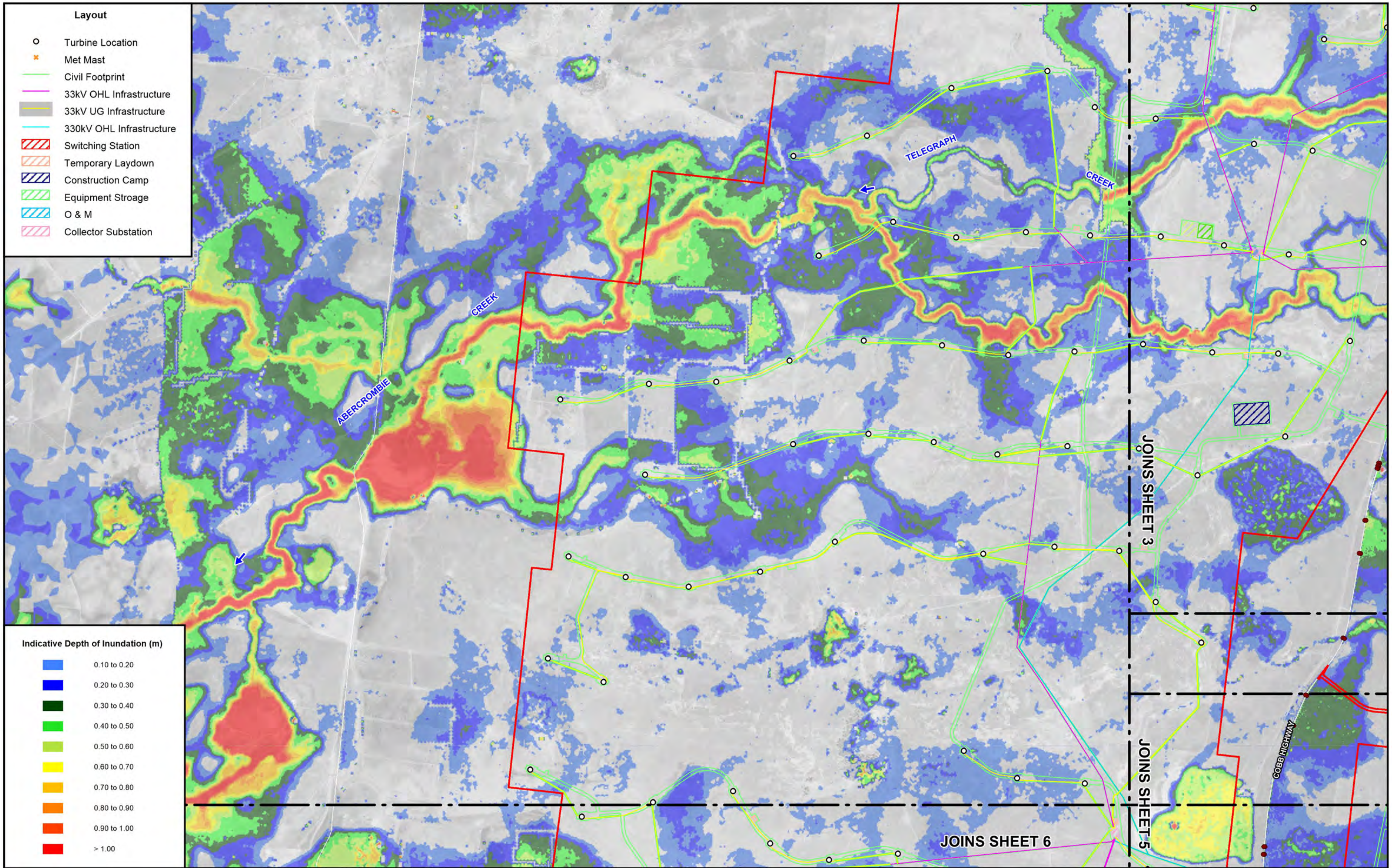
THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure C1
(Sheet 3 of 6)

FLOODING AND DRAINAGE PATTERNS UNDER PRE-PROJECT CONDITIONS
0.5% AEP LOCAL CATCHMENT FLOOD EVENT



N

500 0 500 1000 1500 m

Scale: 1:50,000

Lyall & Associates

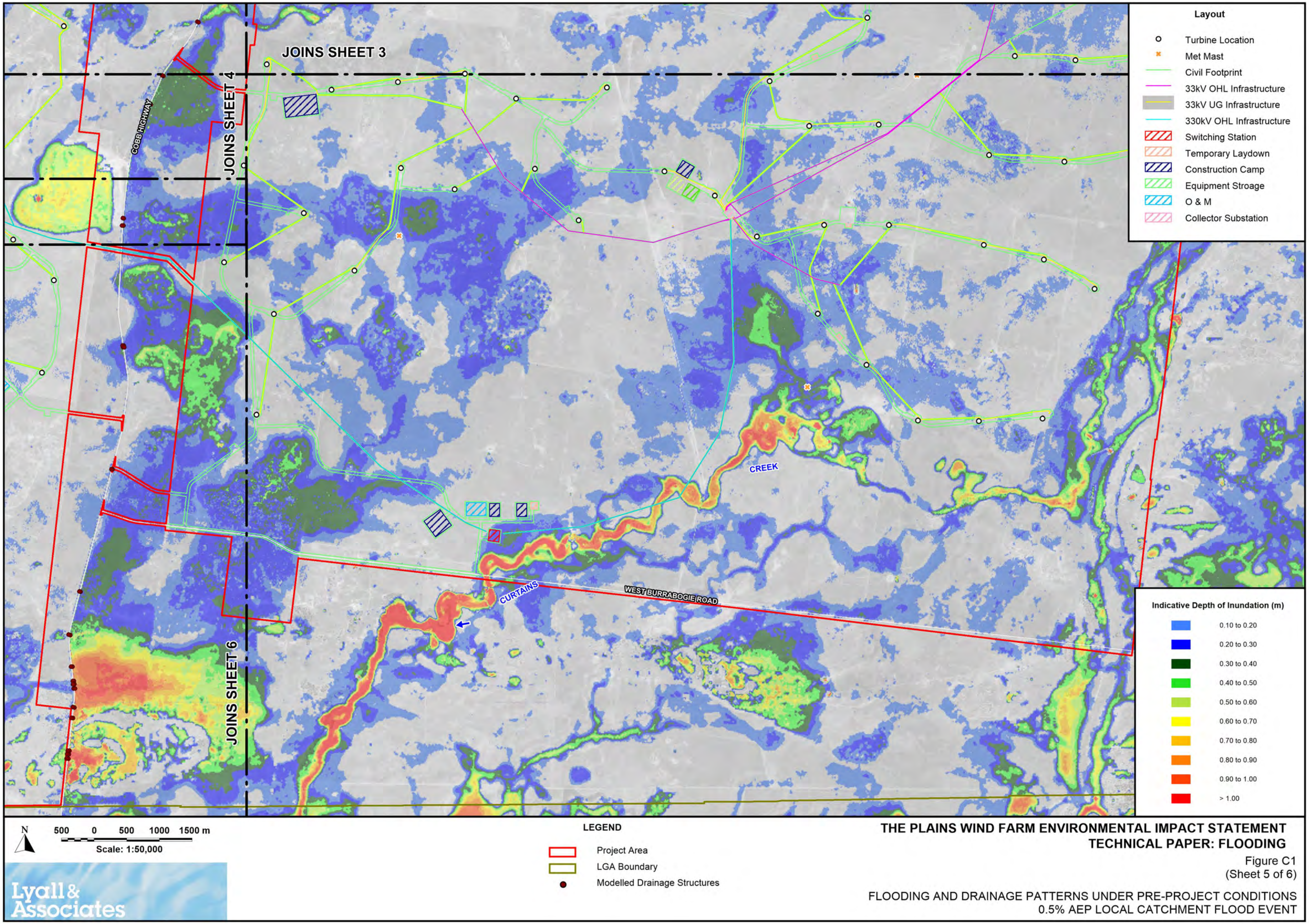
LEGEND

- Project Area
- LGA Boundary
- Modelled Drainage Structures

THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure C1
(Sheet 4 of 6)

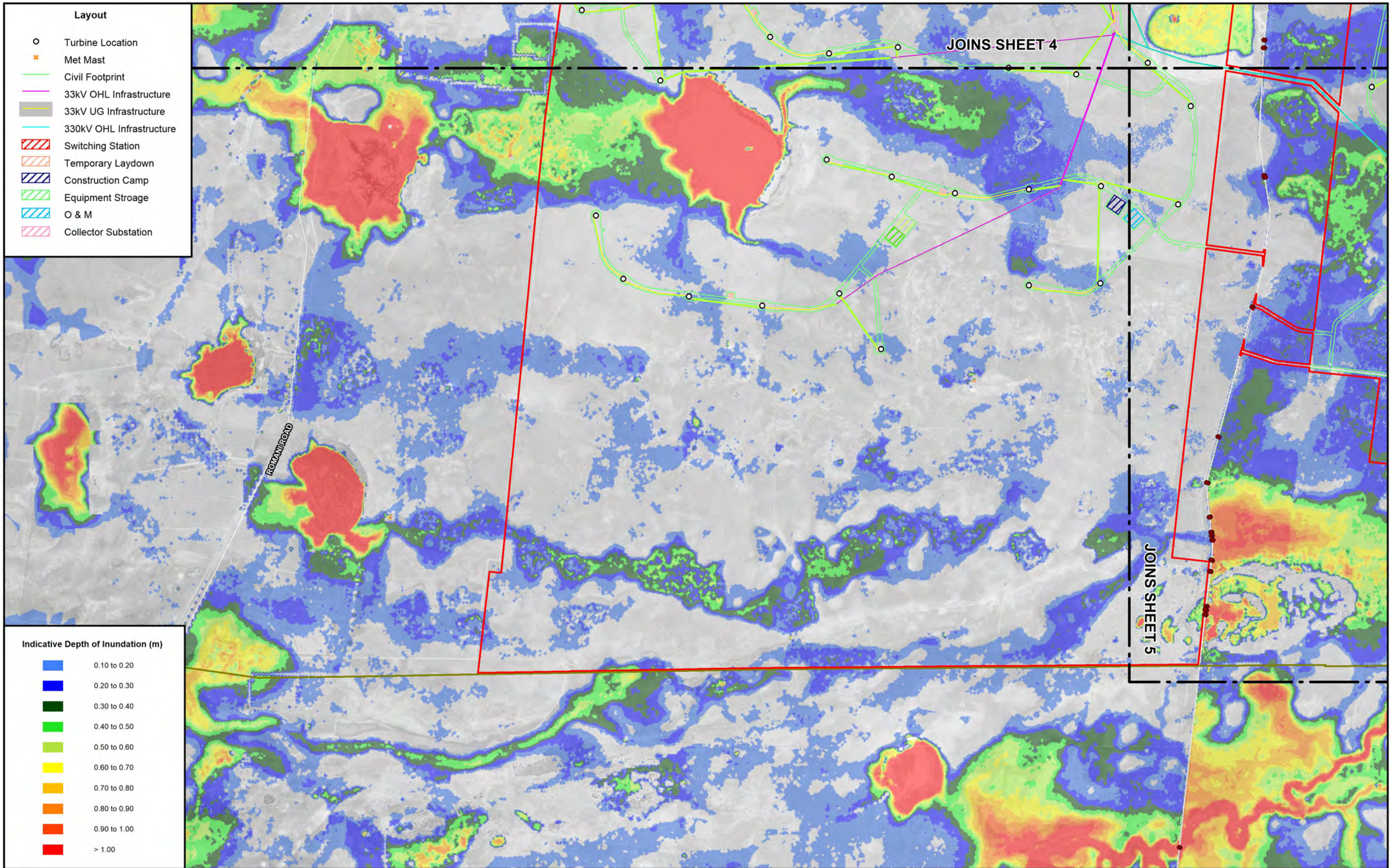
FLOODING AND DRAINAGE PATTERNS UNDER PRE-PROJECT CONDITIONS
0.5% AEP LOCAL CATCHMENT FLOOD EVENT



THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure C1
(Sheet 5 of 6)

FLOODING AND DRAINAGE PATTERNS UNDER PRE-PROJECT CONDITIONS
0.5% AEP LOCAL CATCHMENT FLOOD EVENT



N
500 0 500 1000 1500 m
Scale: 1:50,000

LEGEND

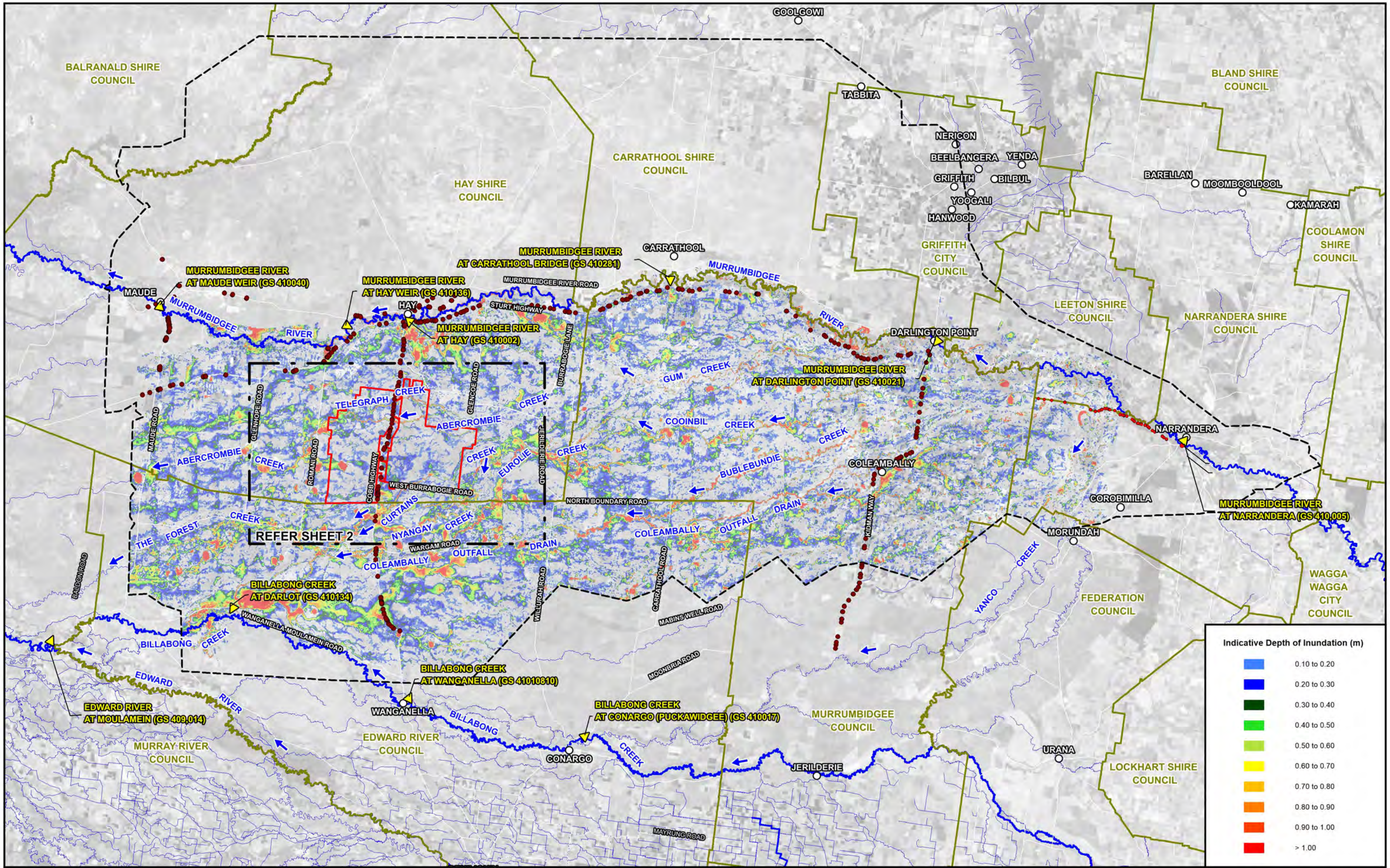
Project Area
LGA Boundary
Modelled Drainage Structures

Lyall & Associates

THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure C1
(Sheet 6 of 6)

FLOODING AND DRAINAGE PATTERNS UNDER PRE-PROJECT CONDITIONS
0.5% AEP LOCAL CATCHMENT FLOOD EVENT



N
7 0 7 14 21 km
Scale: 1:700,000

Lyall & Associates

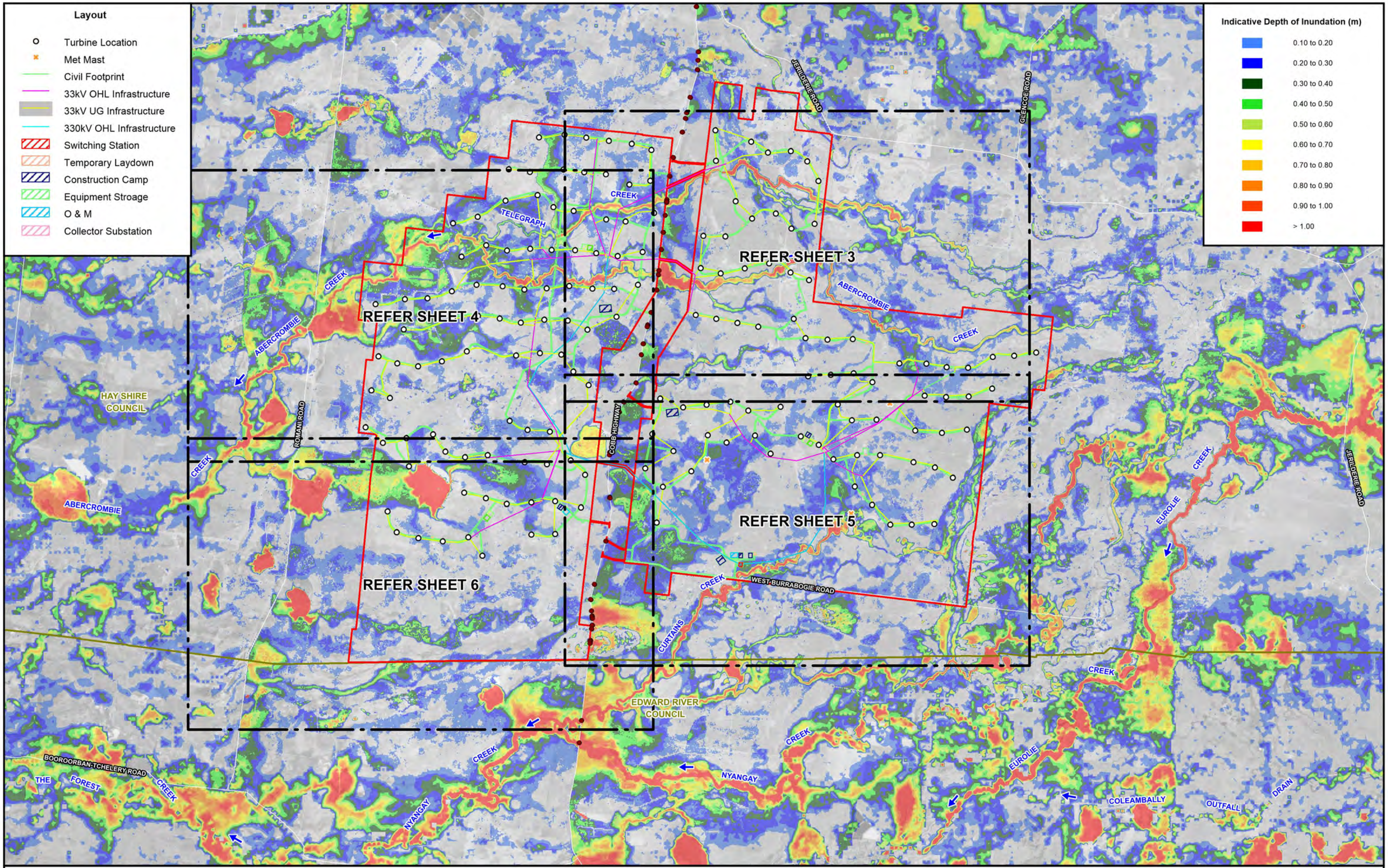
LEGEND

- Project Area
- LGA Boundary
- WaterNSW Stream Gauge
- Two-Dimensional Model Boundary
- Modelled Drainage Structures

THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure C2
(Sheet 1 of 6)

FLOODING AND DRAINAGE PATTERNS UNDER PRE-PROJECT CONDITIONS
0.2% AEP LOCAL CATCHMENT FLOOD EVENT



N

1.5 0 1.5 3 4.5 km

Scale: 1:150,000

Lyall & Associates

LEGEND

Project Area

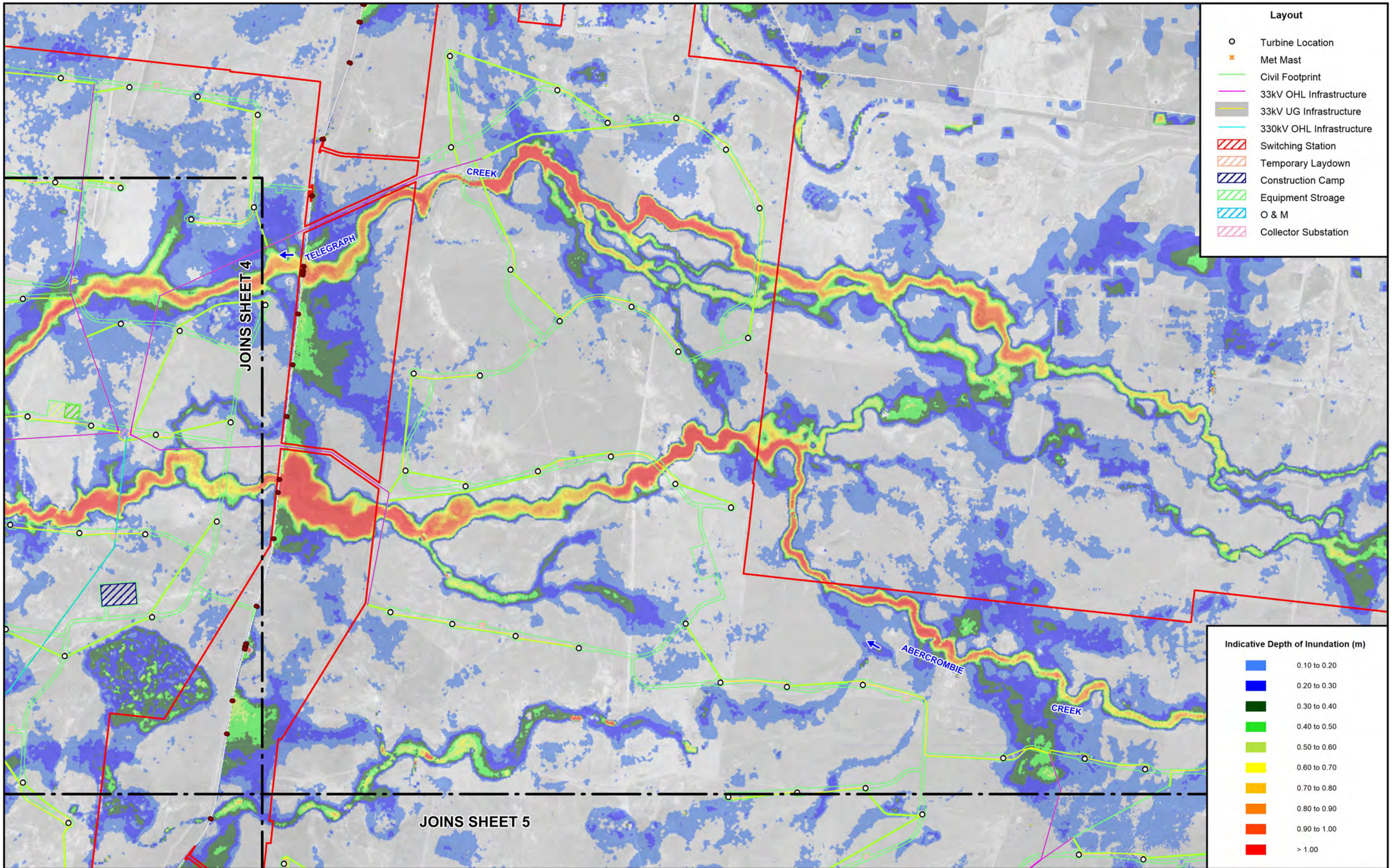
LGA Boundary

Modelled Drainage Structures

THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure C2
(Sheet 2 of 6)

FLOODING AND DRAINAGE PATTERNS UNDER PRE-PROJECT CONDITIONS
0.2% AEP LOCAL CATCHMENT FLOOD EVENT



N
500 0 500 1000 1500 m
Scale: 1:50,000

Lyall & Associates

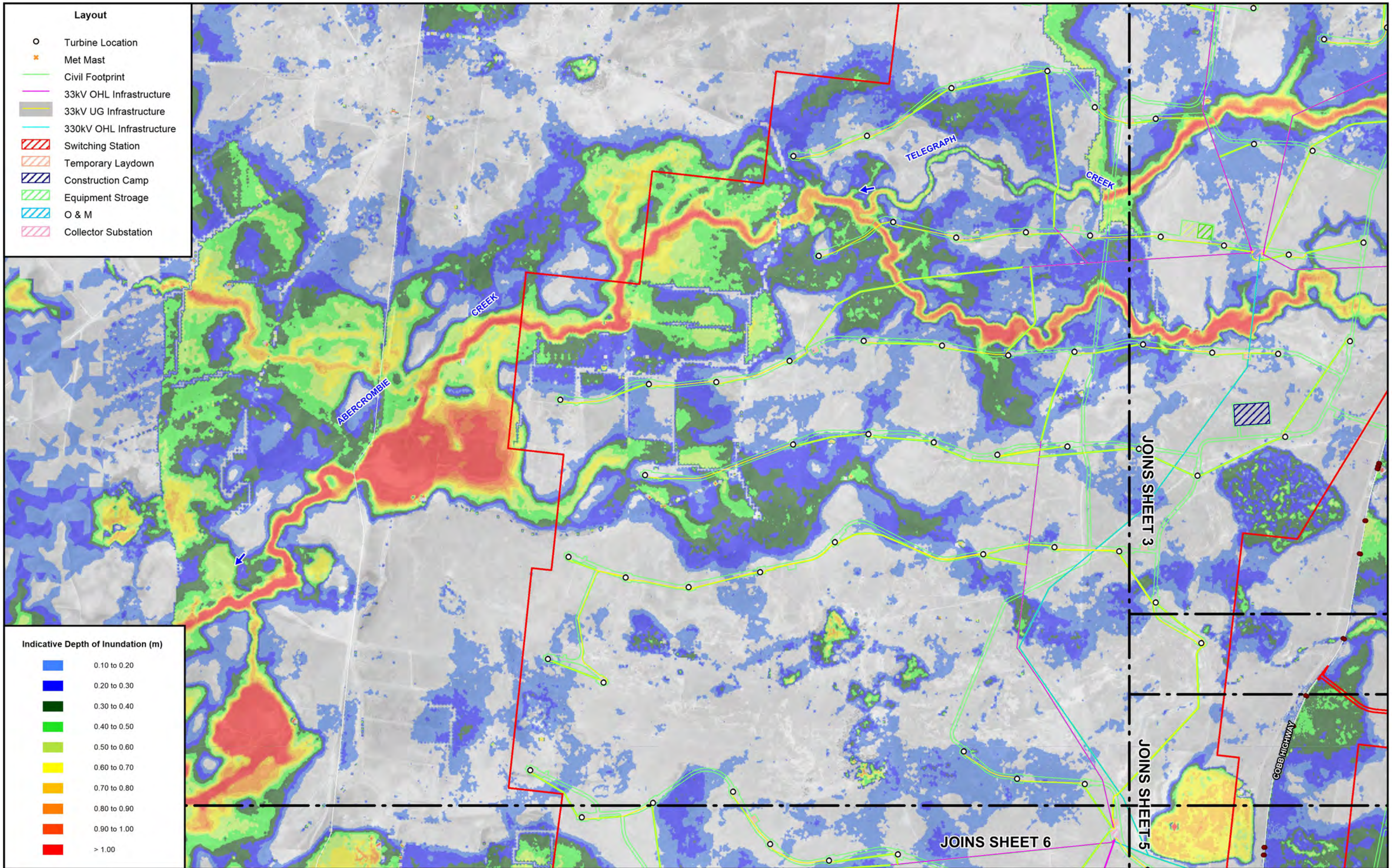
LEGEND

- Project Area
- LGA Boundary
- Modelled Drainage Structures

THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure C2
(Sheet 3 of 6)

FLOODING AND DRAINAGE PATTERNS UNDER PRE-PROJECT CONDITIONS
0.2% AEP LOCAL CATCHMENT FLOOD EVENT



LEGEND

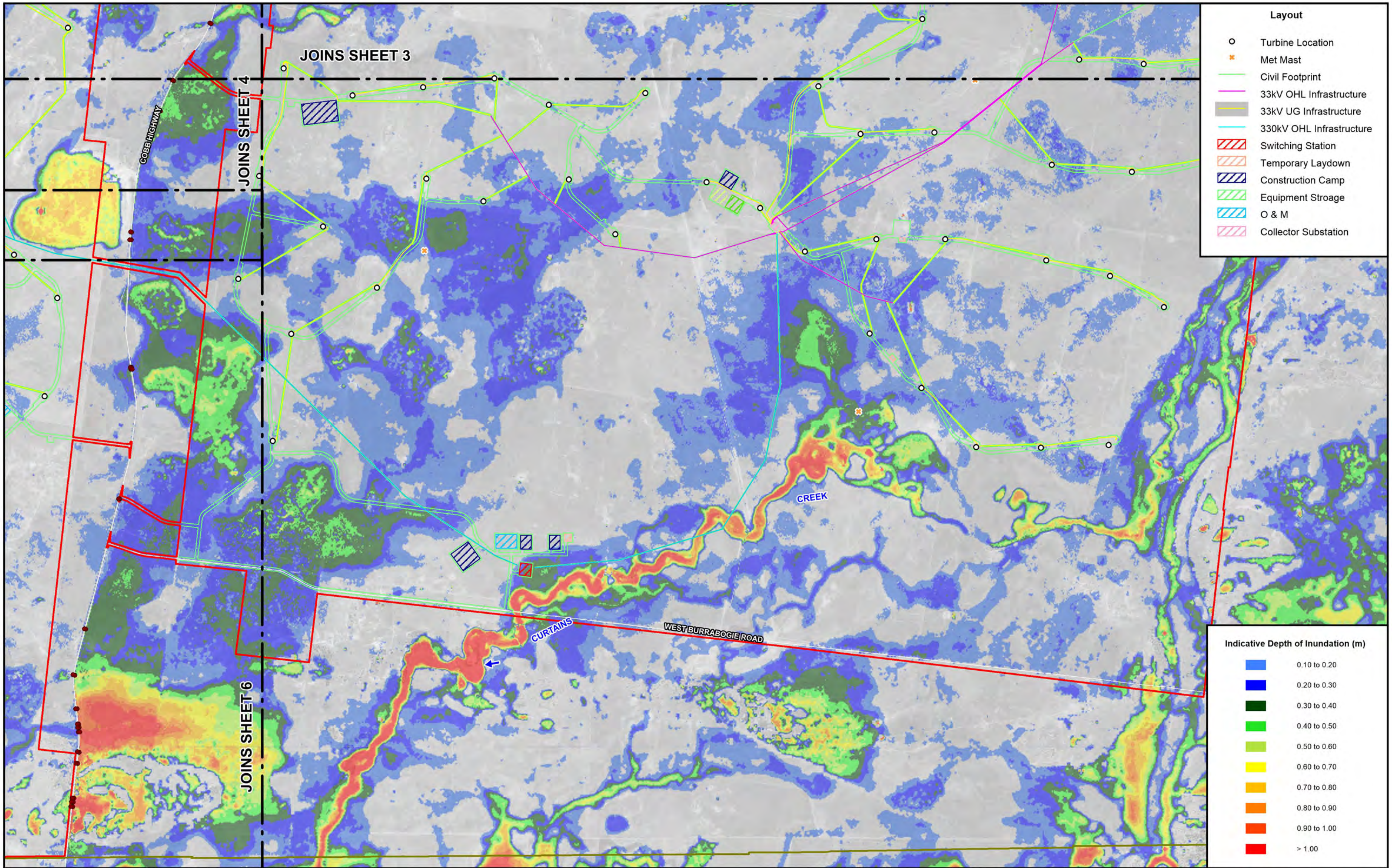
- Project Area
- LGA Boundary
- Modelled Drainage Structures

Lyall & Associates

THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure C2
(Sheet 4 of 6)

FLOODING AND DRAINAGE PATTERNS UNDER PRE-PROJECT CONDITIONS
0.2% AEP LOCAL CATCHMENT FLOOD EVENT



LEGEND

Project Area

LGA Boundary

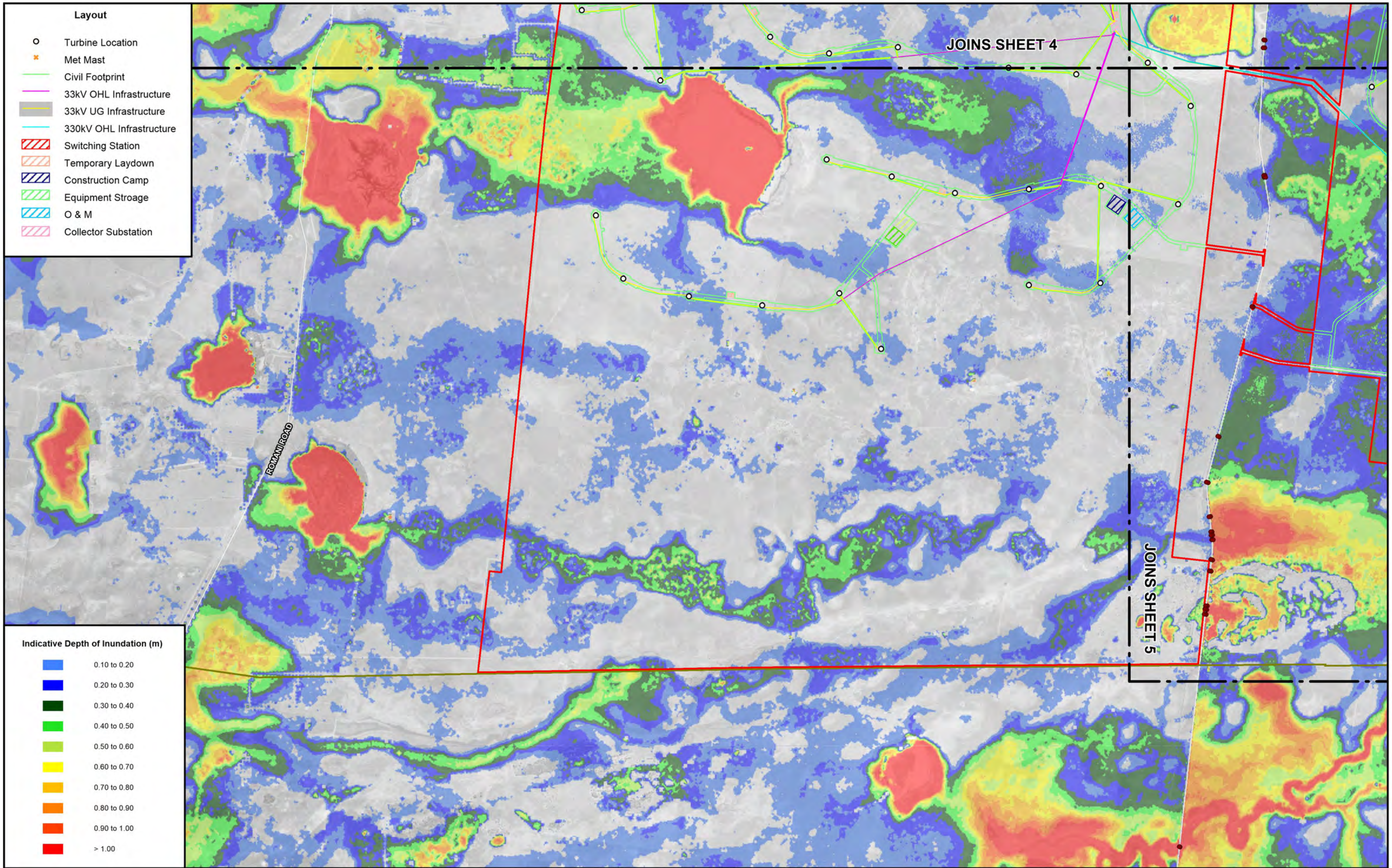
Modelled Drainage Structures

Lyall & Associates

THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure C2
(Sheet 5 of 6)

FLOODING AND DRAINAGE PATTERNS UNDER PRE-PROJECT CONDITIONS
0.2% AEP LOCAL CATCHMENT FLOOD EVENT



Lyall & Associates

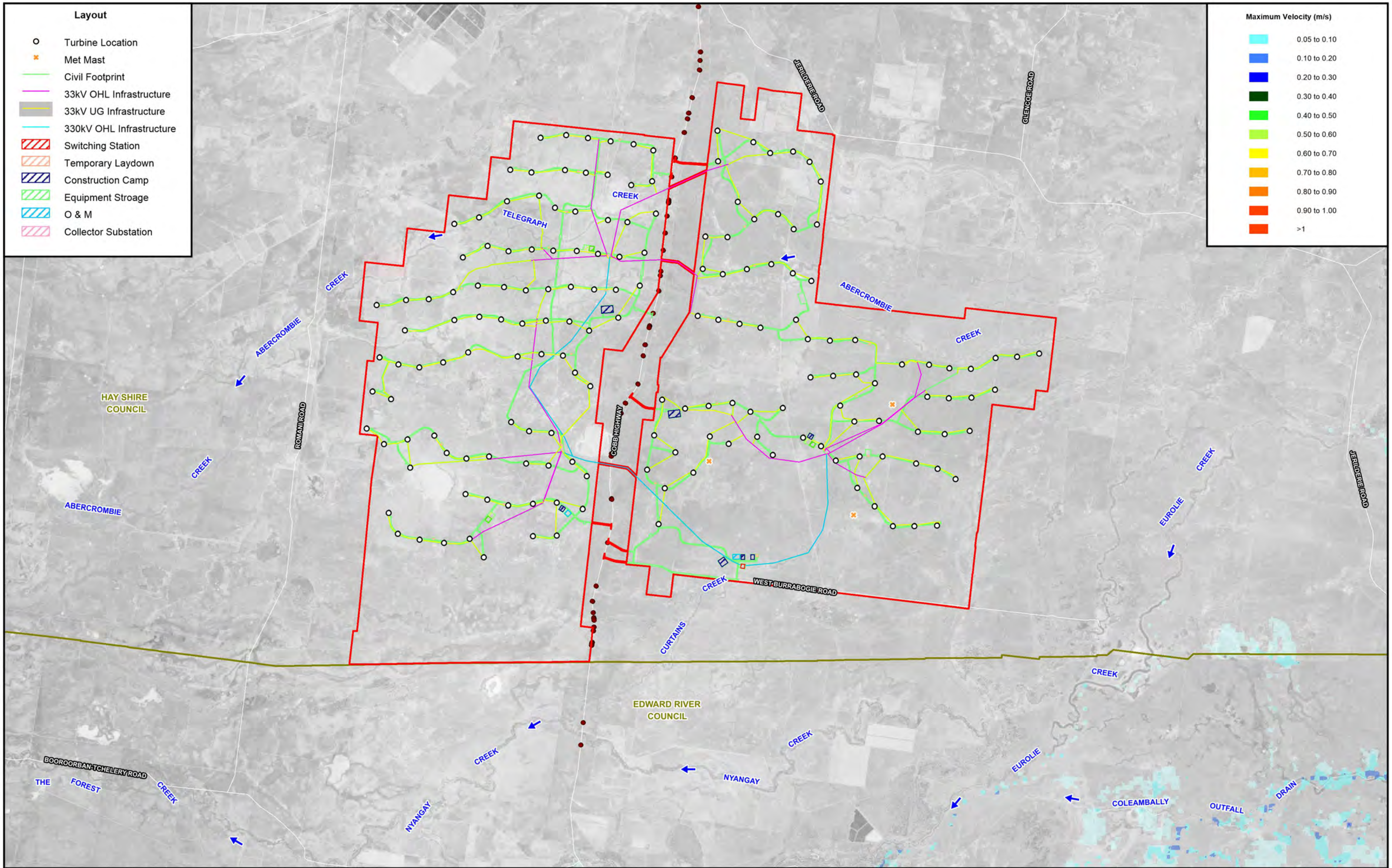
THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure C2
(Sheet 6 of 6)

