COVEY ASSOCIATES PTY LTD

Consulting Engineers

NATURAL HAZARD RISK ASSESSMENT

AT

THEODORE WIND FARM, BANANA SHIRE

FOR

ERM PTY LTD

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Executive Summary

Covey Associates have prepared this Natural Hazard and Risk Assessment (NHRA) focused on bushfire to support the Development Application of the Theodore Wind Farm (the development) in Banana Shire (the site). Covey Associates completed detailed desktop-based fire weather and fuel analysis, to inform the radiant heat flux assessment using advanced modelling and data analysis techniques.

The required setback distances between wind farm infrastructure (including wind turbine generators, site offices/compounds, on-site accommodation, switchboards, substations, BESS, and static water supply) and vegetation prone to bushfire hazards must adhere to the specifications outlined in Table 4.1, ensuring a minimum separation of 20 meters.

The output from the Radiant Heat Flux modelling specifies the necessary distances for separation between wind farm infrastructure and vegetation susceptible to bushfire risks. These prescribed distances must be followed, guaranteeing a minimum separation of 20 meters. The development disturbance corridor has an area sufficient to accommodate the required Asset Protection Zone widths within the design layout.

This NHRA details the measures required to achieve the purpose and outcomes of the Draft State Code 23 (PO 9), State Planning Policy the Rural Zone Code (PO52 to 59) of Banana Shire Council Planning Scheme. These are specified within Section 4 and Appendix E of this report. Subject to the mitigation measures being implemented, the bushfire hazard level and risk applicable to the proposed development is considered to be acceptable.

This NHRA focused on radiant heat flux risk level, and related hazards, and further investigations might be required to support a development application, e.g., bushfire behaviour analysis, Engineering Services Report, electrical transmission line compliance, ecological assessments, etc.

List of Abbreviations

Abbreviation	Full Meaning
AEP	Annual Exceedance Probability
APZ	Asset Protection Zones
AWS	Automated Weather Station
BESS	Battery Energy Storage System
BRC	Bushfire Resilient Communities (2019)
FFDI	Forest Fire Danger Index
GEV	Generalised Extreme Value
NHRA	Natural Hazard Risk Assessment
RH	Relative Humidity
RHF	Radiant Heat Flux
SPP	State Planning Policy
VHC	Vegetation Hazard Classes
WF	Wind Farm

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1 INTRODUCTION

1.1 Scope

ERM Pty Ltd has commissioned Covey Associates Pty Ltd (Covey) to complete a desktop Natural Hazard Risk Assessment (NHRA) to accompany a Material Change of Use (MCU) for the proposed Theodore Wind Farm (WF). Refer to Section 4 of this NHRA for details of the proposed development. The Queensland Floodplain Assessment Overlay identifies Castle Creek's flood plain as a flood hazard area. The Banana Shire Council Planning Scheme 2021 Overlay Flood Hazard Map (Overlay Map OM-0401 – Flood Hazard - Shire) does not identify any further flood hazard areas, other than the one identified by the State. Given that the proposed WF layout is located more than 2.5 km south of Castle Creek flood plain, the impact flooding potential for the Theodore WF assets is not a concern. As such, this NHRA focuses on analysing impact of the potential bushfire constraints and impacts to the proposed development. This analysis is used to inform how the recommended mitigation strategies achieve the purpose and outcomes in Bushfire Resilient Communities Technical Guide (BRC; Queensland Fire and Emergency Services, 2019), Queensland State Planning Policy - Natural hazards, risk and resilience state interest – Bushfire (Queensland Government, 2019) and the draft update of the State Code 23 – Wind farm development: (Department of State Development Infrastructure Local Government and Planning, 2022). This report also demonstrates that the proposed development will be undertaken within the performance outcomes for development affected by the bushfire risk overlay of the Rural Zone Code (PO52 to PO56).

1.2 Objectives

The NHRA reviews historical fire weather and adopts Radiant Heat Flux (RHF) modelling to analyse the bushfire hazard and risk to which the development is subject. This information provides insight to the appropriate bushfire risk mitigation measures required to satisfy the Natural hazards, risk and resilience state interest and draft State Code 23.

The objectives of this NHRA are to:

1. Achieve consistency with objectives and policy measures of State Development Assessment Provisions, BRC, and any local planning scheme provisions relating to bushfire;
2. Understand and document the extent of bushfire hazard for the site and impacts for the proposed development, including modelling RHF;
3. Assess the proposed development against the Banana Shire Planning Scheme 2021, Rural Zone code – performance outcomes for assessable development affected by bushfire risk overlay; and ,
4. Recommend bushfire risk management measures for the site with due regard for people, property, infrastructure, and the environment.

1.3 Document Review

No current Bushfire Management Plan exists for the site. Covey recommends reviewing this NHRA after five years from the date of issue, or until there is a revision to the development, whichever is lesser.

1.4 Planning Context

1.4.1 Bushfire Prone Designation

Formal designation of an area as “Bushfire Prone” provides the legislative trigger to:

- Complete a Bushfire Hazard and Risk Assessment, and
- Enforce all Building Classes to be constructed per AS 3959 – 2018 Construction of buildings in bushfire prone areas (AS 3959).

1.4.2 State Development Assessment Provisions

The draft Planning guidance - *State code 23: Wind farm development*, requires WF layouts to be resilient to the risks posed by natural hazards and extreme weather events that could affect the site.

1.4.3 State Planning Policy - Natural hazards, risk and resilience state interest – Bushfire

The State Planning Policy (SPP) - *Natural hazards, risk, and resilience state interest – Bushfire*, identifies two ways a site may be designated as bushfire prone. These are as follows:

1. If the land is identified by a local government in a local planning instrument as a bushfire-prone area, based on a localised bushfire study, prepared by a suitably qualified person; or,
2. If the local government has not identified bushfire-prone areas in a local planning instrument in accordance with (1) above, the area is shown on the SPP Interactive Mapping System as a bushfire-prone area.

1.4.4 Banana Shire Council

The site is zoned as Rural under the Planning Scheme (Zone Map ZM-001). The site (pre-development) is subject to Medium and High Potential Bushfire Intensity around areas of woody vegetation with Very High Potential Bushfire Intensity typically observed in more rugged terrain (Section 3 of NHRA). Following the development of the site, the setback distance from bushfire hazardous vegetation should allow assets to be located in areas subject to less than 29 kW/m^2 RHF.

Specific outcomes 10 and 11 of Natural Systems and Hazards (s2.6.1.1) within the Shire of Banana Planning Scheme Strategic Framework call for:

10. Developments to manage risks from natural hazards, prioritising in order, the safety of people, protection of public infrastructure and protection of private property; and,
11. Development to avoid impacts on the function of flood plains and does not worsen the severity or impact of natural hazards.

The planning scheme Categories of Assessment – Material Change of Use (s5.10.1 of the Planning Scheme) identifies the benchmarks and requirements for development located with a Rural Zone within this Local Government Area. Performance Outcomes 52 to 59 of the Rural Zone Code (s5.10.2) details the standards, expectations, and specifications incorporated into the project design to protect life and property from bushfire risk. These specifications have been incorporated into the design of the project. Where conflict between the Planning Scheme and the SPP (2019) occurs, the higher standard of bushfire protection was adopted.

1.5 Bushfire Context

The following documents are identified as being referenced to provide the performance criteria and technical specifications for this Bushfire Assessment:

1. Banana Shire Council Planning Scheme (2021).
2. Queensland Government. (2019). Natural hazards, risk and resilience – Bushfire. State Planning Policy – state interest guidance material.
3. Queensland Government. (2021). Natural hazards, risk and resilience state interest – Bushfire. Example, planning scheme assessment benchmarks.
4. Queensland Fire and Emergency Services. (2019). Bushfire Resilient Communities. Technical Reference Guide for the State Planning Policy State Interest “Natural Hazards, Risk and Resilience-Bushfire”.
5. State of Queensland, Department of State Development, Infrastructure, Local Government and Planning (2022). Draft Planning guidance - State code 23: Wind farm development.
6. The State of Queensland. (2017). State Planning Policy
7. Design Guidelines and Model Requirements: Renewable Energy Facilities (2023). Country Fire Authority
8. Standards Australia. (2018). AS 3959 - 2018 Construction of buildings in bushfire-prone areas: SAI Global.
9. SAI Global (2021). AS 2419.1:2021 Fire Hydrant Installations for Buildings; Australian Standards

This NHRA demonstrates that the potential bushfire impacts to people, property, economic activity and the environment have been mitigated and/or avoided, thus complying with the purpose and outcomes of the natural hazards, risk, and resilience state interest. The format of this report is consistent with BRC, and the development is assessed against the requirements of the Planning Scheme, SPP (2019) and BRC.

2 DEVELOPMENT PROPOSAL

The proposed Theodore Wind Farm (WF) is located in Banana Shire – approximately 30 km east of the Theodore township in central Queensland – will see the installation of up to 170 turbines with a battery storage facility to provide up to 1,100 MW of renewable energy to the surrounding communities (Figure 2-1; Appendix A) (https://au.rwe.com/projects/theodore-wind-farm/). The subject site for the proposed project encompasses 46,000 ha, however the footprint of the development will be no larger than 4.6% of this area. Construction of the project is anticipated to commence in 2026, pending relevant development approvals.

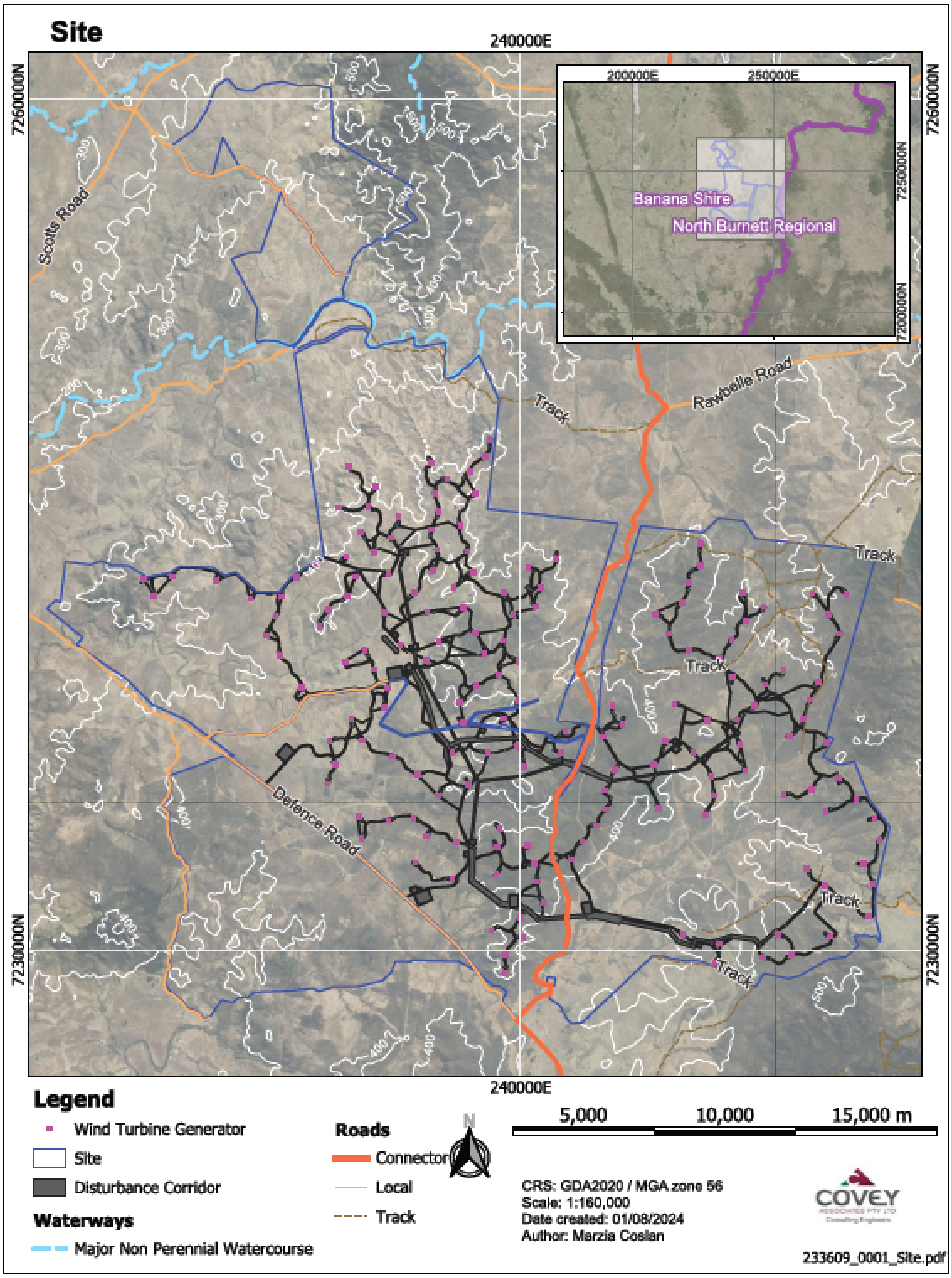


Figure 2-1. Theodore WF site Layout.

2.1 Access

The main access points to the site will be via Defence Road, along the South-West side of the development site, with connections also from Hamiltons Road, and Crowsdale Camboon Road (Figure 2-1). The proposed development will see the construction of vehicular access tracks connecting to each proposed wind turbine. This will ensure suitable vehicle connection routes across the site for firefighting vehicles, as well as suitable escape routes for personnel in case of emergency evacuation.

2.2 Water Supply

No reticulated water supply exists in the area. There are several dams across the site that could provide assistance to firefighters and firefighting vehicles as a water resource. However, due to the unpredictability of weather events such as droughts, these should not be relied upon. Further state planning policy require a water supply dedicated solely to firefighting purposes to be present on site. It is recommended that six static water storage tanks dedicated to firefighting, of at least 45,000 L effective capacity each, at the site entrances depicted in Figure 2-2 per Renewable Energy and Fire Safety Design guidelines (Country Fire Authority, 2023).

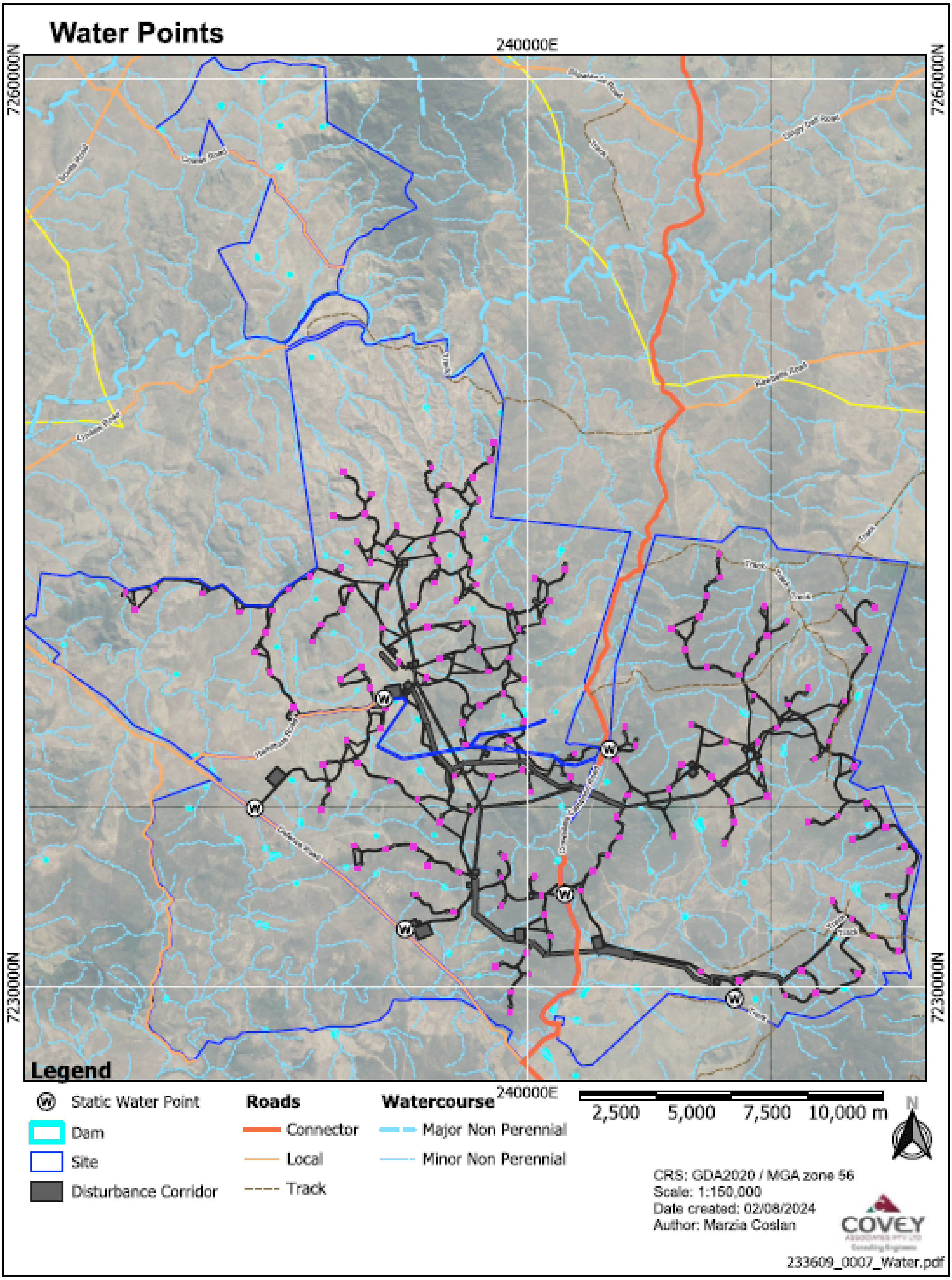


Figure 2-2. Existing ephemeral and proposed static water point locations dedicated to firefighting.