FLOODING AND DRAINAGE PATTERNS UNDER PRE-PROJECT CONDITIONS
0.2% AEP LOCAL CATCHMENT FLOOD EVENT

APPENDIX D

FIGURES SHOWING MAXIMUM FLOW VELOCITIES UNDER PRE-PROJECT CONDITIONS IN THE VICINITY OF THE PROJECT DURING A 5% AND 1% AEP MURRUMBIDGEE RIVER FLOOD EVENT



LEGEND

Project Area

LGA Boundary

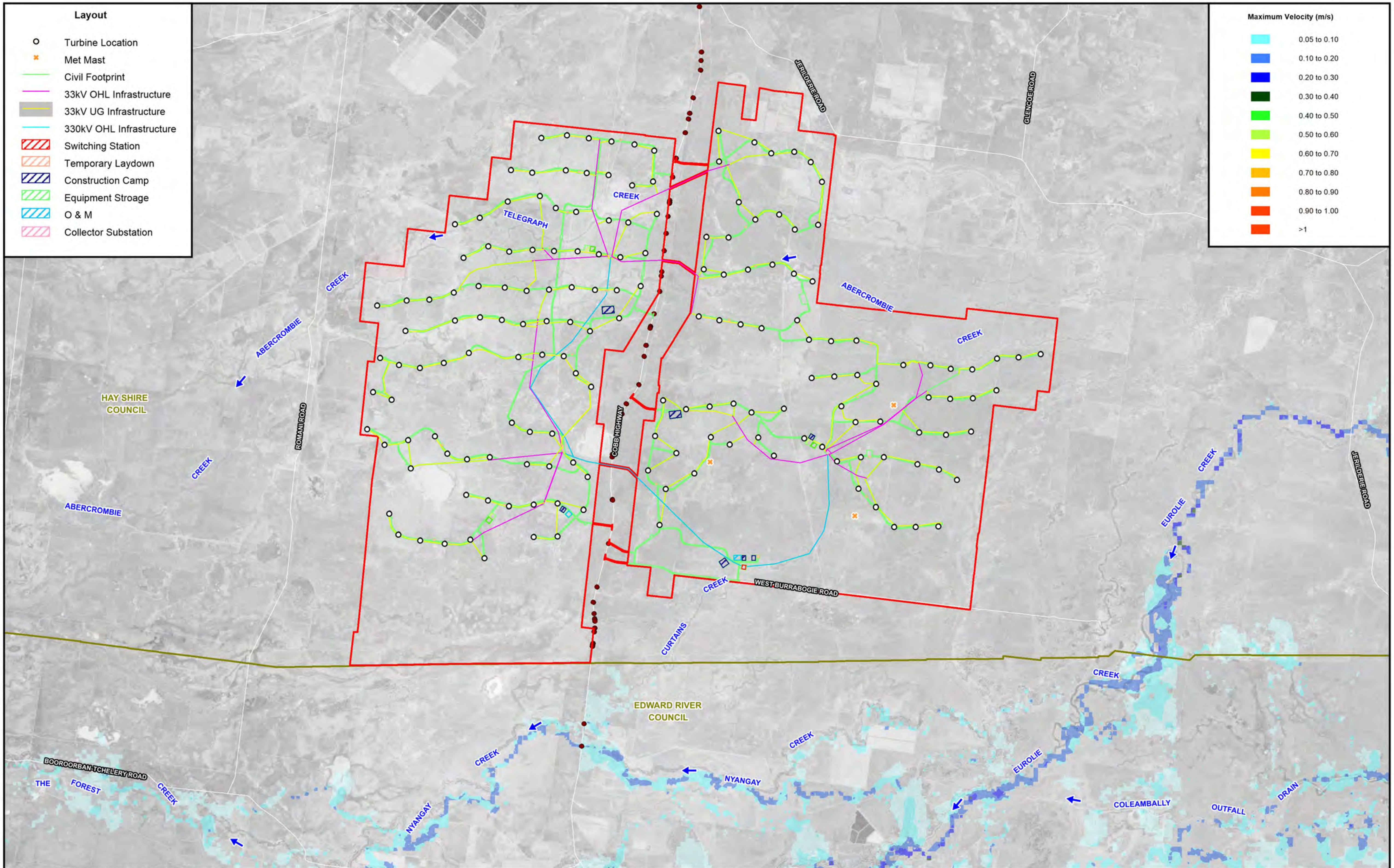
Modelled Drainage Structures

Lyall & Associates

THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure D1

MAXIMUM FLOW VELOCITIES UNDER PRE-PROJECT CONDITIONS
5% AEP MURRUMBIDGEE RIVER FLOOD EVENT



N

1.5 0 1.5 3 4.5 km

Scale: 1:150,000

Lyall & Associates

LEGEND

Project Area

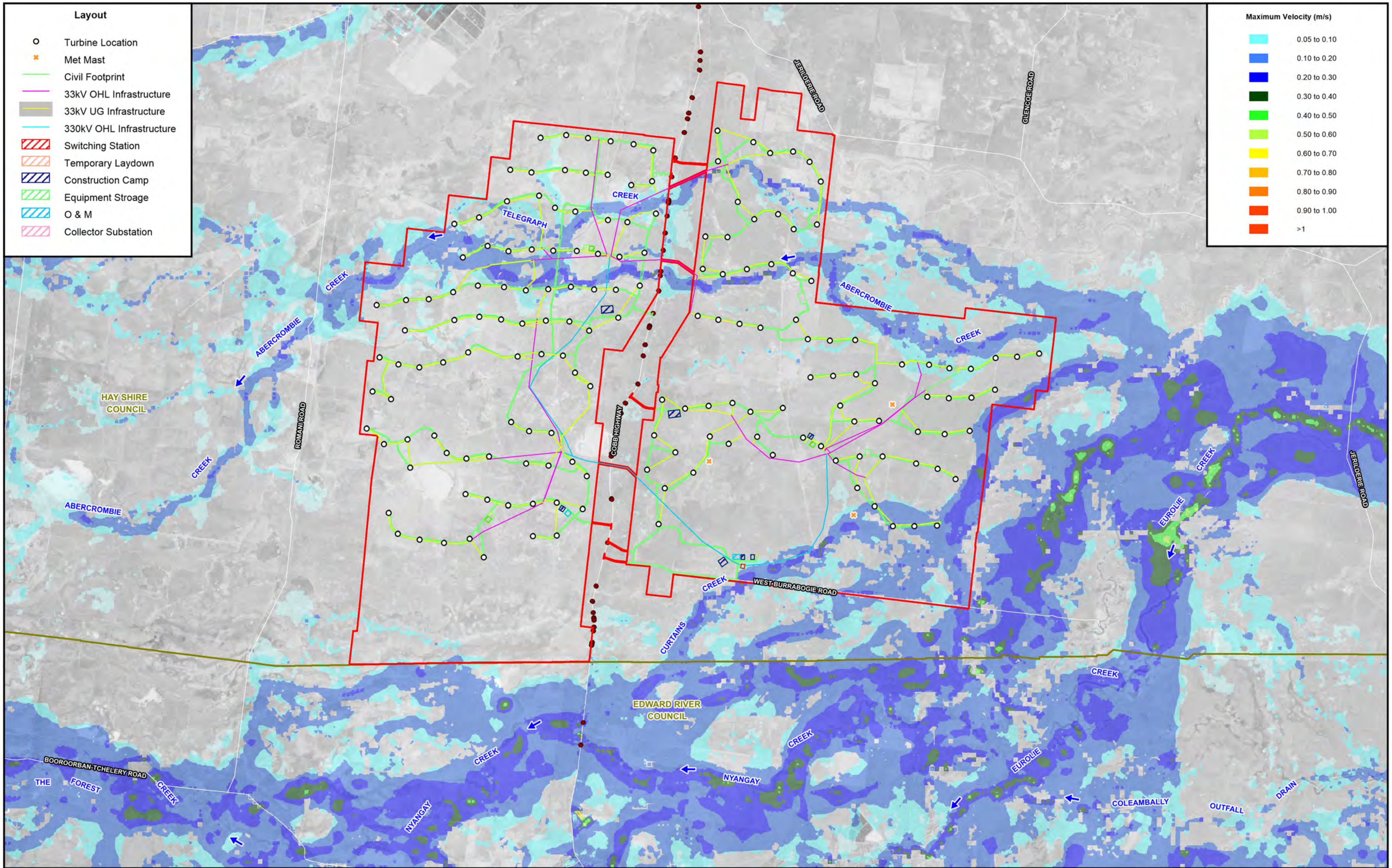
LGA Boundary

Modelled Drainage Structures

THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure D2

MAXIMUM FLOW VELOCITIES UNDER PRE-PROJECT CONDITIONS
1% AEP MURRUMBIDGEE RIVER FLOOD EVENT



N

1.5 0 1.5 3 4.5 km

Scale: 1:150,000

Lyall & Associates

LEGEND

Project Area

LGA Boundary

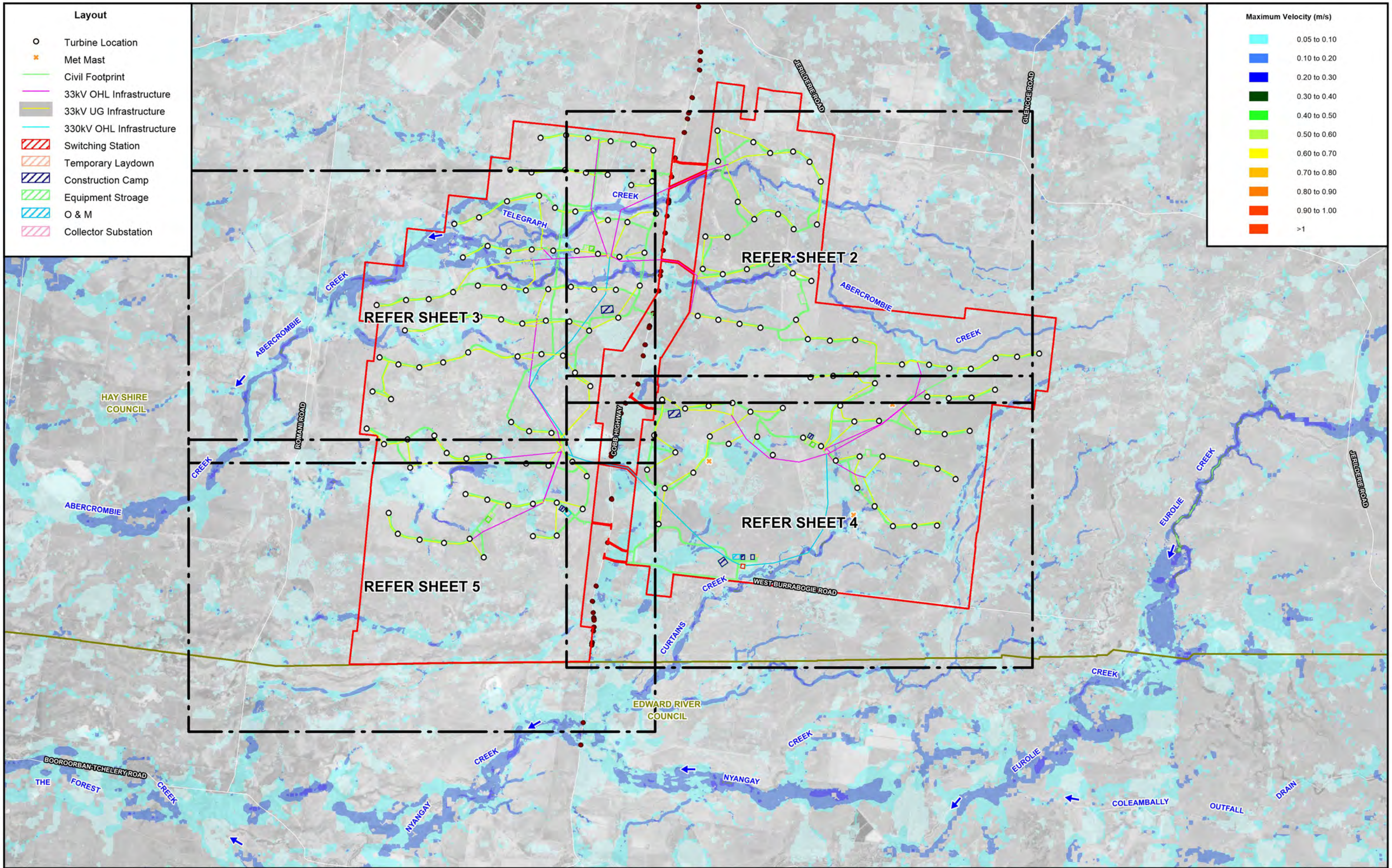
Modelled Drainage Structures

THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure D3

MAXIMUM FLOW VELOCITIES UNDER PRE-PROJECT CONDITIONS
EXTREME MURRUMBIDGEE RIVER FLOOD EVENT

APPENDIX E
FIGURES SHOWING MAXIMUM FLOW VELOCITIES UNDER PRE-PROJECT CONDITIONS IN THE VICINITY OF THE PROJECT DURING A 5% AND 1% AEP LOCAL CATCHMENT FLOOD EVENT



LEGEND

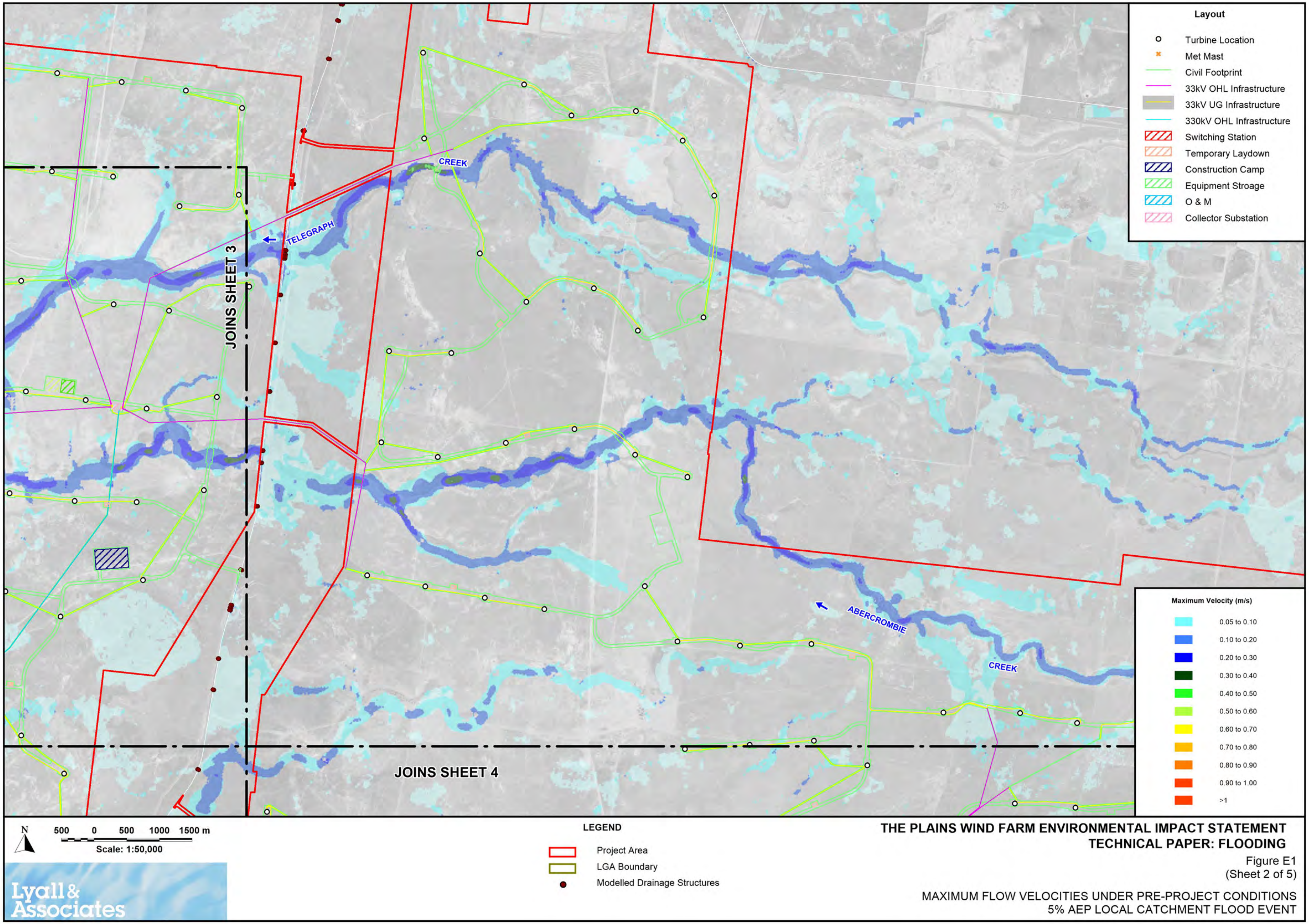
- Project Area
- LGA Boundary
- Modelled Drainage Structures

Lyall & Associates

THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure E1
(Sheet 1 of 5)

MAXIMUM FLOW VELOCITIES UNDER PRE-PROJECT CONDITIONS
5% AEP LOCAL CATCHMENT FLOOD EVENT

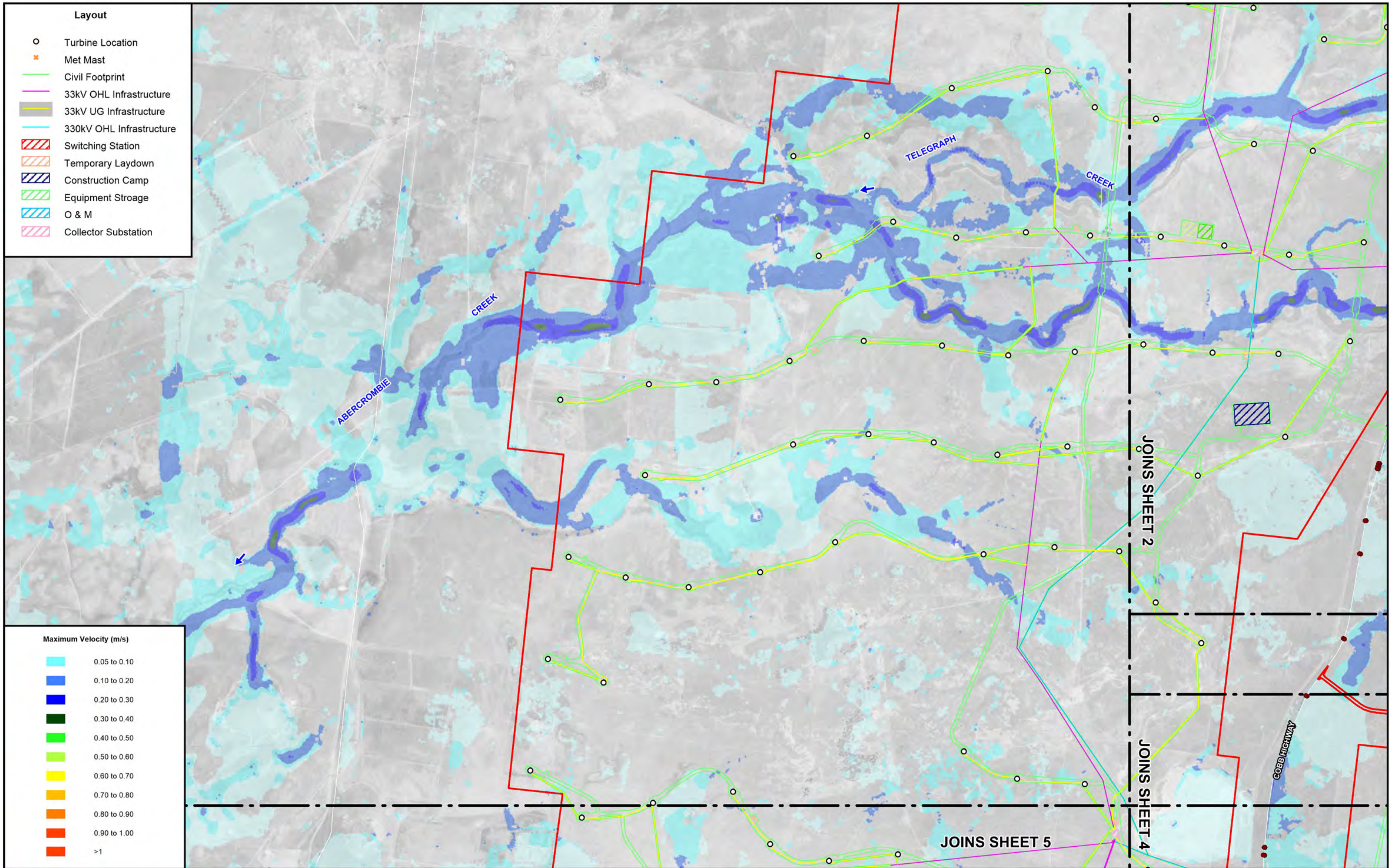


Lyall & Associates

THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure E1
(Sheet 2 of 5)