3 BUSHFIRE HAZARDS

The proposed WF disturbance footprint covers 2,122 ha out of the 46,000 ha area on which it will be located. Although the WF accounts for just 4.6% of the lot, bushfires respect no boundaries; thus, bushfire hazards and risk are better captured at a landscape scale. For this reason, Covey has both:

- Analysed the potential radiant heat flux as per BRC guidelines, thus fulfilling the statutory requirements; as well as,
- Reviewed the vegetation present within 5 km radius of the lot boundaries (study area) and the historical fire weather observed for the area to give a more though understanding of the landscape hazards.

Banana Shire adopts the SPP Bushfire Prone Area mapping as their overlay. This indicates that areas of Medium and High Potential Bushfire Intensity are centred around woody vegetation, with Very High Potential Bushfire Intensity typically observed in more rugged terrain (Figure 3-1 with reference to Figure 3-6 and Figure 3-7). The bushfire prone area designation triggers a Bushfire Hazard and Risk Assessment under SPP and draft State Code 23. The Bushfire Prone Area categories indicates the potential risk of a fire front impacting the area with intensity as per Table 3-1.

***Table 3-1. Bushfire Prone Area categories and associated intensities* (Queensland Fire and Emergency Services, 2019a).**

Bushfire Prone Area Category	Potential Fire Line Intensity	Colour Code
Low	< 4,000 kW/m	clear
Medium	4,000 – 20,000kW/m	
High	20,000 – 40,000kW/m	
Very High	> 40,000kW/m+	

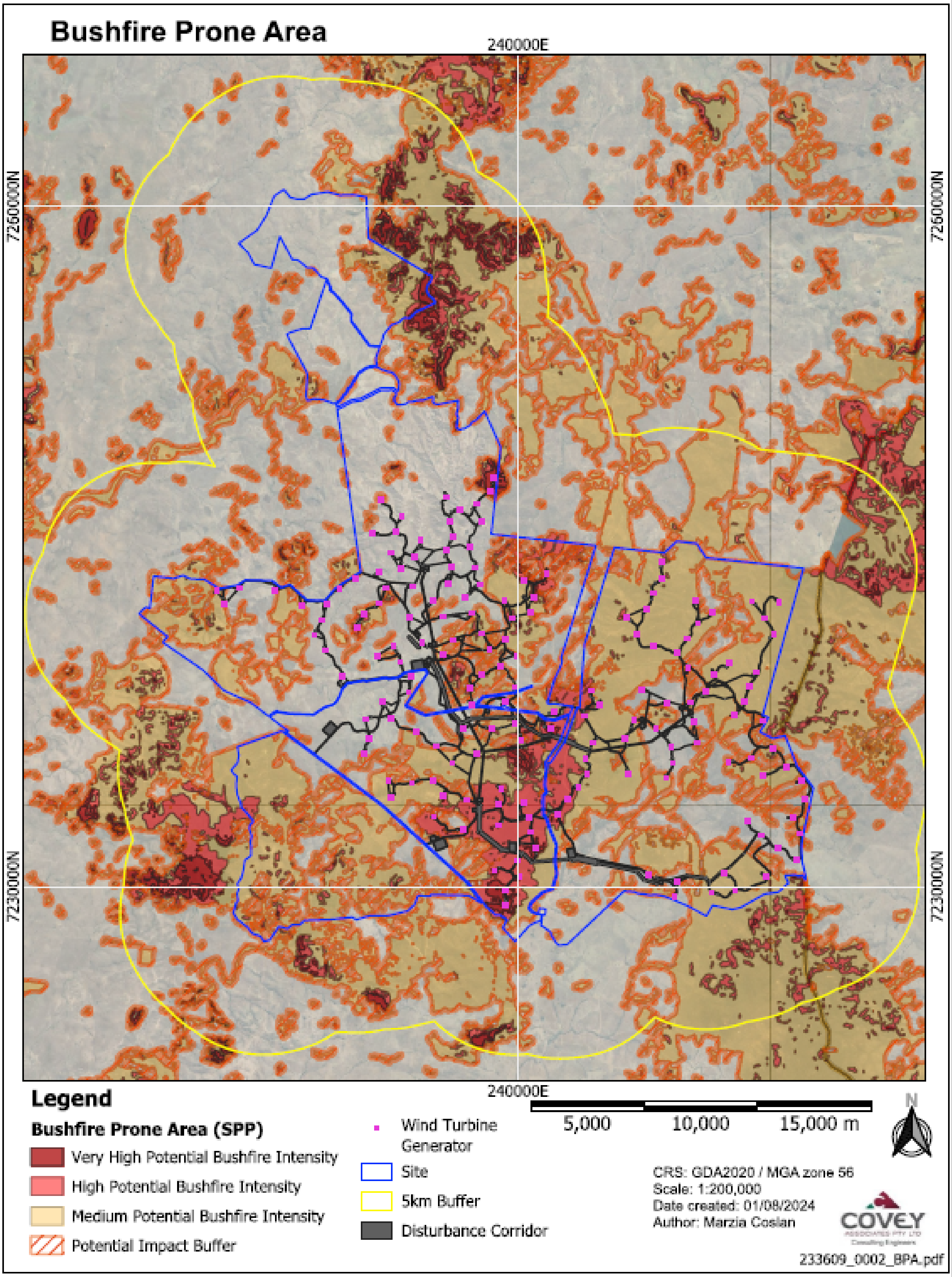


Figure 3-1. State Planning Policy Bushfire Prone Area Mapping.

3.1 Weather

Fire weather is often associated with meteorological conditions that generate increased fire behaviour, resulting in difficulty suppressing wildfires. Fire weather can be influenced by many local factors including temperature, wind, relative humidity, and drought factor – all of which are used to calculate Forest Fire Danger Index (FFDI). Fire risk is typically linked to the occurrence of fire weather days or sequences of days of FFDI above 25 (Queensland Parks and Wildlife Service, 2013).

Weather information for nearby Automated Weather Stations (AWS) are available from Gayndah (approximately 140 km ESE from the site), and Thangool (approximately 50 km NNE from the site). The proposed site of the Theordore WF, and the two selected AWS locations are within the Brigalow Belt Bioregion in Queensland. The individual assessment from each AWS (Gayndah for 2003-2024, and Thangool 2009-2024), shall remain separate in the weather analysis with the aim to provide greater insight of likely fire weather locally from two available datasets as opposed to a singular AWS.

Analysis of monthly FFDI distribution indicates that the fire season typically extends between August and January, peaking in October (seasonally dependant) (Figure 3-2).

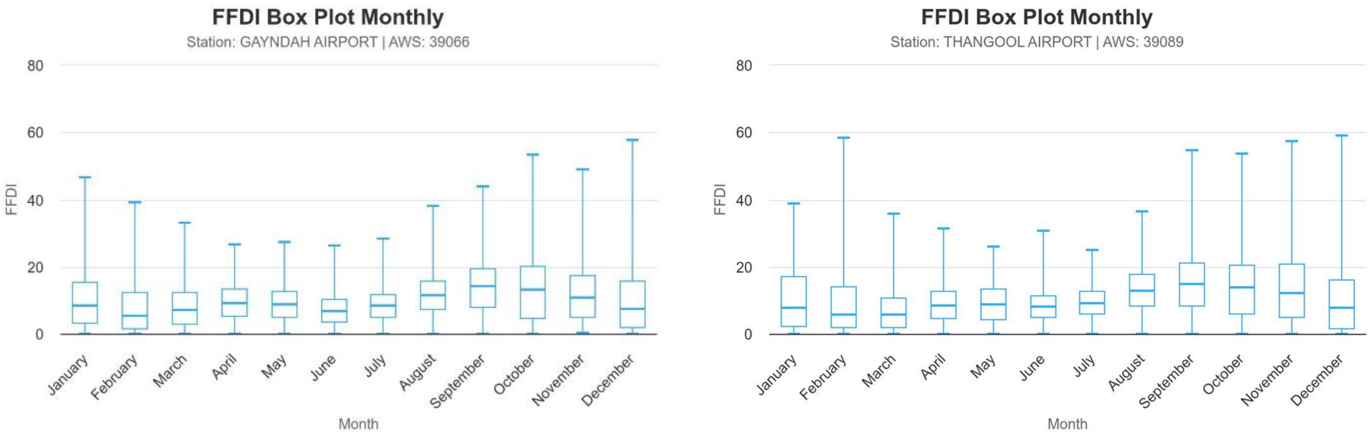


Figure 3-2 – Box Plot of FFDI by Month and Season for Gayndah and Thangool

Table 3-2 and Table 3-3 provide the highest ranked FFDIs over the recorded period – where the total number in the ranking is the number of complete years of historical weather data from the two AWS assessed (i.e., thirteen years for Thangool from 2010-2023). These show that the highest ranked fire danger days are typically associated with:

- Air temperatures in excess of 30^{O}C;
- Low Relative Humidity (>20%);
- Westerly arc winds; and,
- Relatively dry conditions (Drought Factor >8).

Table 3-2 - Highest Ranked FFDI for Gayndah AWS 2003-2023

Rank	Date	T (°C)	Dew Point (°C)	RH (%)	Wind Speed (km/hr)	Wind direction (deg)	Wind Cardinal Direction	KBDI	Drought Factor	FFDI
1	2019-12-05	38.3	-7.9	5	20.5	240	SW	153.37	10	57.59
2	2004-10-08	36.9	5	14	29.5	260	WSW	162.83	10	53
3	2008-12-31	41	3.4	10	20.5	290	W	144.89	9.91	51.61
4	2019-11-08	37.8	-3.9	7	24.1	260	WSW	134.14	9.37	48.73
5	2016-11-10	38.3	6.1	14	25.9	270	W	145.82	9.9	48.5
6	2019-12-02	35.6	-0.7	10	24.1	250	WSW	151.1	9.99	48.42
7	2005-10-08	36.3	7.4	17	31.3	330	NW	136.21	9.73	47.87
8	2019-11-05	31.8	0	13	35.3	230	SW	131.57	9.5	47.24
9	2019-12-04	36.8	-2.8	8	22.3	270	W	152.51	10	47.01
10	2009-01-01	40.9	8.1	14	18.4	340	NNW	146.83	9.93	46.47
11	2014-10-28	40.8	7	13	16.6	270	W	151.22	9.99	46.24
12	2005-10-12	36.2	1.1	11	20.5	260	WSW	140.64	9.82	45.99
13	2019-11-17	38.6	2.9	11	25.9	270	W	141.37	9.8	44.58
14	2016-11-24	35.5	0.6	11	20.5	190	S	152.21	9.86	44.5
15	2013-09-19	35.2	2.6	13	22.3	330	NW	174.43	10	43.73
16	2009-10-14	32.4	-1.8	11	27.7	260	WSW	165.32	10	43.13
17	2019-09-06	33.8	-6.8	7	25.9	310	WNW	112.62	9.17	43.03
18	2009-09-23	28.5	-1.6	14	31.3	230	SW	154.85	9.55	42.41
19	2005-10-07	37.4	0.7	10	20.5	350	NNW	134.65	9.68	42.13
20	2009-10-13	33.7	9	22	35.3	290	W	164.74	10	42.05

Table 3-3 - Highest Ranked FFDI for Thangool AWS 2010-2023

Rank	Date	T (°C)	Dew Point (°C)	RH (%)	Wind Speed (km/hr)	Wind direction (deg)	Wind Cardinal Direction	KBDI	Drought Factor	FFDI
1	2019-12-02	37.2	-0.9	9	25.9	280	W	164.85	10	58.88
2	2019-02-13	40.6	0	8	18.4	140	SE	148.87	9.96	58.11
3	2018-11-28	38	-1.9	8	35.3	260	WSW	146.62	8.46	57.38
4	2019-09-06	32.4	-7.8	7	29.5	320	NW	151.44	10	54.55
5	2019-10-08	39.3	0.6	9	25.9	310	WNW	157.88	9.72	53.38
6	2012-12-05	34.4	-3	9	24.1	210	SSW	146.03	9.92	48.81
7	2019-12-05	37.5	-8.5	5	20.5	270	W	166.28	10	47.89
8	2019-12-04	37.3	-0.9	9	18.4	310	WNW	165.76	10	47.21
9	2016-11-14	31.1	-7	8	24.1	270	W	142.22	9.83	46.75
10	2013-09-27	34.4	8.2	20	31.3	40	NNE	186.57	10	45.87
11	2018-11-25	38.1	3.8	12	33.5	310	WNW	144.19	7.26	45.74
12	2016-11-06	34.3	-3.1	9	20.5	240	SW	131.32	9.38	44.77
13	2019-12-03	35.7	3	13	20.5	240	SW	165.29	10	43.41

3.1.1 Rainfall

The occurrence of days with high fire danger is also influenced by annual rainfall, as seen for the two analysed AWSs, where typically low annual rainfall results in higher accumulated annual FFDIs (Figure 3-3). Conversely, years of above average rainfall typically lead to increased vegetation growth. Therefore, although high rainfall levels are less conducive to extensive wildfire impact in the short term, this effect might be reversed in successive years. As such, having an above average year of rainfall cannot be perceived as reducing the on-going fire risk.

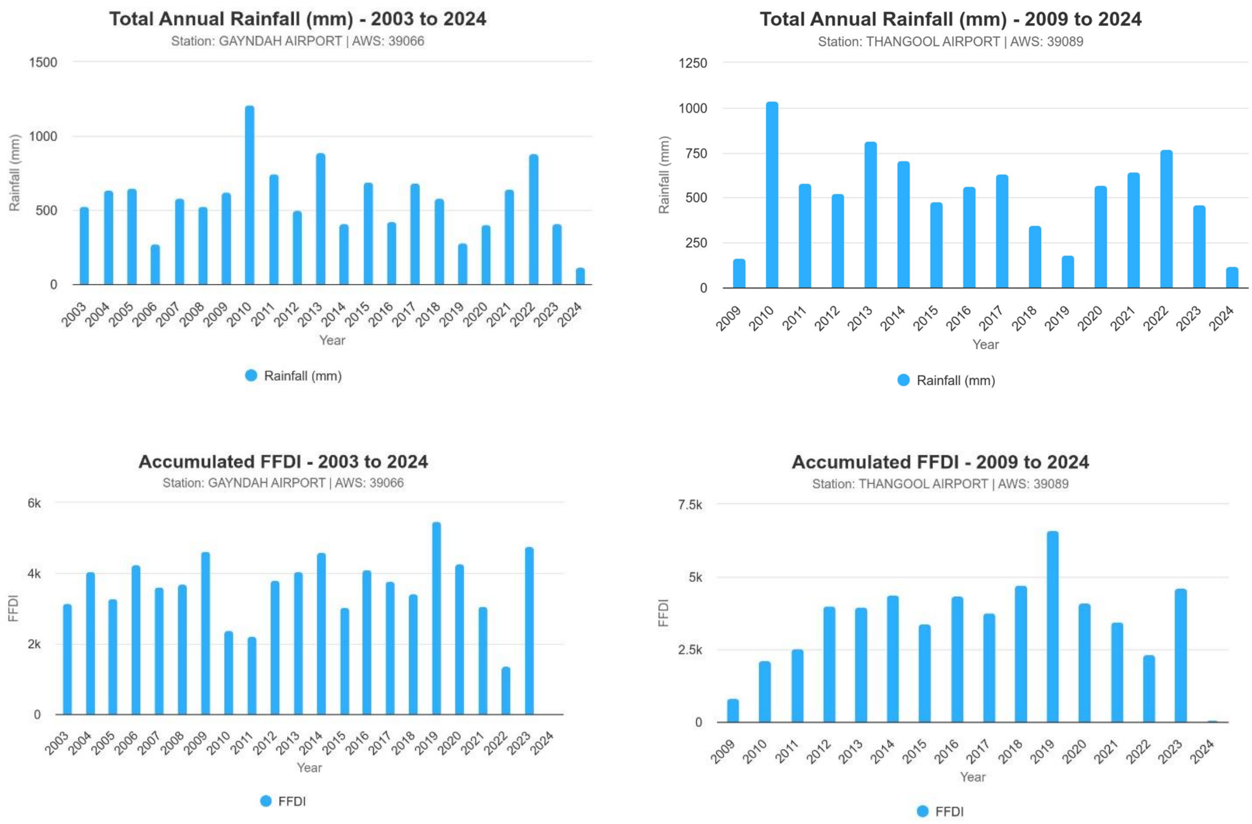


Figure 3-3 - Annual Rainfall vs Accumulated FFDI

3.1.2 Wind

Fire weather patterns are also dependent on wind signatures, e.g., coastal locations where maritime winds typically have higher moisture content, as opposed to warm-dry continental winds from inland.

Figure 3-4 shows wind directions for days with recorded FFDI above 25. The analysis reveals that FFDI above 50 tend to come from a westerly arc, under inland continental winds influence.