MAXIMUM FLOW VELOCITIES UNDER PRE-PROJECT CONDITIONS
5% AEP LOCAL CATCHMENT FLOOD EVENT



LEGEND

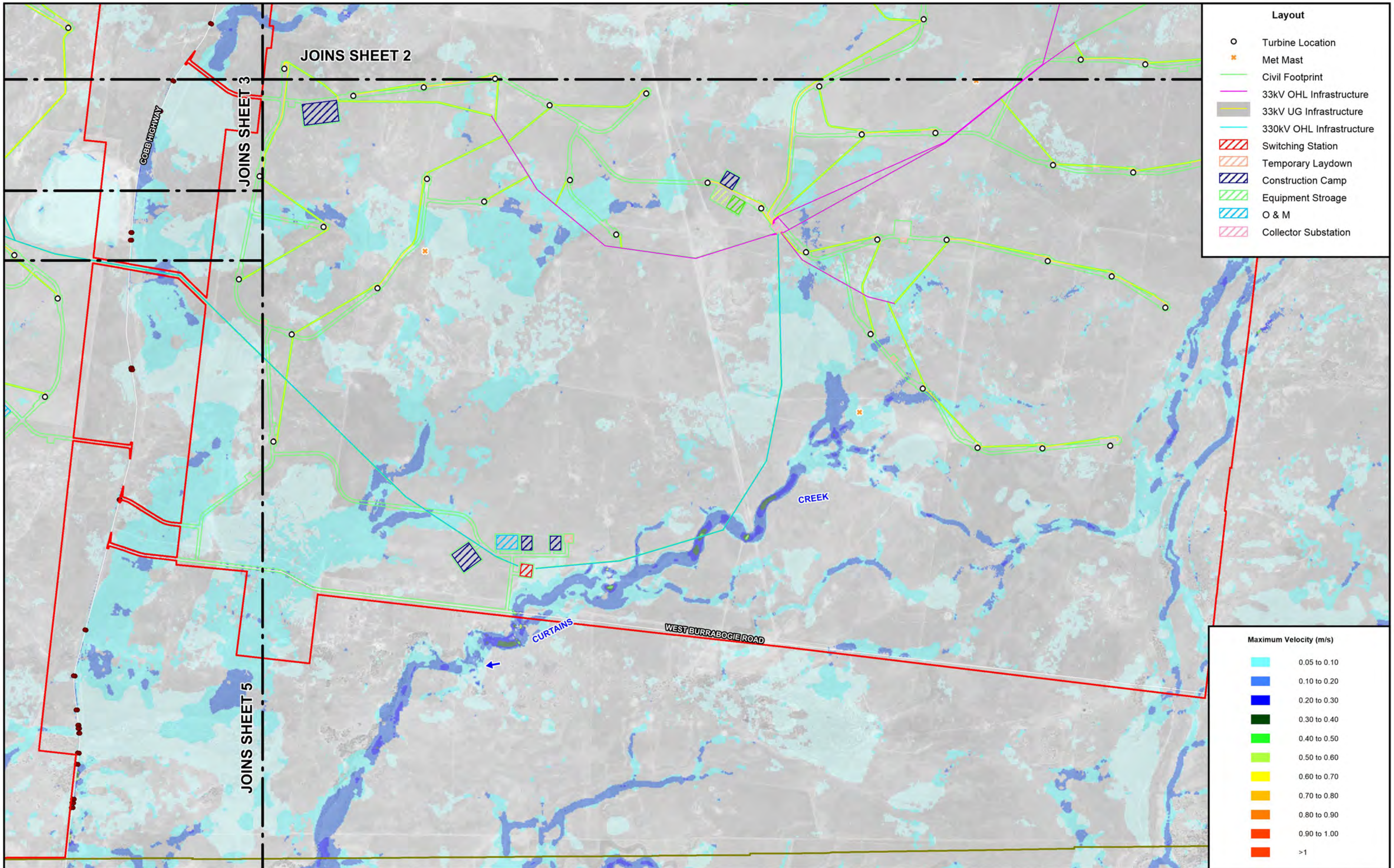
Project Area
LGA Boundary
Modelled Drainage Structures

Lyall & Associates

THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure E1
(Sheet 3 of 5)

MAXIMUM FLOW VELOCITIES UNDER PRE-PROJECT CONDITIONS
5% AEP LOCAL CATCHMENT FLOOD EVENT



N

500 0 500 1000 1500 m

Scale: 1:50,000

LEGEND

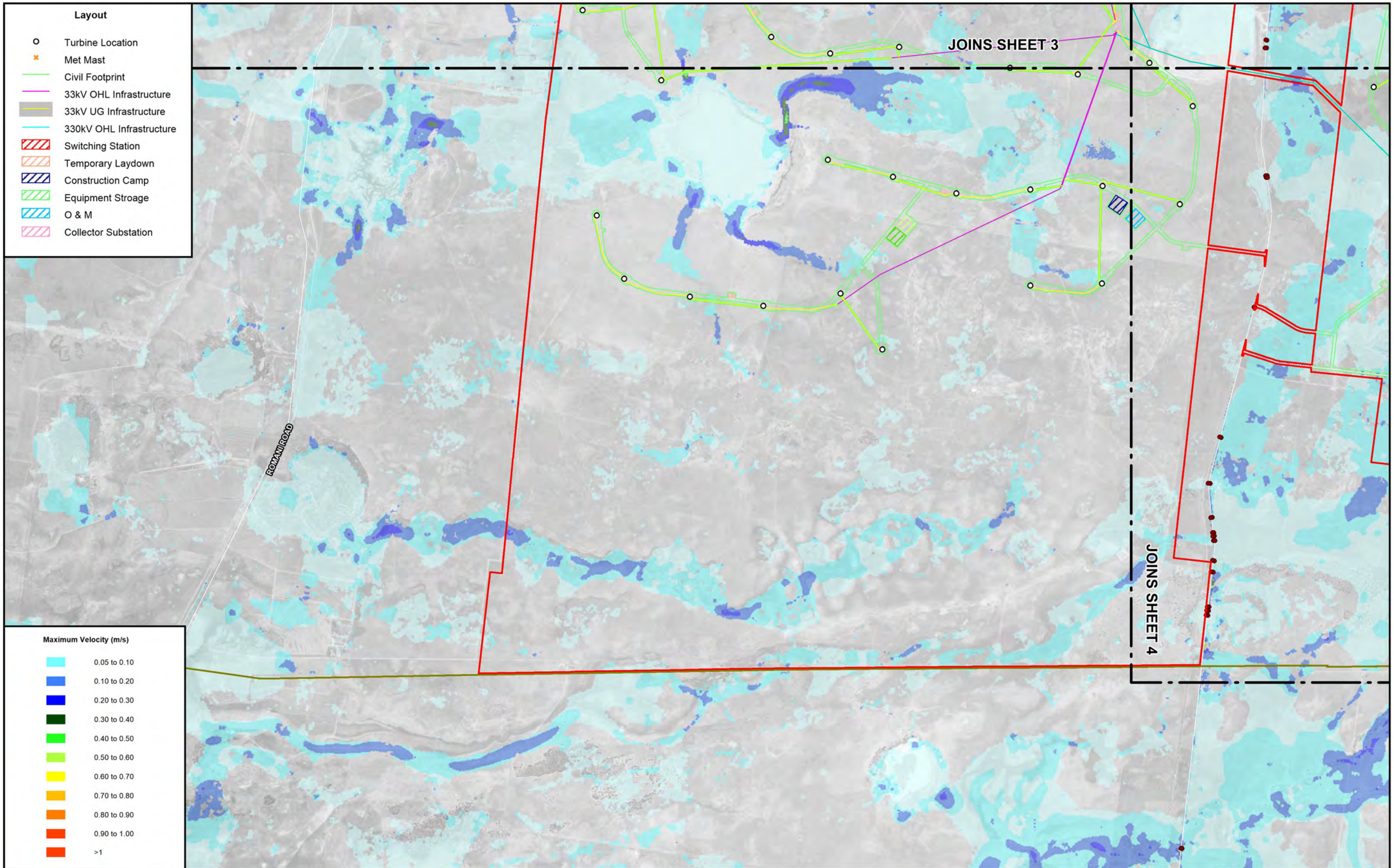
- Project Area
- LGA Boundary
- Modelled Drainage Structures

Lyall & Associates

THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure E1
(Sheet 4 of 5)

MAXIMUM FLOW VELOCITIES UNDER PRE-PROJECT CONDITIONS
5% AEP LOCAL CATCHMENT FLOOD EVENT



N
500 0 500 1000 1500 m
Scale: 1:50,000

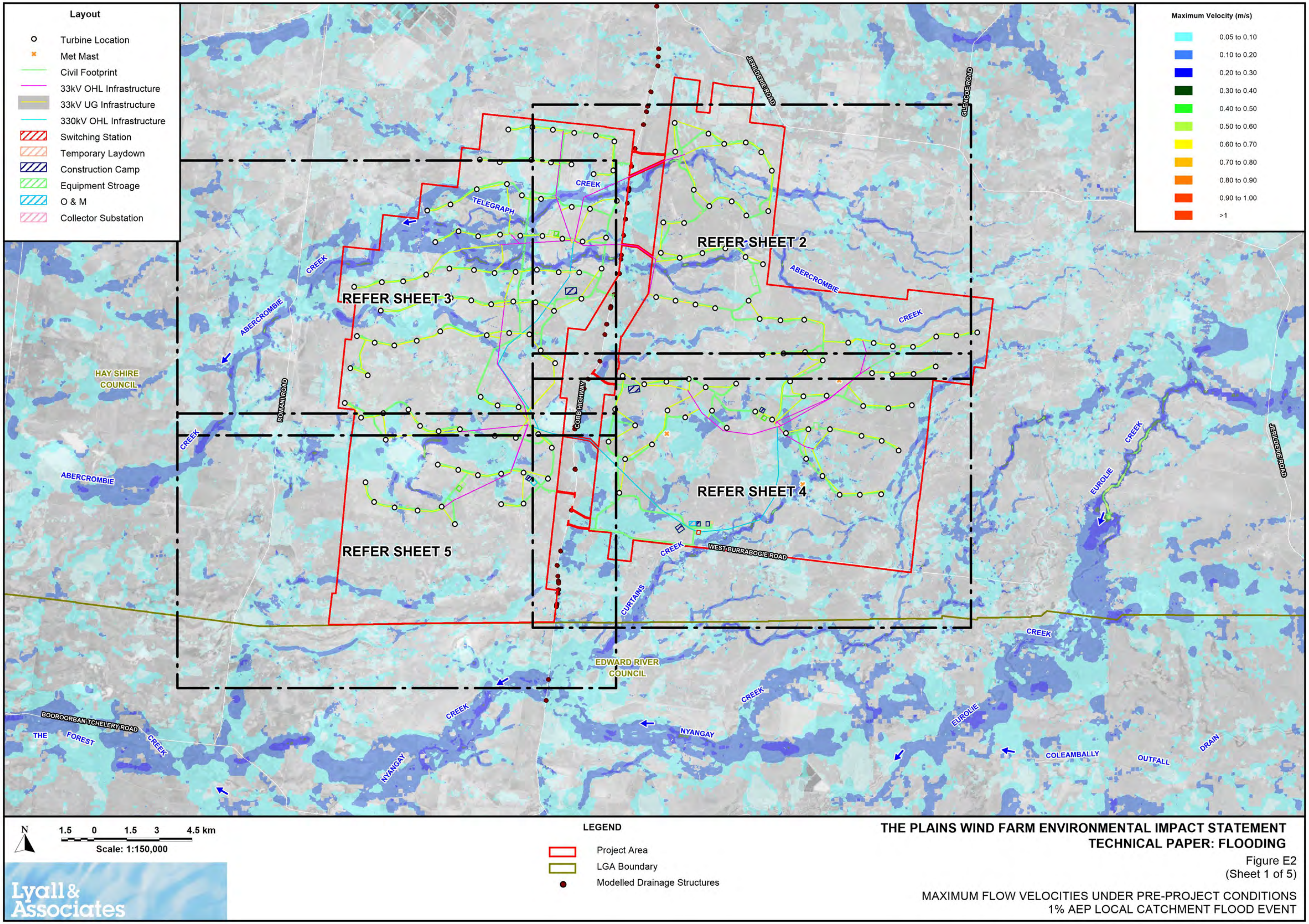
Lyall & Associates

LEGEND
Project Area
LGA Boundary
Modelled Drainage Structures

THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure E1
(Sheet 5 of 5)

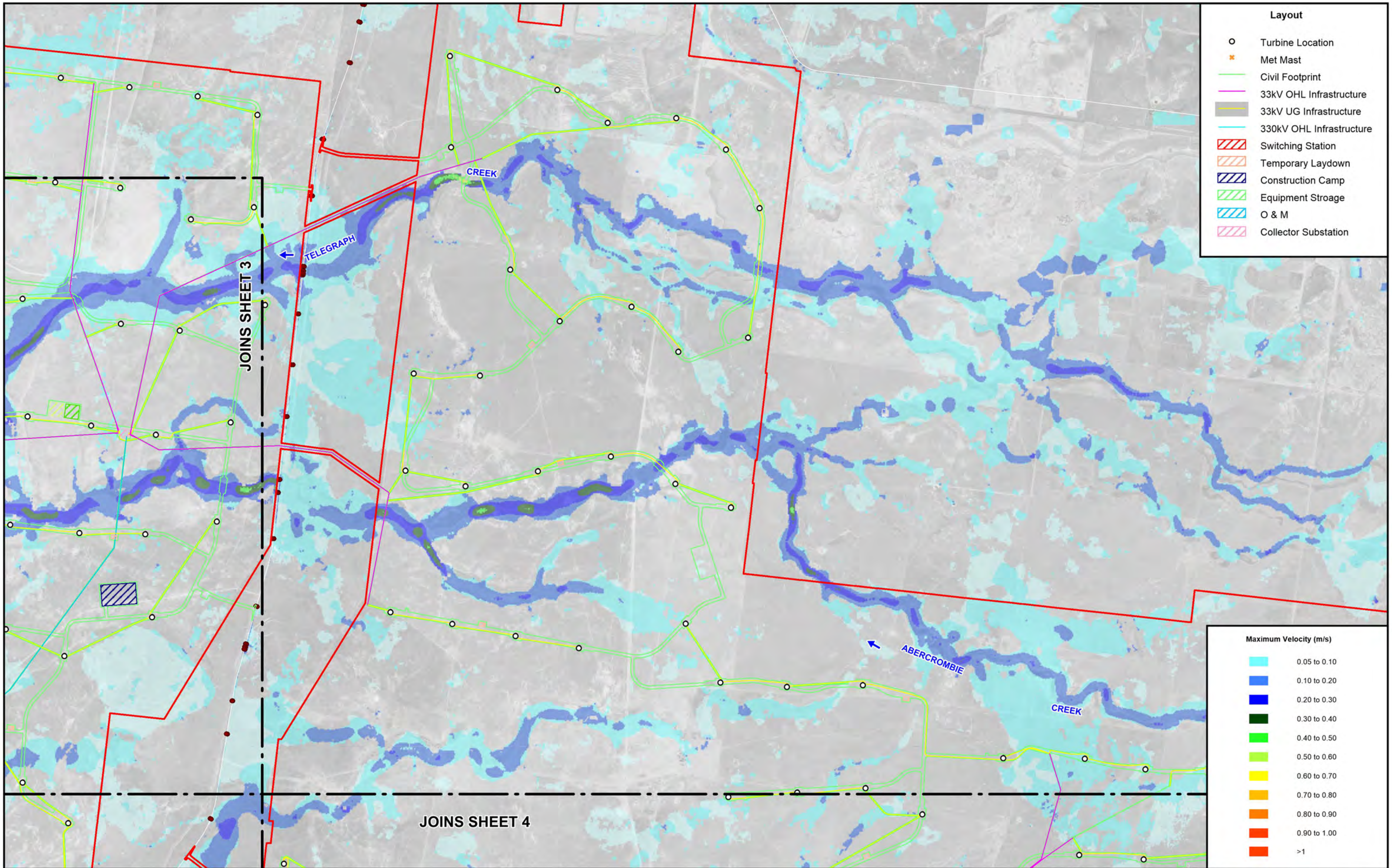
MAXIMUM FLOW VELOCITIES UNDER PRE-PROJECT CONDITIONS
5% AEP LOCAL CATCHMENT FLOOD EVENT



THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure E2
(Sheet 1 of 5)

MAXIMUM FLOW VELOCITIES UNDER PRE-PROJECT CONDITIONS
1% AEP LOCAL CATCHMENT FLOOD EVENT



N

500 0 500 1000 1500 m

Scale: 1:50,000

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LEGEND

Project Area

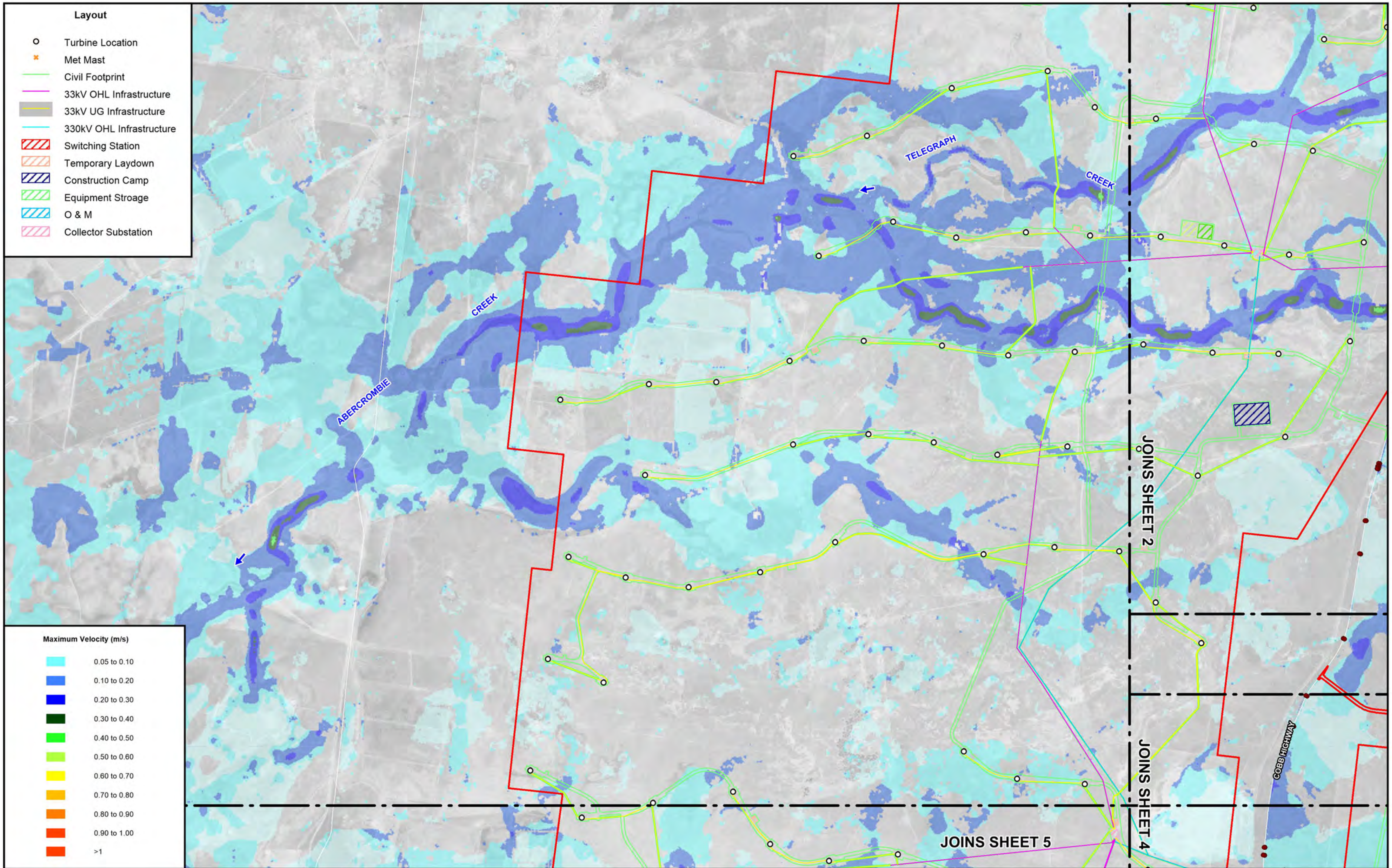
LGA Boundary

Modelled Drainage Structures

THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure E2
(Sheet 2 of 5)

MAXIMUM FLOW VELOCITIES UNDER PRE-PROJECT CONDITIONS
1% AEP LOCAL CATCHMENT FLOOD EVENT



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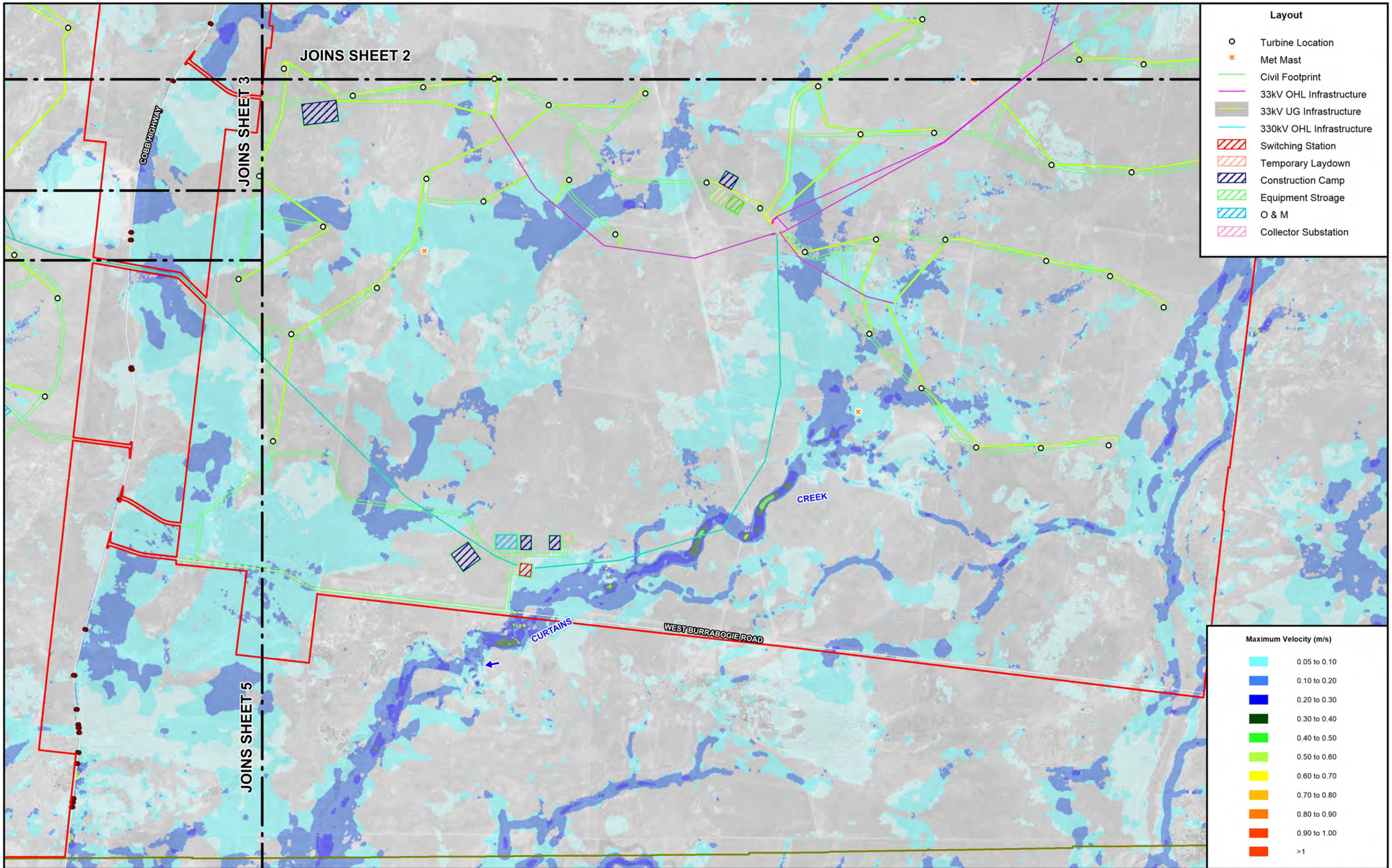
THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure E2
(Sheet 3 of 5)

MAXIMUM FLOW VELOCITIES UNDER PRE-PROJECT CONDITIONS
1% AEP LOCAL CATCHMENT FLOOD EVENT



N
500 0 500 1000 1500 m
Scale: 1:50,000

Lyall & Associates

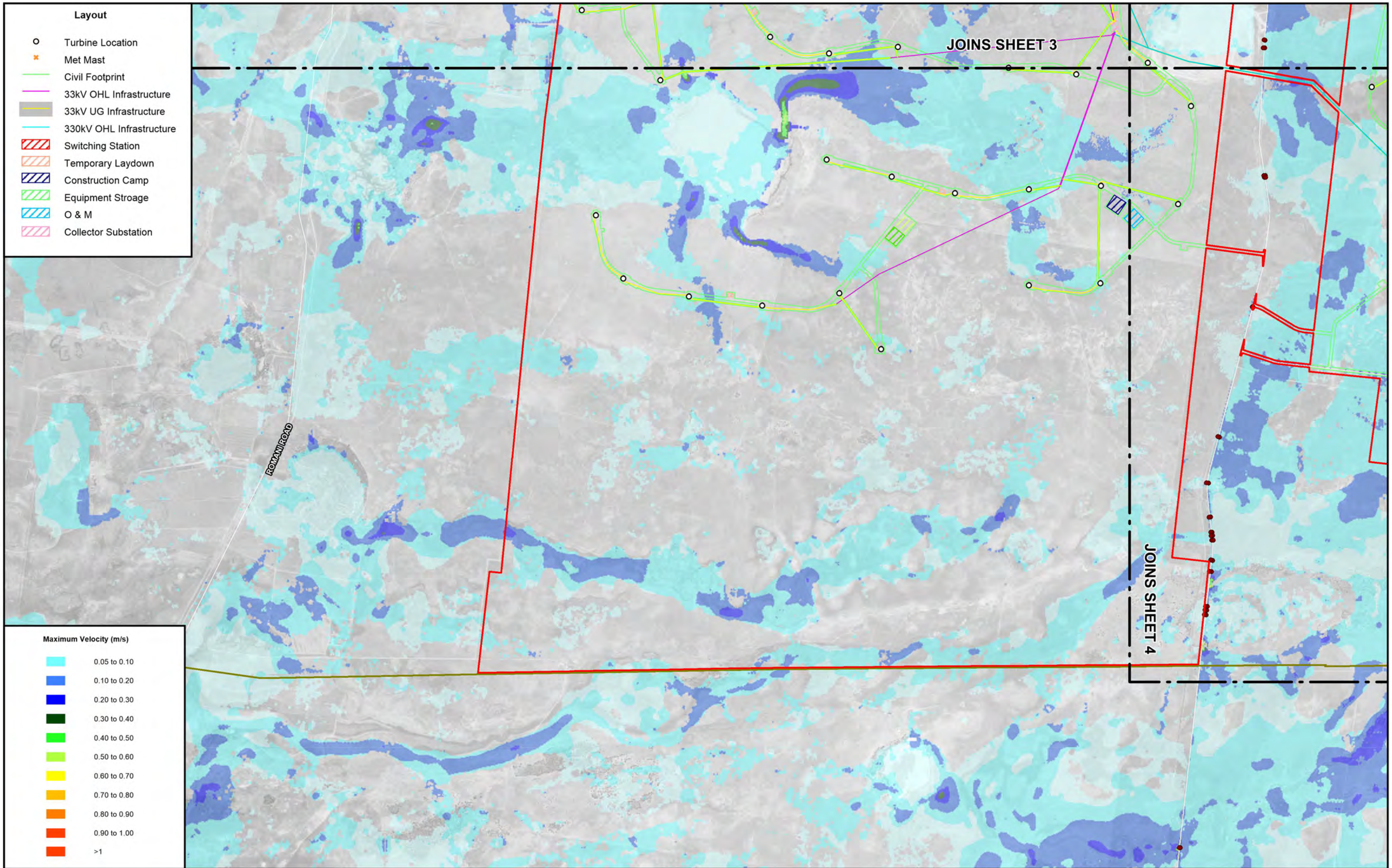
LEGEND

Project Area
LGA Boundary
Modelled Drainage Structures

THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure E2
(Sheet 4 of 5)

MAXIMUM FLOW VELOCITIES UNDER PRE-PROJECT CONDITIONS
1% AEP LOCAL CATCHMENT FLOOD EVENT



N

500 0 500 1000 1500 m

Scale: 1:50,000

Lyall & Associates

LEGEND

Project Area

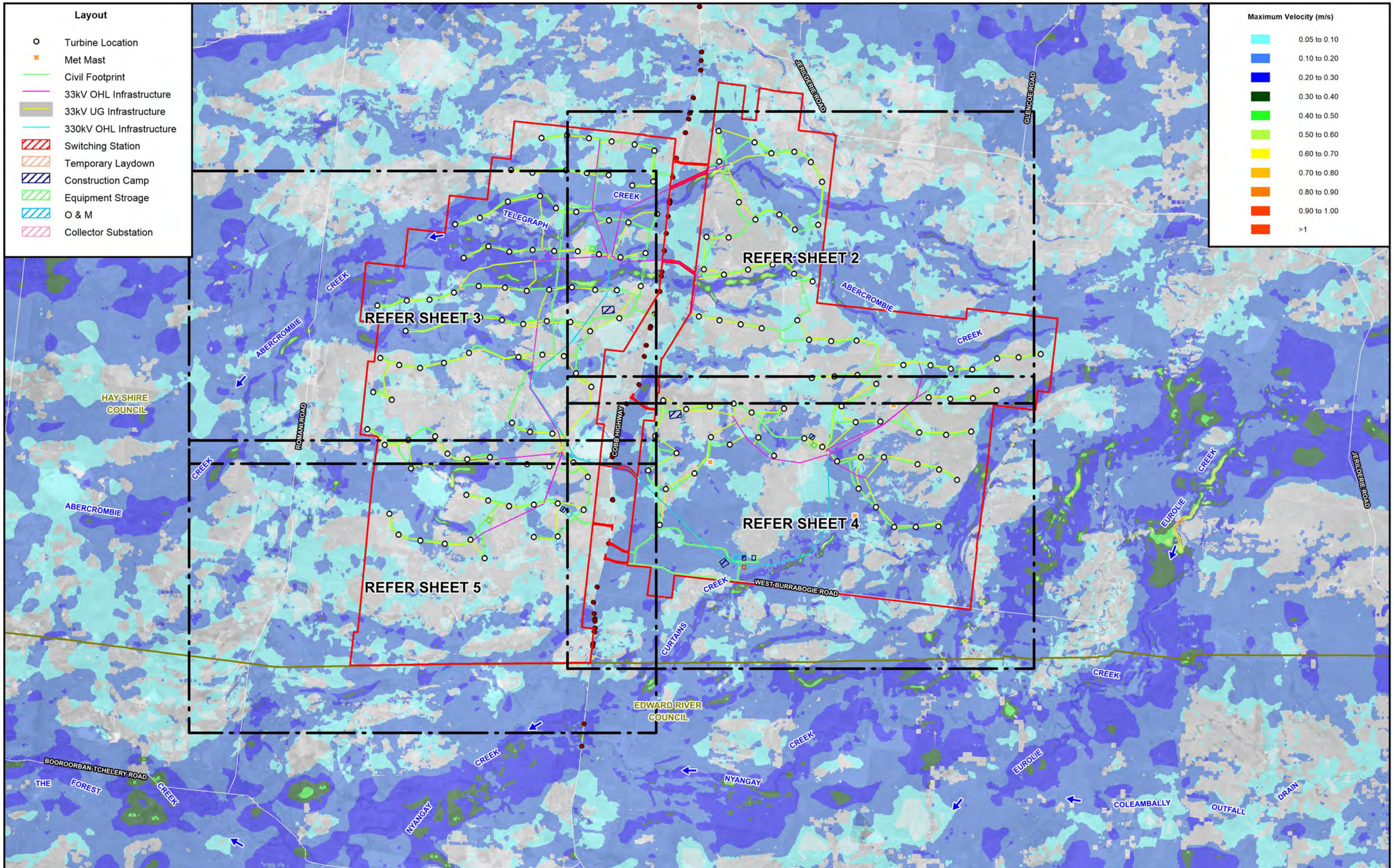
LGA Boundary

Modelled Drainage Structures

THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure E2
(Sheet 5 of 5)

MAXIMUM FLOW VELOCITIES UNDER PRE-PROJECT CONDITIONS
1% AEP LOCAL CATCHMENT FLOOD EVENT



N

1.5 0 1.5 3 4.5 km

Scale: 1:150,000

Lyall & Associates

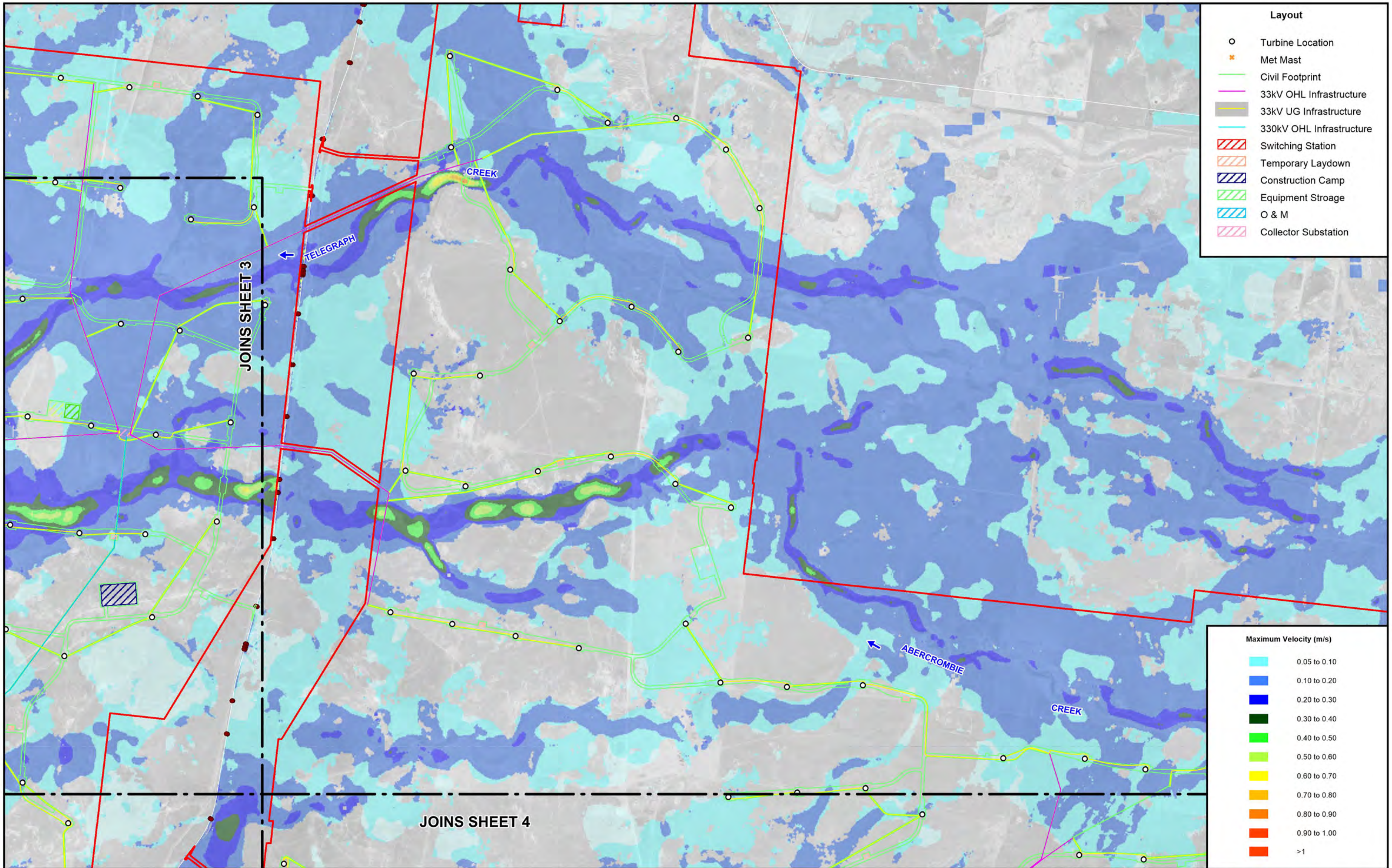
LEGEND

- Project Area
- LGA Boundary
- Modelled Drainage Structures

THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure E3
(Sheet 1 of 5)