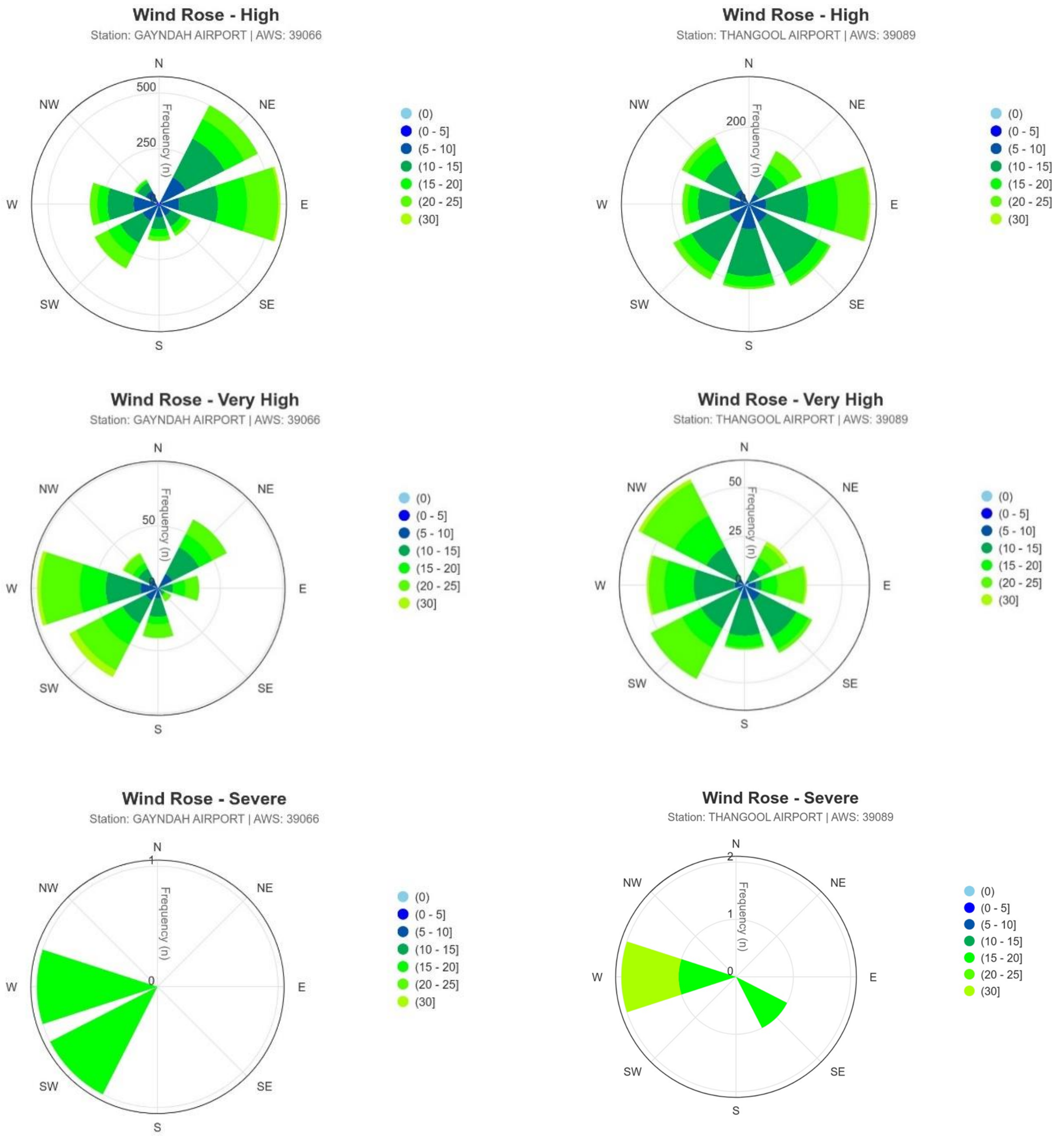


Figure 3-4 – Wind Rose and accumulated days (count) for 'High'(25<FFDI<50), 'Very High' (50<FFDI<75) and 'Severe'(75<FFDI<100) Fire Danger Rating Days

3.1.3 Generalised Extreme Value

A Generalised Extreme Value Analysis (GEV), a regression technique, indicates the frequency of extreme values. The GEV technique is frequently used to predict extreme weather such as storms, cyclones and flooding events (Douglas et al., 2014). Covey completed a GEV analysis based on the recorded FFDI data at Gayndah and Thangool AWS for the study period (Figure 3-5).

$$y = 26.3567 + 12.454 \times \ln(x) \qquad (r^2 = 0.872) \qquad \text{(Gayndah AWS)}$$

$$y = 28.617 + 12.7909 \times \ln(x) \qquad (r^2 = 0.8004) \qquad \text{(Thangool AWS)}$$

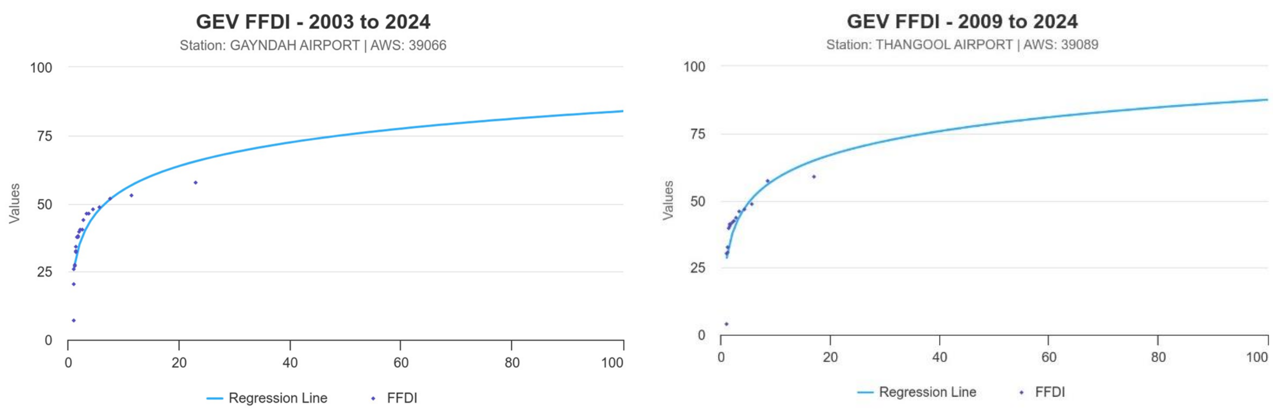


Figure 3-5. GEV Regression analysis Gayndah (2003-2024), and Thangool (2009-2024). y axis = FFDI; x axis = recurrence years.

Table 3-4 contains the calculated FFDI values for key return intervals. It is important to note that the GEV recurrence value indicates the likely return period of fire weather and not a fire event. Extreme fire weather may come and go without a fire occurring. Therefore, the probability of a fire occurring within the right position within the landscape during these periods of extreme weather and impacting the wind farm are orders of magnitude lower.

Table 3-4. GEV Recurrence Interval of FFDI Gayndah (2003-2024), and Thangool (2009-2024).

Gayndah AWS FFDI	Recurrence Interval (Years)	Thangool AWS FFDI
26	**1**	29
64	**20**	67
67	**25**	70
75	**50**	79
84	**100**	88
93	**200**	96
104	**500**	108

Based on the SPP spatial data (https://catalyst.qfes.qld.gov.au/.) the mapped 1:20 year Recurrence Interval FFDI spatial data for Gayndah is 51, and for Thangool FFDI 61; these equate to approximately a 1 in 7.2-year recurrence Interval for Gayndah, and a 1:12.5-year recurrence interval for Thangool using the GEV equation.

As a point of reference, the proposed project site has a spatially varying FFDI value of between 59 to 67, where the variation of 1 in 20-year FFDI can be accounted from the scale of the project.

3.1.4 Climate Change impact on FFDI

Climate change relative to the project site can be referenced in the *Climate Change in Australia Report for East Coast Cluster* developed by CSIRO and BOM (A. Dowdy et al., 2015), key findings for projected climate change within the East Coast Cluster is summarized below:

- Very high confidence in;
  - Higher temperatures,
  - Hot and more frequent hot days, with less frost,
- High Confidence in;
  - Increased intensity of heavy rainfall events, though changes to drought less clear,
  - Increase evaporation rates and reduced soil moisture,
  - Little change in solar radiation and reduced humidity throughout the year,
  - Some decrease in Winter wind speed, with fewer East Coast Lows,
  - An overall harsher Fire Weather climate in the future.

Climate modelling projections for predicted fire weather and fire danger (FDI) based on the latest IPCC reports (AR5 and AR6) are available and could provide valuable information when assessing potential future fire risk to the site – as projections exist from the current year to 2100. These climate models have been developed by the Department of Environment and Science, based on accepted climate models and data, and are available in gridded format relative to the project site (CSIRO et al., 2021).

3.2 Topography

The slope and topography of land beneath areas of vegetation influence the rate of spread and subsequent severity of bushfire behaviour. To ensure the slope has been considered when undertaking this risk assessment, the landforms within the subject area have been modelled using available Digital Elevation Model data sourced from Geoscience Australia at one second resolution (Elvis - Elevation and Depth - Foundation Spatial Data). The site is located on the southern end of the Bowen Basin, with the proposed development situated on largely flat or gently slopy terrain, with the exception of a few areas of rugged terrain, including around Mt Appenben, Mt Kandoonan, Mt Coangal and the northern-most extent of the wind farm (Figure 3-6).