MAXIMUM FLOW VELOCITIES UNDER PRE-PROJECT CONDITIONS
PMF LOCAL CATCHMENT FLOOD EVENT



N
500 0 500 1000 1500 m
Scale: 1:50,000

Lyall & Associates

LEGEND

Project Area

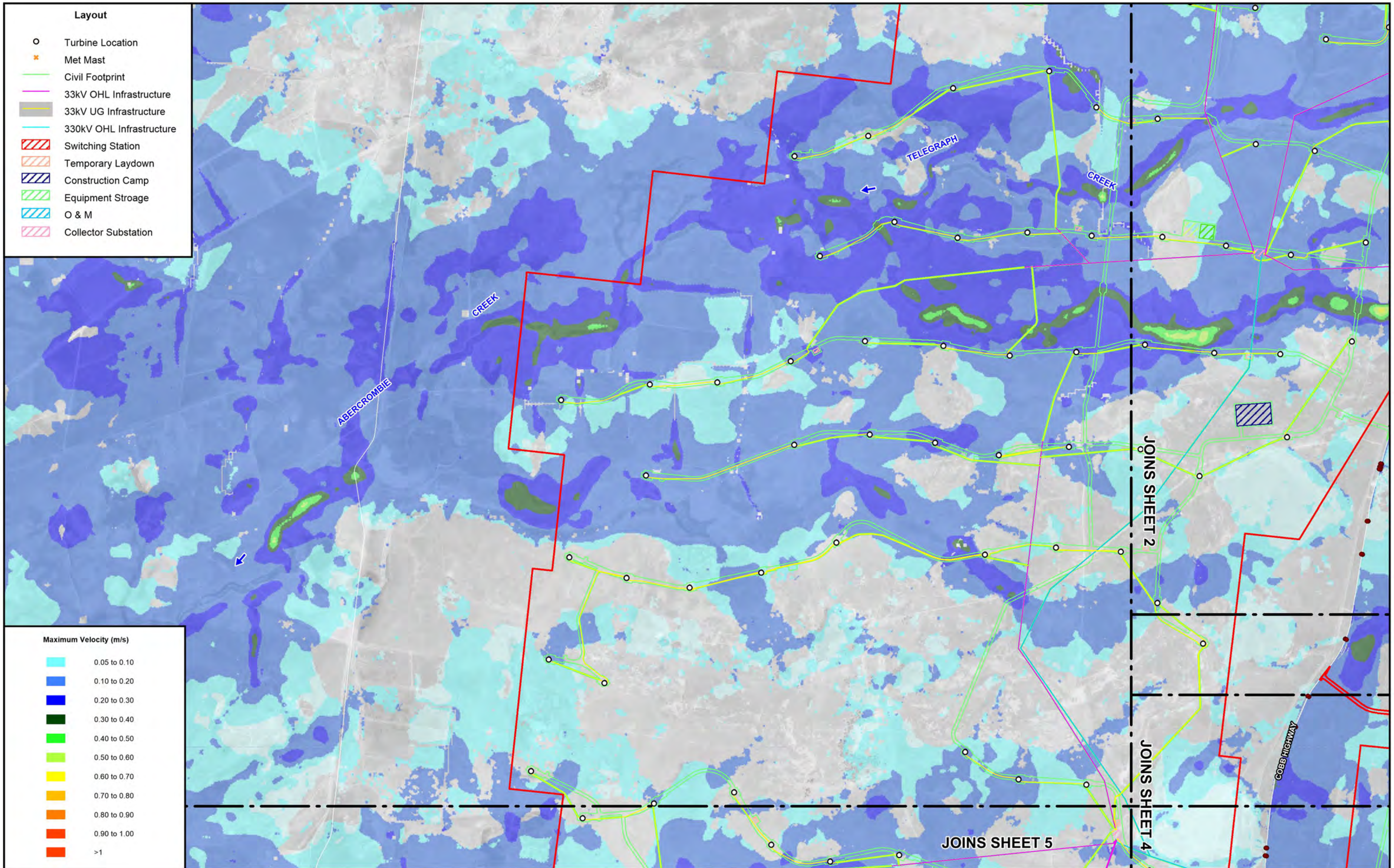
LGA Boundary

Modelled Drainage Structures

THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure E3
(Sheet 2 of 5)

MAXIMUM FLOW VELOCITIES UNDER PRE-PROJECT CONDITIONS
PMF LOCAL CATCHMENT FLOOD EVENT



N 500 0 500 1000 1500 m

Scale: 1:50,000

Lyall & Associates

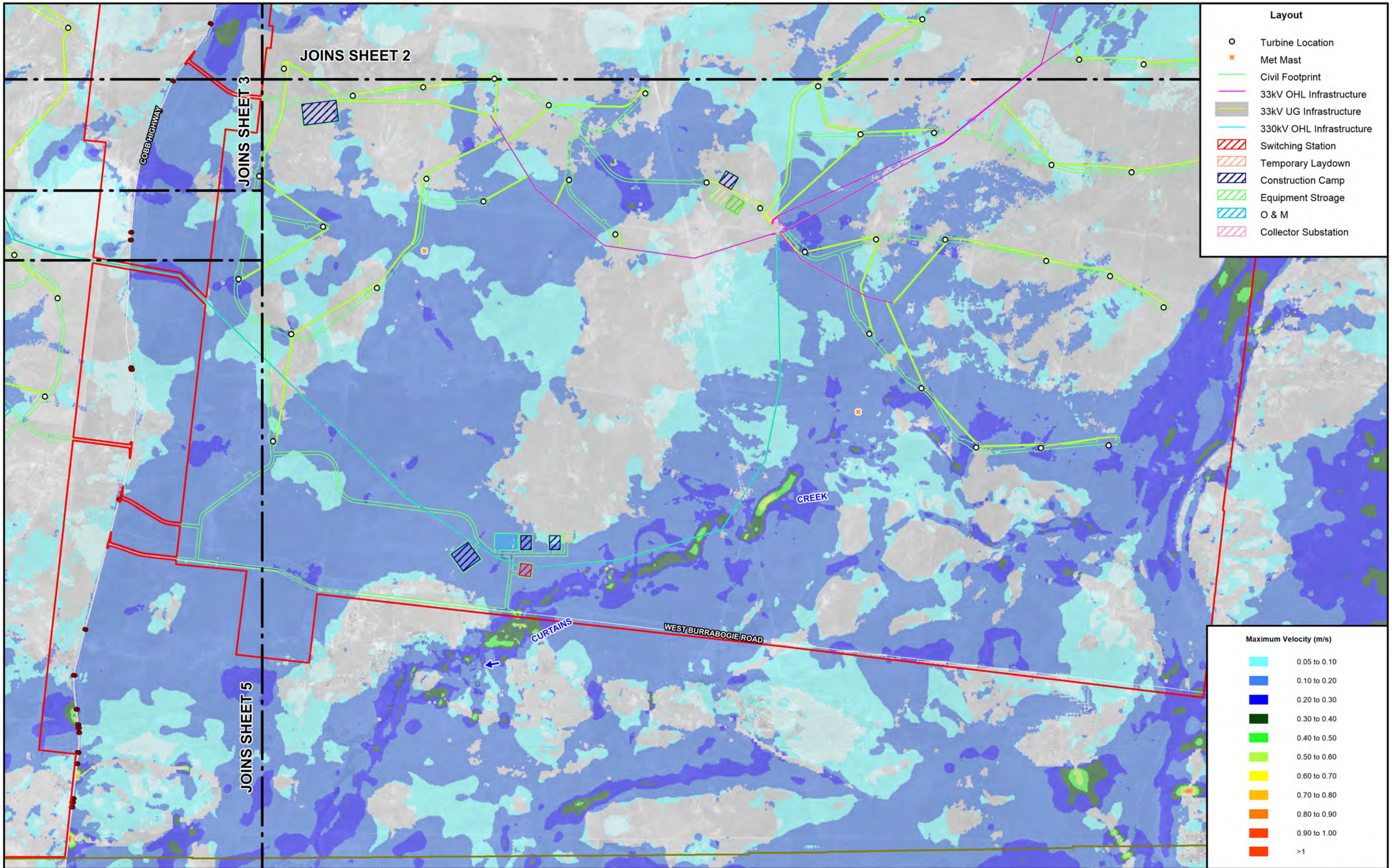
LEGEND

- Project Area
- LGA Boundary
- Modelled Drainage Structures

THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure E3
(Sheet 3 of 5)

MAXIMUM FLOW VELOCITIES UNDER PRE-PROJECT CONDITIONS
PMF LOCAL CATCHMENT FLOOD EVENT



N

500 0 500 1000 1500 m

Scale: 1:50,000

Lyall & Associates

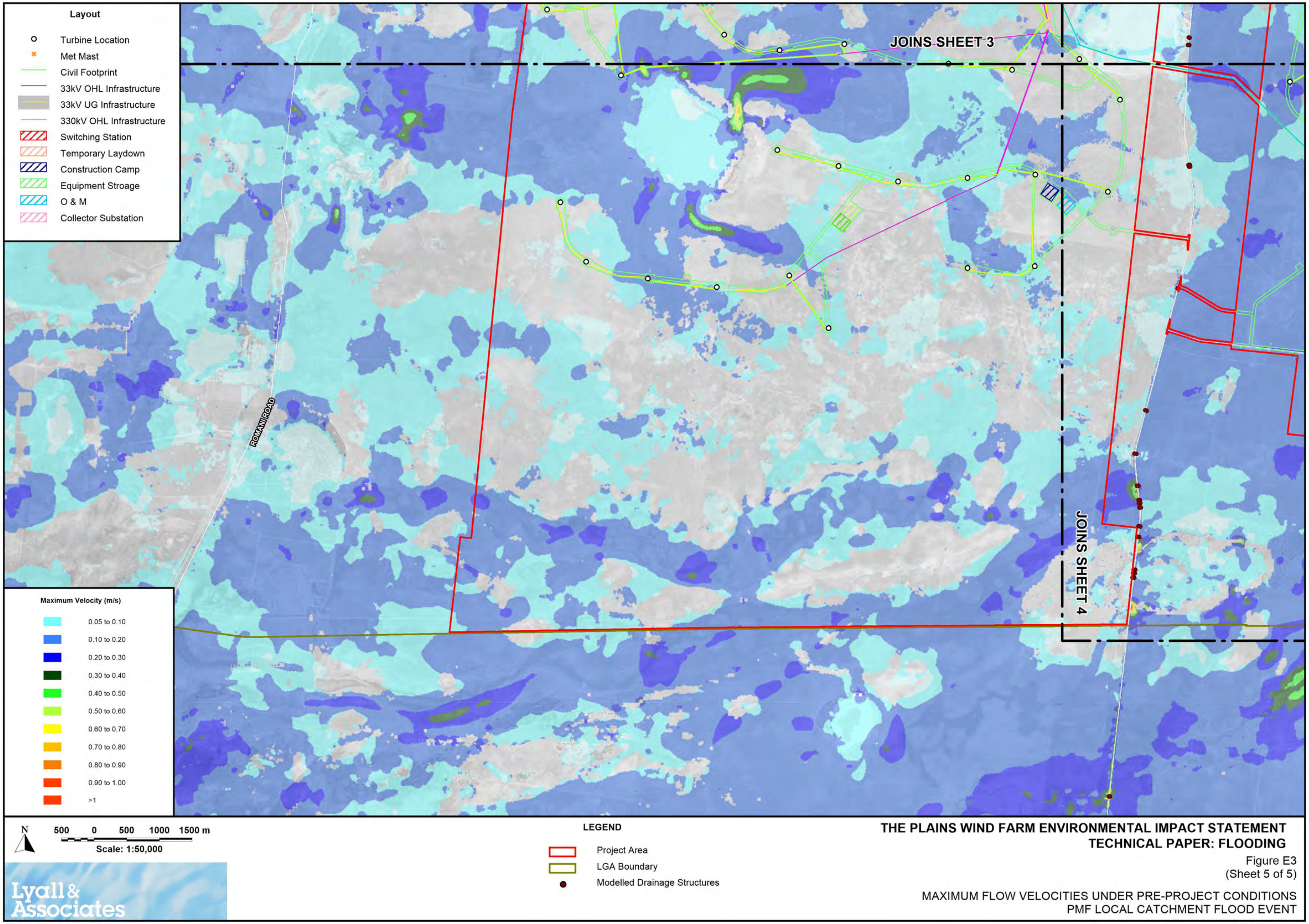
LEGEND

- Project Area
- LGA Boundary
- Modelled Drainage Structures

THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure E3
(Sheet 4 of 5)

MAXIMUM FLOW VELOCITIES UNDER PRE-PROJECT CONDITIONS
PMF LOCAL CATCHMENT FLOOD EVENT



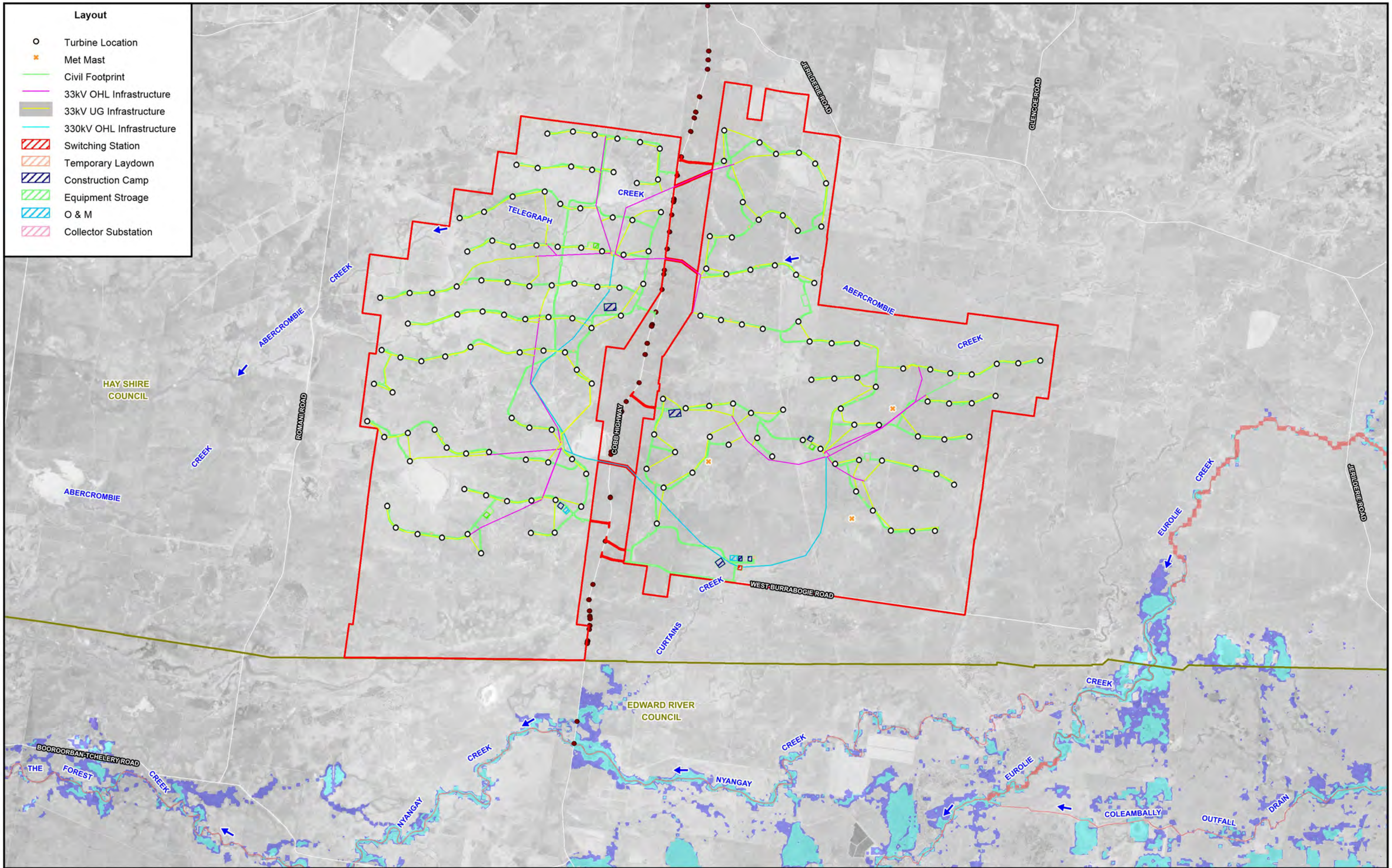
THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure E3
(Sheet 5 of 5)

MAXIMUM FLOW VELOCITIES UNDER PRE-PROJECT CONDITIONS
PMF LOCAL CATCHMENT FLOOD EVENT

APPENDIX F

FIGURES SHOWING THE HYDRAULIC CATEGORISATION AND FLOOD HAZARD VULNERABILITY CLASSIFICATION IN THE VICINITY OF THE PROJECT DURING A 1% AEP MURRUMBIDGEE RIVER FLOOD EVENT



N

1.5 0 1.5 3 4.5 km

Scale: 1:150,000

Lyall & Associates

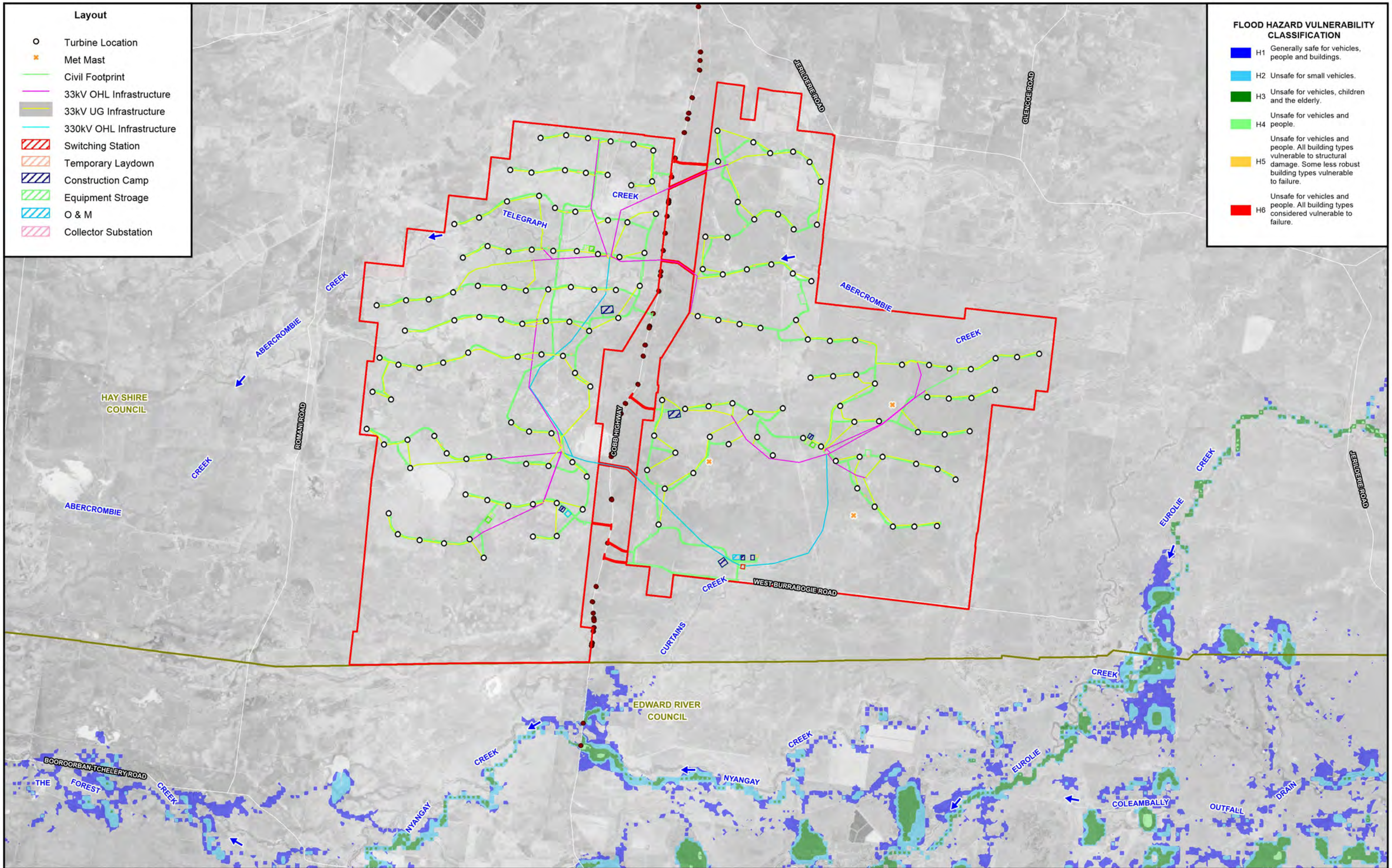
LEGEND

- Project Area
- LGA Boundary
- Modelled Drainage Structures
- Floodway
- Flood Storage
- Flood Fringe

THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure F1

HYDRAULIC CATEGORISATION
1% AEP MURRUMBIDGEE RIVER FLOOD EVENT



N

1.5 0 1.5 3 4.5 km

Scale: 1:150,000

LEGEND

Project Area

LGA Boundary

Modelled Drainage Structures

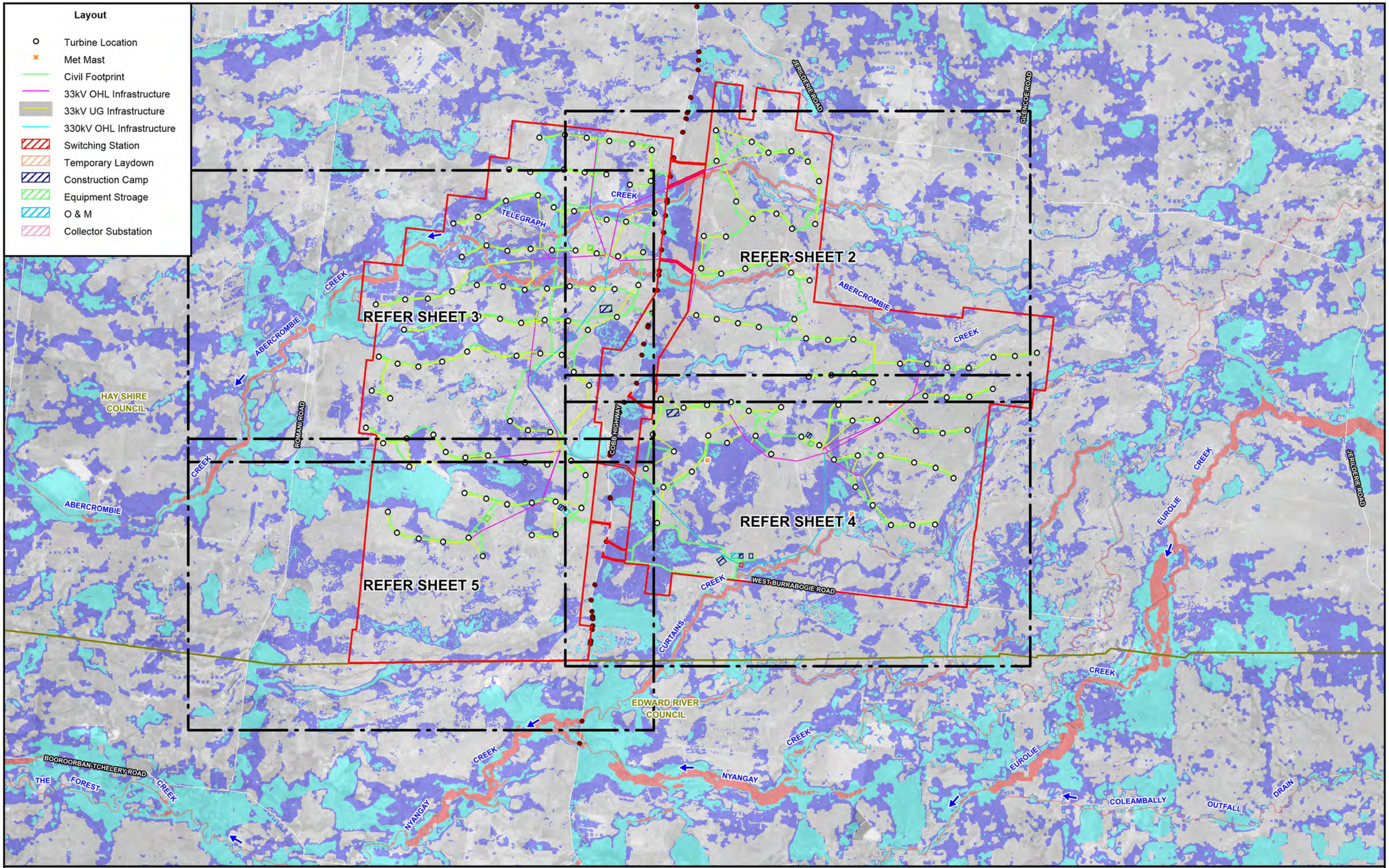
Lyall & Associates

THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure F2

FLOOD HAZARD VULNERABILITY CLASSIFICATION
1% AEP MURRUMBIDGEE RIVER FLOOD EVENT

APPENDIX G
FIGURES SHOWING THE HYDRAULIC CATEGORISATION AND FLOOD HAZARD VULNERABILITY CLASSIFICATION IN THE VICINITY OF THE PROJECT DURING A 1% AEP LOCAL CATCHMENT FLOOD EVENT



LEGEND

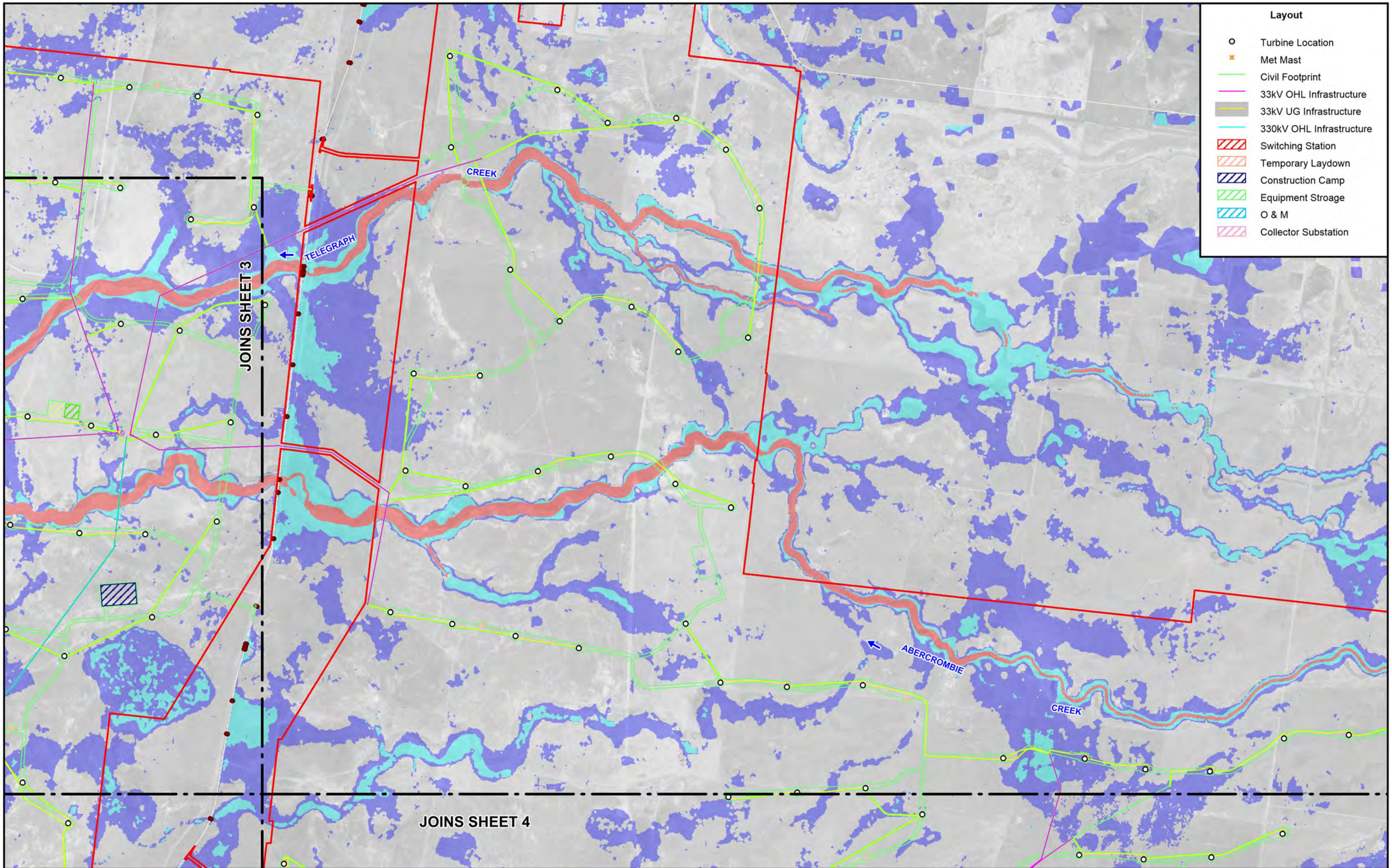
Project Area	Floodway
LGA Boundary	Flood Storage
Modelled Drainage Structures	Flood Fringe

Lyall & Associates

THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure G1
(Sheet 1 of 5)

HYDRAULIC CATEGORISATION
1% AEP LOCAL CATCHMENT FLOOD EVENT



500 0 500 1000 1500 m
Scale: 1:50,000

N

LEGEND

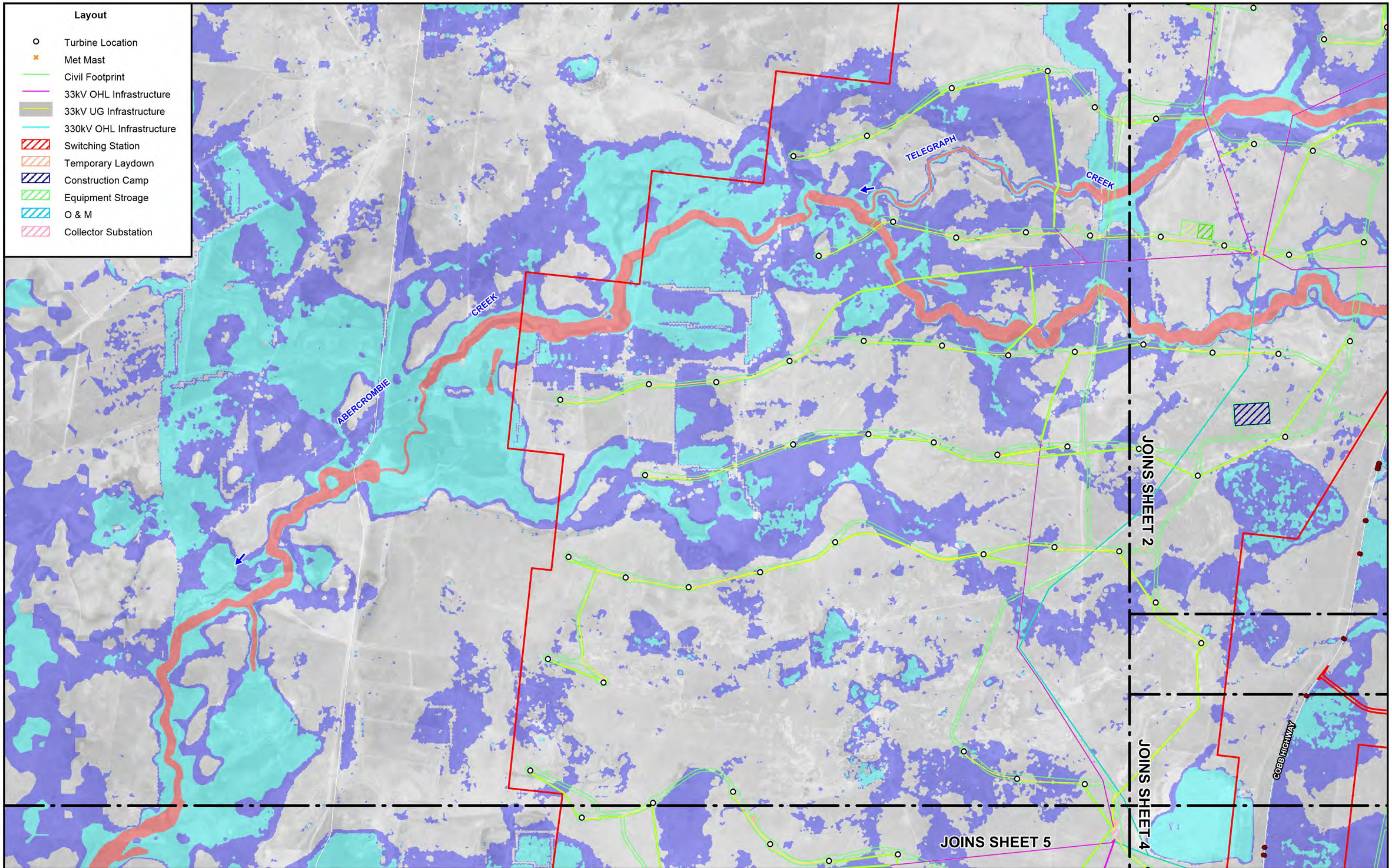
Project Area
LGA Boundary
Modelled Drainage Structures
Floodway
Flood Storage
Flood Fringe

Lyall & Associates

THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure G1
(Sheet 2 of 5)

HYDRAULIC CATEGORISATION
1% AEP LOCAL CATCHMENT FLOOD EVENT



N
500 0 500 1000 1500 m
Scale: 1:50,000

Lyall & Associates

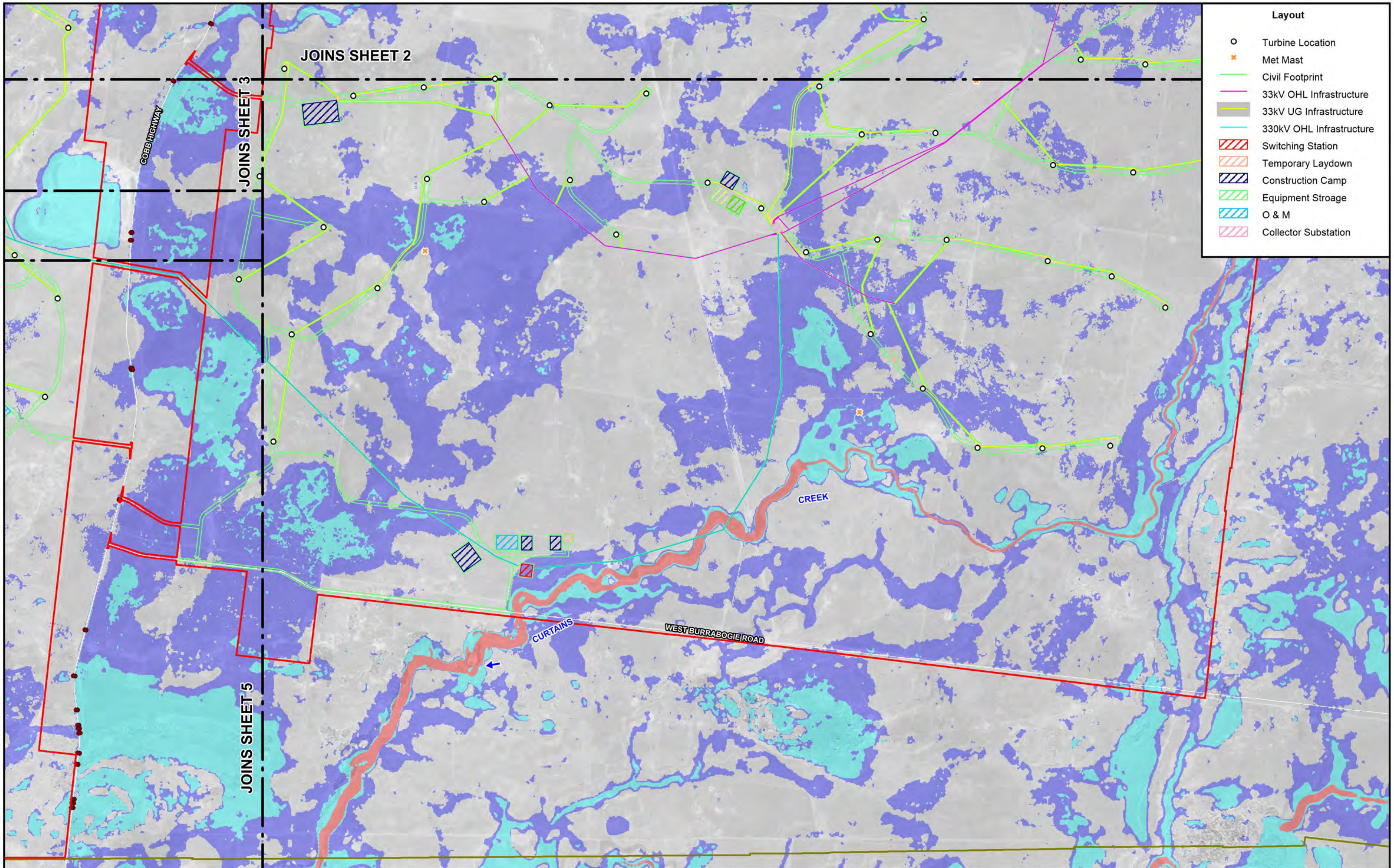
LEGEND

- Project Area
- LGA Boundary
- Modelled Drainage Structures
- Floodway
- Flood Storage
- Flood Fringe

THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure G1
(Sheet 3 of 5)

HYDRAULIC CATEGORISATION
1% AEP LOCAL CATCHMENT FLOOD EVENT



N

500 0 500 1000 1500 m

Scale: 1:50,000

Lyall & Associates

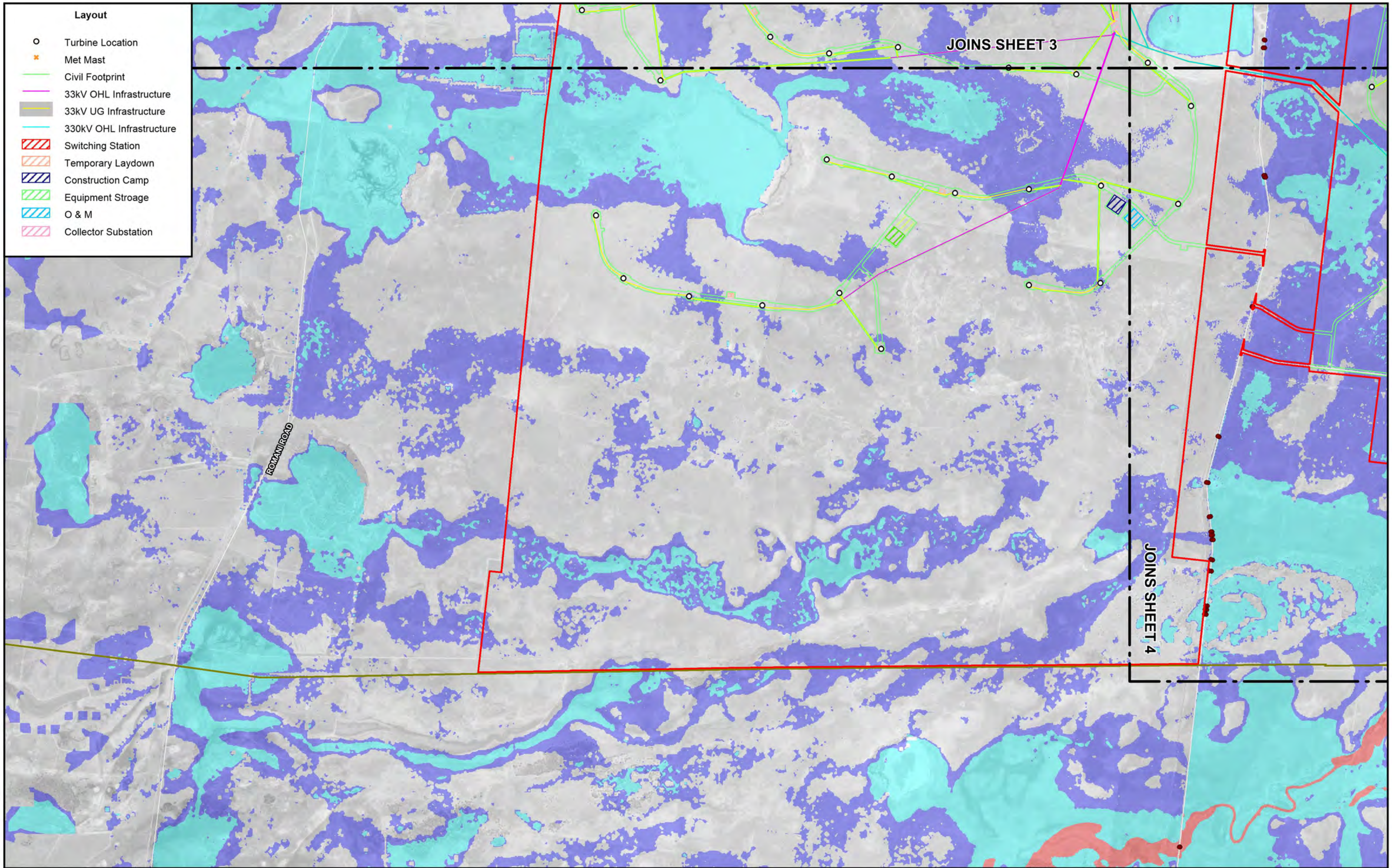
LEGEND

- Project Area
- LGA Boundary
- Modelled Drainage Structures
- Floodway
- Flood Storage
- Flood Fringe

THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure G1
(Sheet 4 of 5)