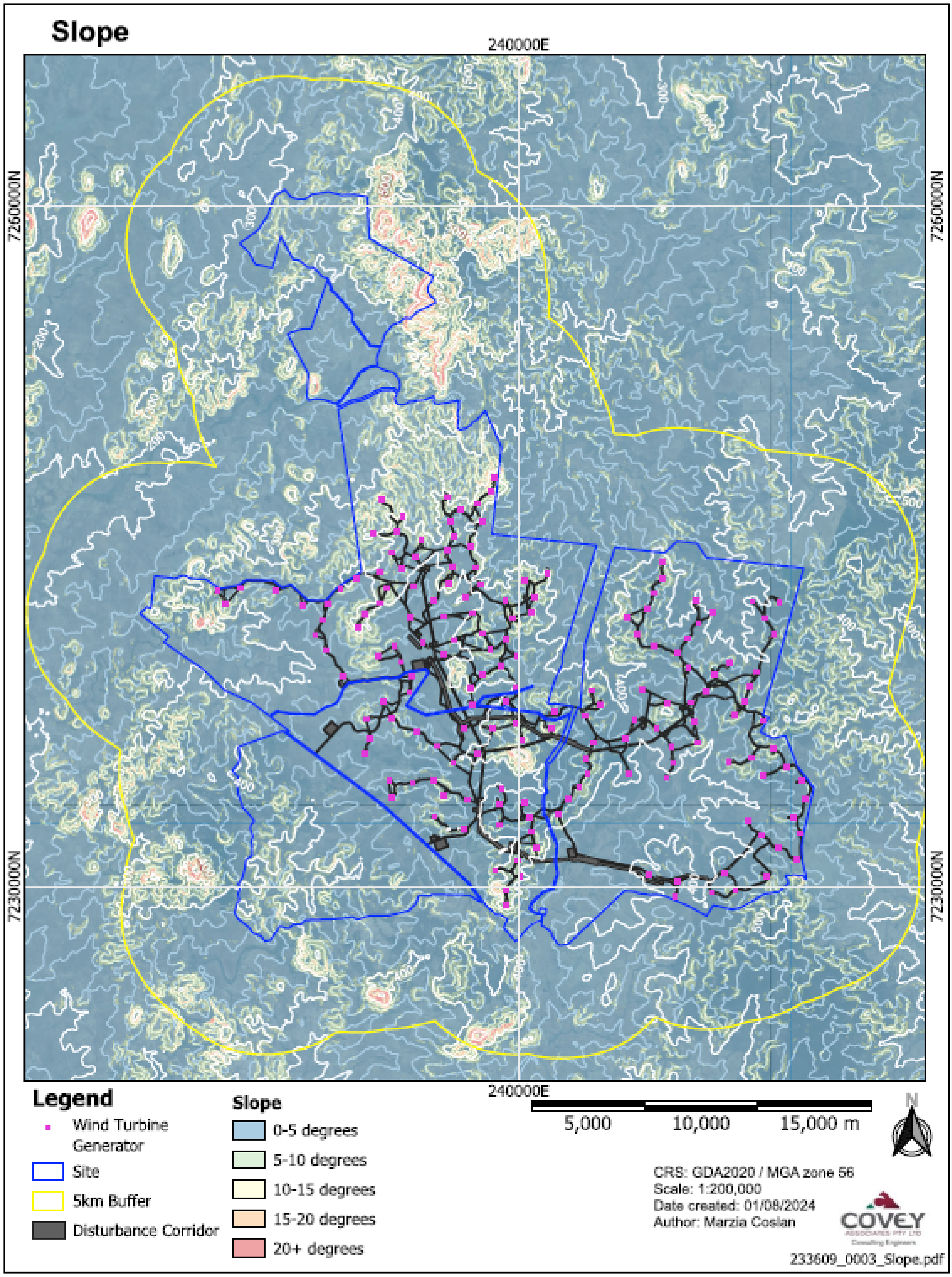


Figure 3-6 - Slope analysis at 1 second resolution (Source-Geosciences Australia)

3.3 Fuel

Fuel load and arrangement significantly impact bushfire behaviour's potential severity and scale. Fuel characteristics vary along with changes in type, density and extent of vegetation communities and land uses. Also, fuel loads for this site, especially for grass, varies greatly depending on rainfall and, the cattle grazing land use. The SPP only requires assessment of the 150 m of vegetation adjacent to assets. Nonetheless, we reviewed a 5 km radius around the site to better assess the landscape fuel hazard. The vegetation within the study areas was classified into Vegetation Hazard Classes (VHC) (Queensland Fire and Emergency Services, 2019a) based on information gathered from a combination of:

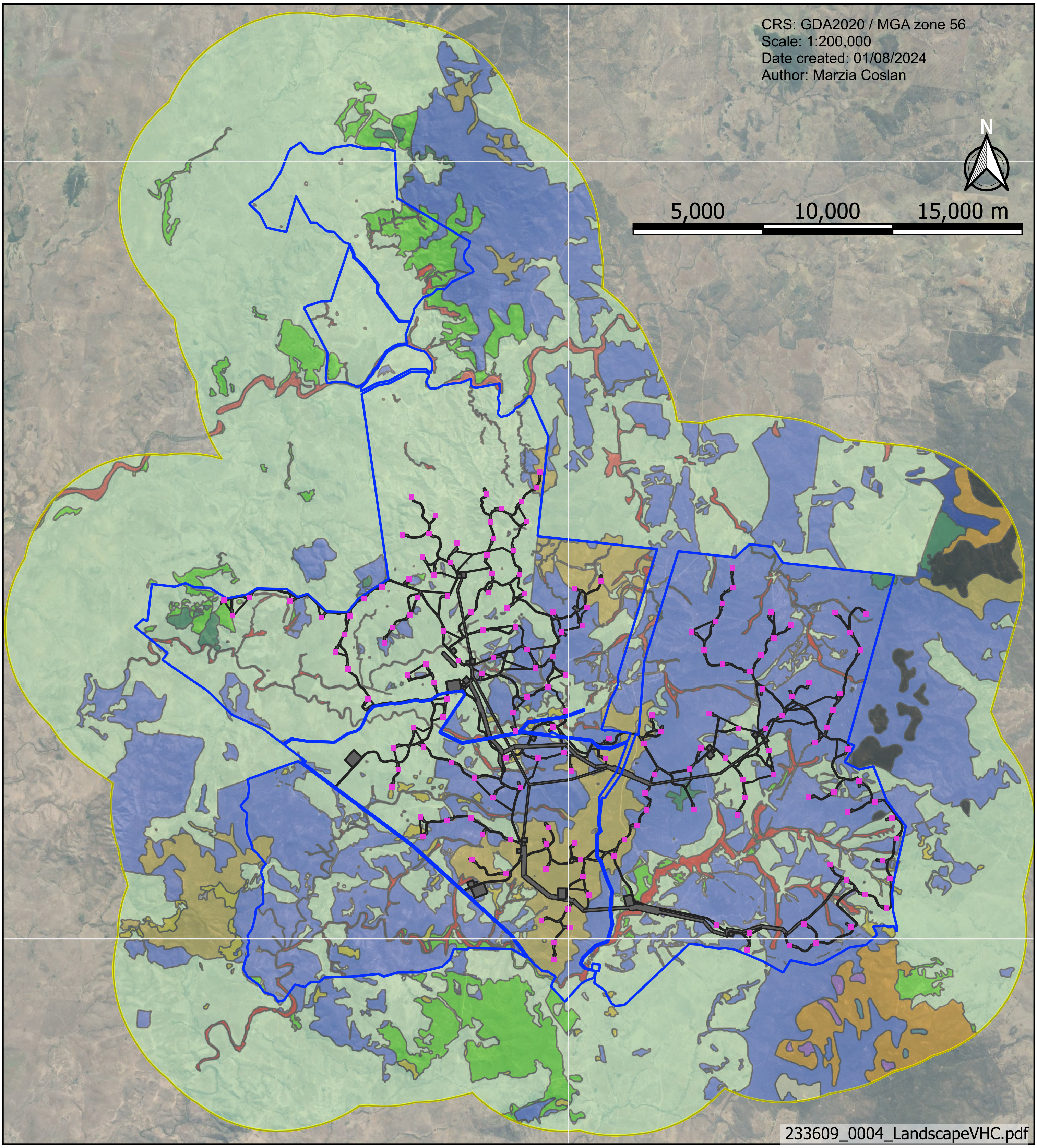
- Site-verified Regional Ecosystem data from the Ecological Baseline Assessment prepared by ERM;
- State Regional Ecosystem spatial data (https://qldspatial.information.qld.gov.au/catalogue);
- Vegetation Hazard Class (https://qldspatial.information.qld.gov.au/catalogue); and
- Aerial imagery.

Grasslands and dry to moist eucalypt woodlands and open forests, on undulating to hilly terrain of metamorphic and acid igneous rocks, constitute more than 85% of the landscape vegetation for the area (Table 3-5). Figure 3-7 depicts the constructed spatial VHC layer.