HYDRAULIC CATEGORISATION
1% AEP LOCAL CATCHMENT FLOOD EVENT



N

500 0 500 1000 1500 m

Scale: 1:50,000

Lyall & Associates

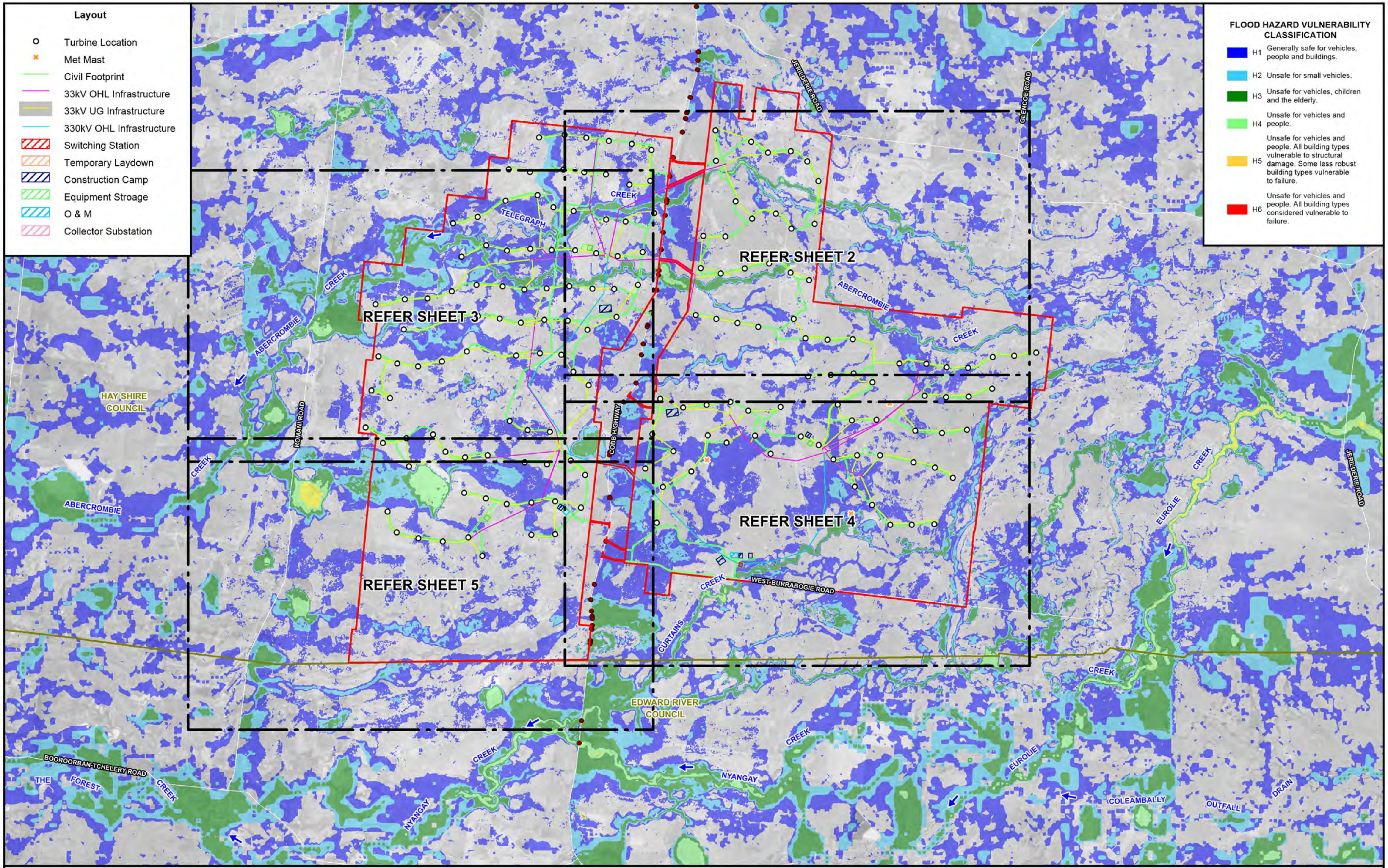
LEGEND

- Project Area
- LGA Boundary
- Modelled Drainage Structures
- Floodway
- Flood Storage
- Flood Fringe

THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure G1
(Sheet 5 of 5)

HYDRAULIC CATEGORISATION
1% AEP LOCAL CATCHMENT FLOOD EVENT



N

1.5 0 1.5 3 4.5 km

Scale: 1:150,000

Lyall & Associates

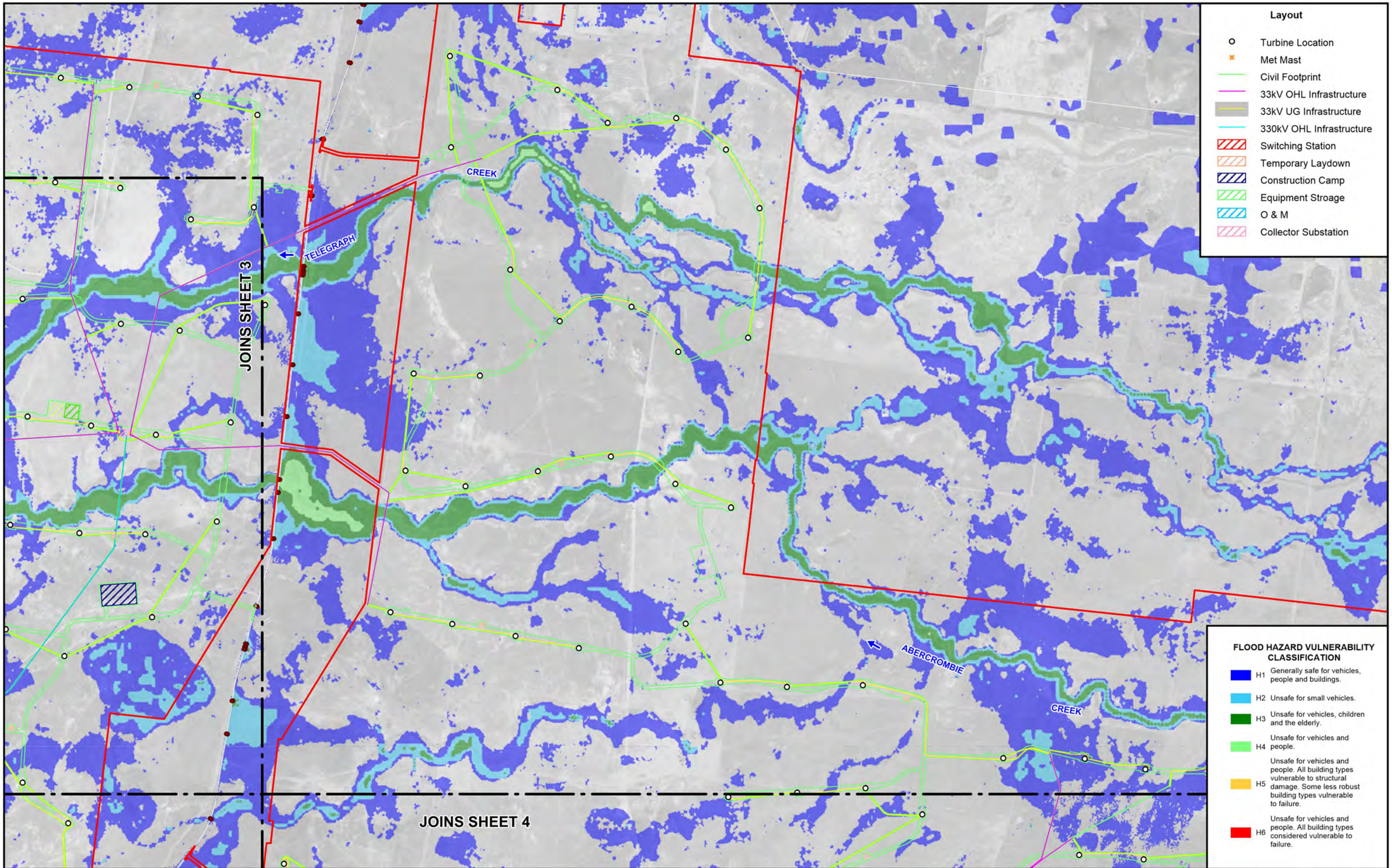
LEGEND

- Project Area
- LGA Boundary
- Modelled Drainage Structures

THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure G2
(Sheet 1 of 5)

FLOOD HAZARD VULNERABILITY CLASSIFICATION
1% AEP LOCAL CATCHMENT FLOOD EVENT



LEGEND

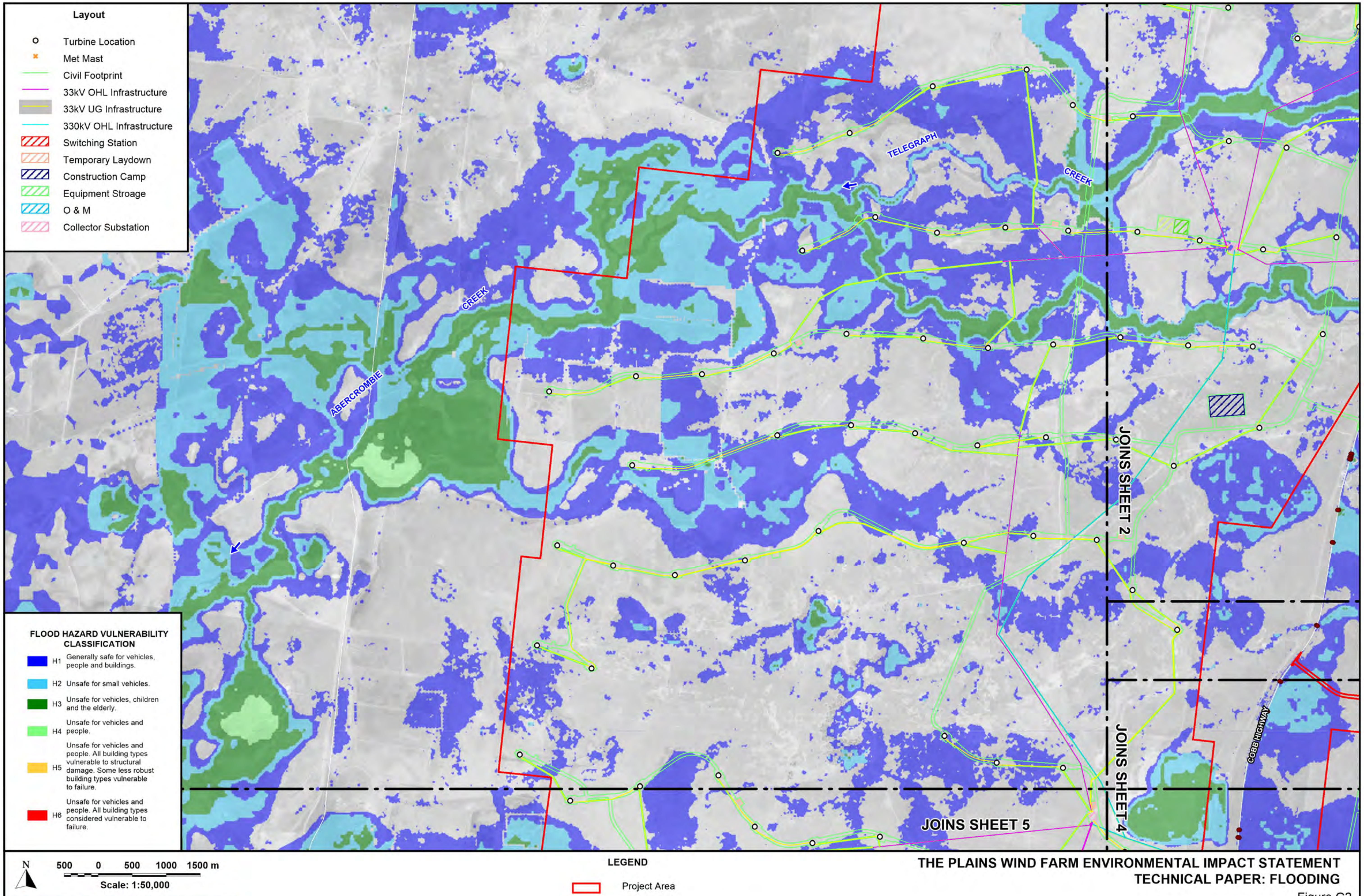
- Project Area
- LGA Boundary
- Modelled Drainage Structures

Lyall & Associates

THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure G2
(Sheet 2 of 5)

FLOOD HAZARD VULNERABILITY CLASSIFICATION
1% AEP LOCAL CATCHMENT FLOOD EVENT



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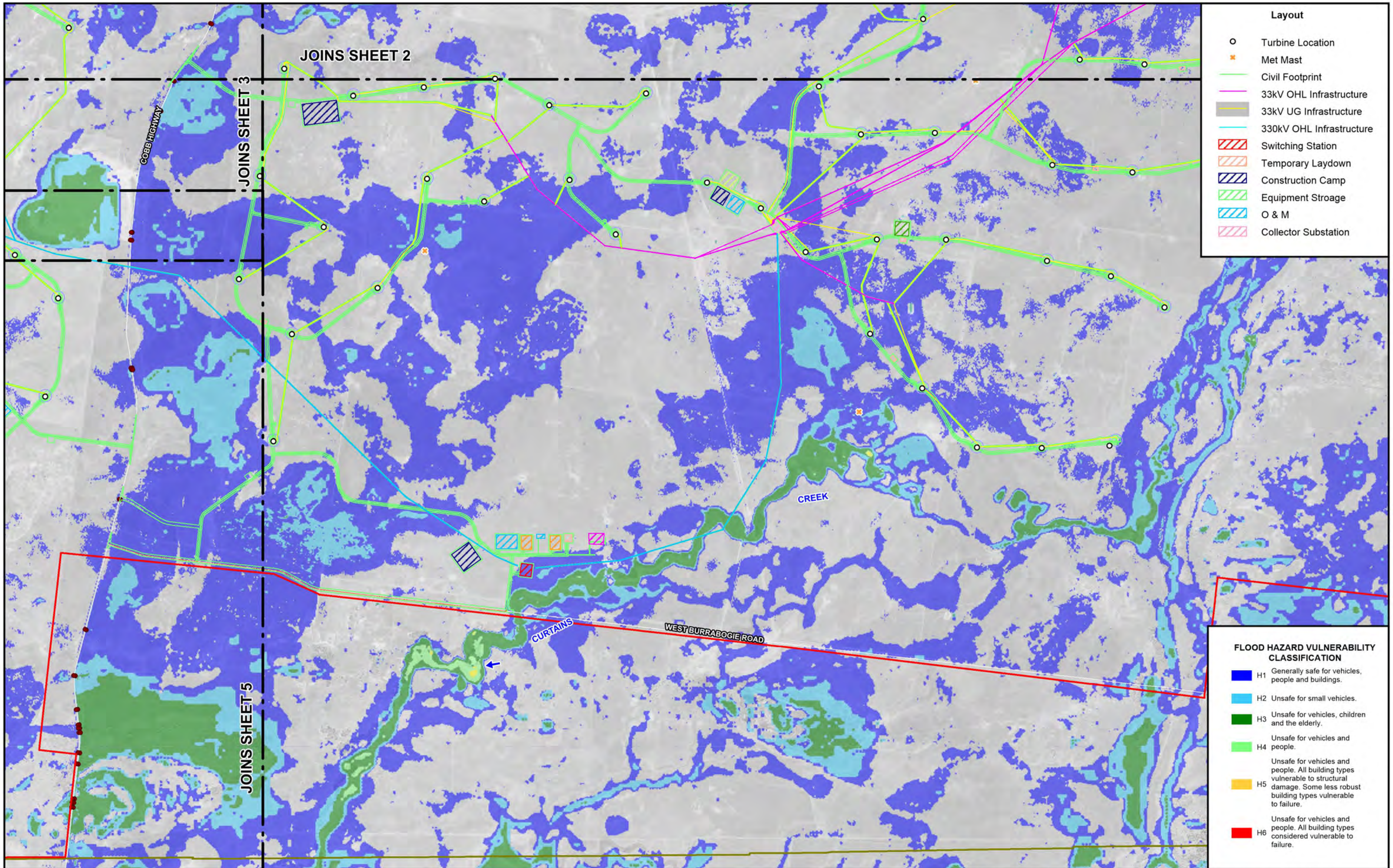
THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure G2
(Sheet 3 of 5)

FLOOD HAZARD VULNERABILITY CLASSIFICATION
1% AEP LOCAL CATCHMENT FLOOD EVENT



N

500 0 500 1000 1500 m

Scale: 1:50,000

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LEGEND

Project Area

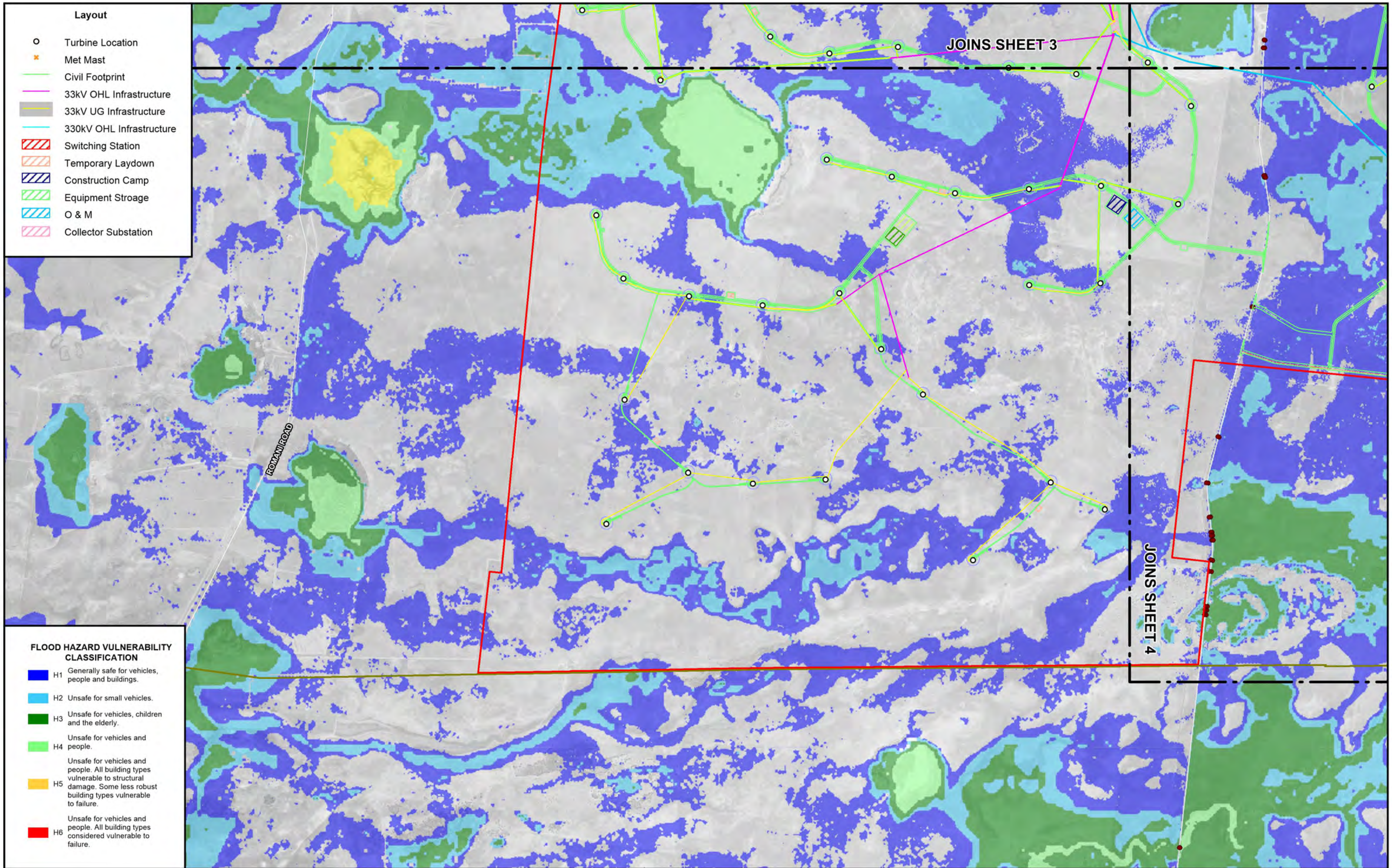
LGA Boundary

Modelled Drainage Structures

THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure G2
(Sheet 4 of 5)

FLOOD HAZARD VULNERABILITY CLASSIFICATION
1% AEP LOCAL CATCHMENT FLOOD EVENT



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THE PLAINS WIND FARM ENVIRONMENTAL IMPACT STATEMENT
TECHNICAL PAPER: FLOODING

Figure G2
(Sheet 5 of 5)

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