Table 3-5. Landscape Vegetation within 5 km buffer of the site.

VHC	Description	Area (ha)	Area (%)
7.1	Semi-evergreen to deciduous microphyll vine forest	501.0	0.42%
10.1	Spotted gum dominated open forests	5420.5	4.58%
10.2	Spotted gum dominated open woodlands	1894.9	1.60%
12.2	Dry eucalypt woodlands on sandstone and shallow soils	973.8	0.82%
13.1	Dry to moist eucalypt open forests on undulating metamorphics and granite	303.8	0.26%
13.2	Dry to moist eucalypt woodlands on undulating metamorphics and granite	33,340.8	28.18%
16.1	Eucalyptus dominated forest on drainage lines and alluvial plains	1870.2	1.58%
16.2	Eucalyptus dominated woodland on drainage lines and alluvial plains	636.0	0.54%
17.2	Dry woodlands dominated by poplar box, silver-leaved ironbark or White's ironbark on sand or depositional plains	4,500.6	3.80%
18.2	Dry eucalypt woodlands on sand or depositional plains	116.7	0.10%
24.2	Acacia woodlands on residuals	29.0	0.02%
25.1	Brigalow belah open forests on heavy clay soils	687.3	0.58%
29.3	Brigalow belah woodlands on heavy clay soils	116.3	0.10%
40.4	Continuous low grass or tree cover	6,7851.1	57.35%
43.6	Water bodies or very low vegetation cover	63.8	0.05%
	Grand Total	**118,305.9**	**100%**

Vegetation Hazard Class



Vegetation Hazard Class

- 7.1 Semi-evergreen microphyll vine forest
- 10.1 Spotted gum dominate open forests
- 10.2 Spotted gum dominated woodlands
- 12.2 Dry Ecualyptus woodlands on shallow soils
- 13.1 Dry to moist eucalypt open forests on igneous rocks
- 13.2 Dry to moist eucalypt woodlands on igneous rocks
- 16.1 Eucalyptus dominated forest on drainage lines
- 16.2 Eucalyptus dominated woodland on drainage lines
- 17.2 Poplar box, silver-leaved ironbark dry woodlands on sand or depositional plains
- 18.2 Dry eucalypt woodlands on sand or depositional plains
- 24.2 Acacia woodlands on residuals
- 25.1 Brigalow belah open forests on heavy clay soils
- 29.3 Heathlands and associated scrubs and shrublands
- 40.4 Continuous low grass or tree cover
- 43.6 Water bodies or very low vegetation cover
- Site

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Figure 3-7. Landscape Fuel Environment

The VHC observed within the site or within 150 m of the site footprint were:

- VHC 7.1 - Semi-evergreen to deciduous microphyll vine forest;
- VHC 10.1 - Spotted gum dominated open forests;
- VHC 13.2 - Dry to moist eucalypt woodlands on undulating metamorphics and granite;
- VHC 16.1 - Eucalyptus dominated forest on drainage lines and alluvial plains;
- VHC 17.2 - Dry woodlands dominated by poplar box, silver-leaved ironbark or White's ironbark on sand or depositional plains;
- VHC 25.1 - Brigalow belah open forests on heavy clay soils;
- VHC 40.4 - Continuous low grass or tree cover; and,
- VHC 43.6 - Water bodies.

Refer to Appendix B for enlarged maps. The VHCs were then used to extrapolate the fuel loads to be adopted in the RHF model (Table 3-6).

Table 3-6. VHC observed within 150 m of wind farm disturbance corridor and associated fuel load as per BRC.

Vegetation Description	Vegetation Type	Surface Fuel Load (t/ha)	Total Fuel Load (t/ha)	Prone Type	Modelled
VHC 7.1	Rainforest	6	6	Low hazard	N
VHC 10.1	Forests	19.3	20.8	Bushfire	Y
VHC 13.2	Woodlands	12.8	14.4	Bushfire	Y
VHC 16.1	Forests	13.8	16	Bushfire	Y
VHC 17.2	Woodlands	9	9.6	Bushfire	Y
VHC 25.1	Forests	13.1	15	Bushfire	Y
VHC 40.4	Grassland	4.5	5	Grassfire	Y
VHC 43.6	Low-threat	0	0	Low hazard	N

According to BRC, fuel loads vary between 9 t/ha and 20 t/ha for eucalypt forests, which largely dominate the southeastern section of the site, while grasslands are typically observed on the hilly northwest of site. Brigalow acacias and rainforest patches are dispersed through the site (refer to Ecological Report prepared by ERM). Note that, to maintain ecological function and health, these last two communities (VHC 7.1, VHC 25.1 and VHC 25.2) should not be deliberately burnt.

Note that rainfalls could increase fuel loads above the statutory prescribed fuel loads (refer to BRC), while grazing would reduce it.

3.4 Radiant Heat Flux Analysis

A potential bushfire impact analysis was undertaken as per Method 2 of AS 3959. The Spark-BAL software was used to model the Radiant Heat Flux (RHF) (Hilton & Swedosh, 2017). The model incorporated the following input values, satisfying Bushfire Resilient Communities (2019):

- The 5% annual exceedance probability fire weather vary between FFDI 59 in the east to 67 in the west, according to SPP Bushfire Prone Area Input Mapping https://catalyst.qfes.qld.gov.au/).
  We adopted the higher FFDI 67 in our model to be conservative, and also due to our GEV FFDI regression analysis aligning with this value (refer to Table 3-4);
- Site specific vegetation hazard classes and their associated potential fuel loads determined in accordance with procedure 5.4.2 Step 2 of BRC (2019) (Table 3-6).
- A flame temperature of 1090° K.

According to section 7.6 of the BRC, radiant heat flux and bushfire attack level are not required to be calculated for grassfire prone VHCs or low hazard VHCs (Queensland Fire and Emergency Services, 2019b). As such, VHC 7.1 and 43.6 were excluded from the model. However, due to grasslands constituting the majority of the landscape hazard and surrounding some and or/part of the proposed substation, site compounds, accommodation and switching stations, we include VHC 40.4 in the Covey RHF model. Appendix C details the input values and assumptions adopted in the RHF model.

SPP guidance material (Natural hazards, risk and resilience state interest – Bushfire) recommends development footprints to be separated from the closest assessable vegetation by a distance that achieves a RHF of 29 kW/m^2 or less. Table 3-7 details the minimum required setback distances required to achieve key radiant heat levels, including 29 kW/m^2. The outputs within Table 3-7 represent indicative clearing distance from assessable vegetation required to achieve statutory requirements (as per Method 2 of AS 3959:2018). The four RHF values (40 kW/m^2, 29 kW/m^2, 19 kW/m^2 and 12.5 kW/m^2) trigger specific construction requirements under the Building Code of Australia. However, wind turbine generators would be exempt from this.

Design Guidelines and Model Requirements: Renewable Energy Facilities (Country Fire Authority, 2023) recommends the implementation of a minimum 20 m setback from bushfire and grass fire prone vegetation.

All wind turbine generators, site offices/compounds, on-site accommodation, switchboards, substations, BESS and static water supply should be located to achieve a minimum of 20 m setback or as per Table 3-7, whichever is greater. This will mitigate the level of bushfire risk assets could be exposed to in case of bushfire, to an acceptable level, under current planning legislation and guidance material.

The development disturbance footprint has a sufficient area to allow the required APZ widths to be implemented in the design layout.

Table 3-7. 1D calculations of required setbacks based on varying slopes and vegetation type (FFDI 67 per State Planning Policy).

FFDI	Vegetation	Slope		Distance required to achieve				
		Site	Effective	40 kW/m²	29 kW/m²	19 kW/m²	12.5 kW/m²	10 kW/m²
67	VHC 10.1	1°	1°	11 m	15 m	22 m	37 m	43 m
		5°	5°	14 m	18 m	26 m	26 m	31 m
		10°	10°	17m	23 m	33 m	45 m	53 m
		15°	15°	22 m	23 m	41 m	55 m	64 m
		15°	20°	30 m	38 m	52m	68 m	77 m
67	VHC 13.2	1°	1°	8 m	11 m	15 m	22 m	27 m
		5°	5°	9 m	13 m	19 m	27 m	32 m
		10°	10°	12 m	16 m	24 m	35 m	40 m
		15°	15°	15 m	22 m	30 m	42 m	49 m
		15°	20°	21 m	27 m	39 m	52 m	60 m
67	VHC 16.1	1°	1°	9 m	11 m	17 m	24 m	29 m
		5°	5°	10 m	14 m	20 m	28 m	34 m
67	VHC 17.2	1°	1°	6 m	8 m	11 m	16 m	20 m
		5°	5°	7 m	9 m	13 m	20 m	24 m
		10°	10°	9 m	12 m	17 m	25 m	30 m
67	VHC 25.1	1°	1°	8 m	11 m	16 m	23 m	27 m
		5°	5°	10 m	13 m	19 m	27 m	33 m
		10°	10°	12m	17 m	24 m	34 m	40 m
67	VHC 40.4	1°	1°	6 m	8 m	12 m	18 m	22 m
		5°	5°	7 m	9 m	14 m	20 m	24 m
		10°	10°	8 m	11 m	16 m	23 m	28 m
		15°	15°	9 m	12 m	18 m	27 m	32 m
		15°	20°	10 m	14 m	21 m	30 m	36 m

The impact of predicted RHF on the wind turbines is difficult to discern. However, the advice provided by the client indicates that the turbines are constructed of non-flammable exterior materials, highly unlikely to be ignited. The likelihood of loss of life is considered very rare given that:

- Only essential personnel (indicated to be around 10 to 15 people) will be present on site upon the development completion;
- Areas of low RHF zones exist for safety and can be equipped with bushfire shelters for emergencies; and,
- Suitable escape routes can be established.

The process for effective risk management is identified in Figure 3-8, used under Creative Commons CC BY 4.0 from SPP Natural hazards, risk and resilience state interest – Bushfire (Queensland Fire and Emergency Services, 2019a).

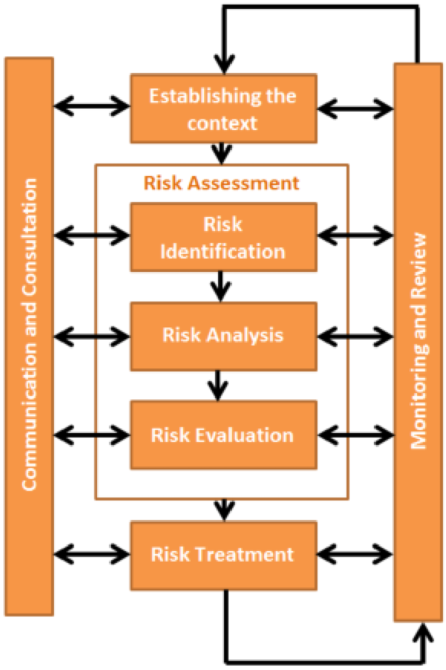

Figure 3-8. Risk Management Process (Queensland Government, 2019***, Figure 3).***

3.4.1 Potential human impact and sheltering sites

RHF and expected impacts on the human body are outlined in Table 3-8 for reference. Based on the Preliminary RHF modelling, an RHF of less than 29 kW/m^2 will be achieved for the assets of the development. The proposed development will be largely constructed of non-flammable materials that can sustain much higher levels of RHF exposure during the passage of a bushfire.

***Table 3-8. Radiant heat flux impacts* (Penney et al., 2020).**

Radiant Heat Flux (kW/m^2)	*Human effect*
30	Significant chance of instantaneous fatality for unprotected exposed persons.
23.5	Likely fatality for extended exposure and chance of instantaneous fatality for unprotected exposed persons.
16.7	Significant chance of fatality for unprotected extended exposure.
10	Tenability threshold for bushfire fighters.
5	Limited human trials indicated no adverse effects
4.2	Will cause pain in 15-20 seconds unprotected exposure. Will cause injury after 30 seconds unprotected exposure.
3	Operational threshold for bushfire fighters attempting suppression.
2.5	Level of exposure permitted for evacuating occupants in the Building Code of Australia
2.1	Minimum heat radiation required to cause pain after 60 seconds unprotected exposure
1.3	Exposure from mid-day sun

3.5 Fire Behaviour Discussion

Historical fire weather analysis indicates the potential for large fires to develop. Weather analysis indicates that these are more likely to approach the WF from a westerly arc. High fire intensity and flame lengths can be expected in patches of higher fuels and steep slopes. Fires in the region would typically be expected to be wind-driven within grasslands and fuel-driven in forested and wooded areas. Historical fire data reveals that seven wildfires have occurred within and around the study area since 2006 (Figure 3-9) (Queensland Parks and Wildlife Services Spatial data - https://qldspatial.information.qld.gov.au/catalogue/) burning a total of about 62,700 ha. These were focused around bushland areas rather than open grasslands and seem to align well with Bushfire Prone Area Mapping (Figure 3-1). Following periods of higher rainfall when sufficient biomass is present, large fires may occur across the semi-arid landscapes, in some cases burning over 27,000 ha as the Belmont State Forest Fire of September 2011 or the Camboon State Forest fire of November 2006 which burnt over 12,000 ha.

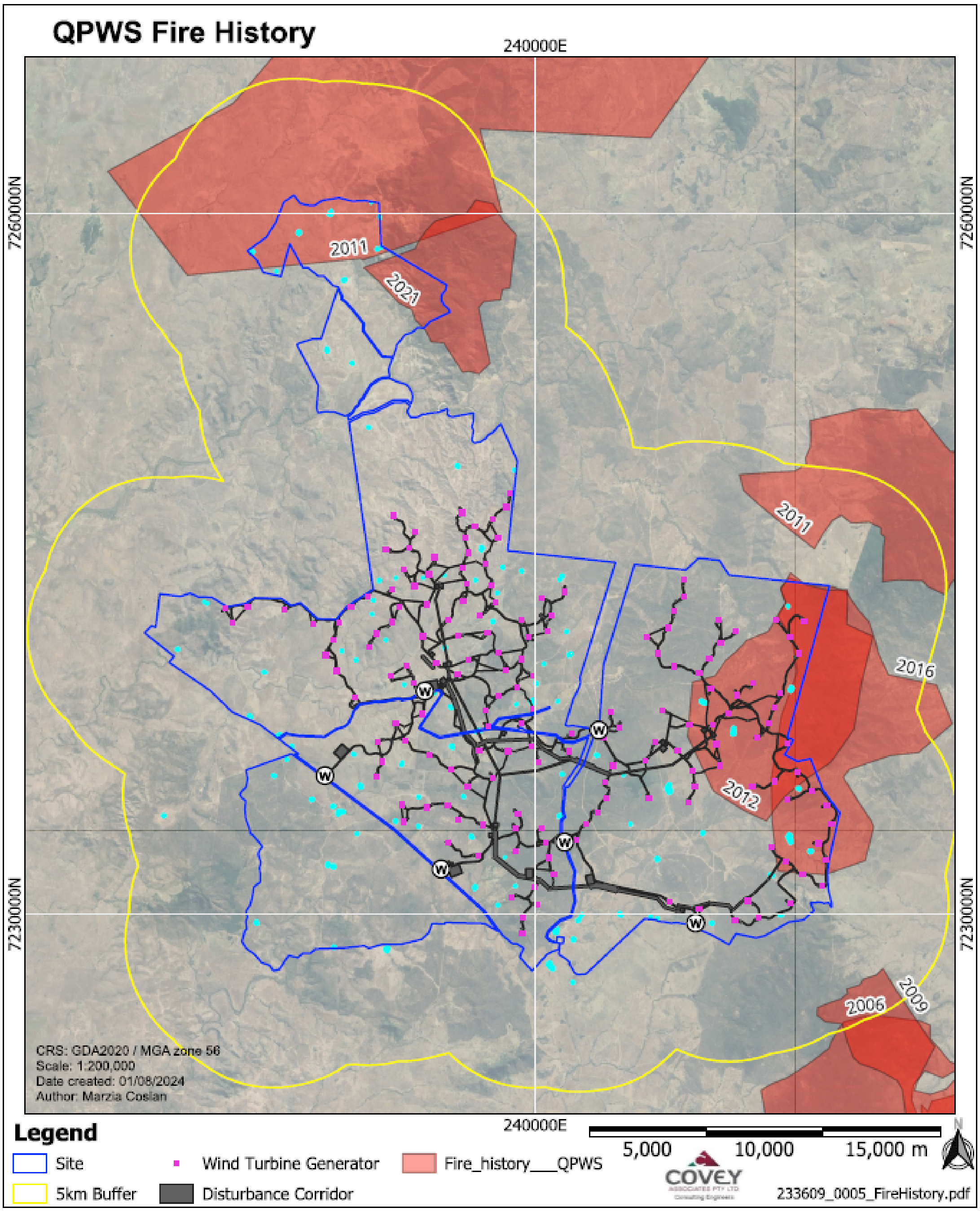

Figure 3-9. Fire History based on QPWS spatial data.

Five sources of fire ignition have been identified at the wind farm itself, including:

1. Electrical faults/failure from electrical components and/or Battery Energy Storage System;
2. Inverter failure may catch the inverter station on fire;
3. Transformer failure may catch the transformer on fire;
4. Lighting strike;
5. Vegetation management (i.e., mowing) in dry conditions;
6. Maintenance activities that may cause a spark (such as welding); and
7. External bushfire spreading via vegetation.

The likelihood of a fire starting within the WF can be significantly reduced through appropriate design standards, maintenance, and active management.

The modelling completed assumes that fuels are contiguous and with loading as per SPP, and land management treatments (e.g., grazing) are not accounted for. Therefore, the modelling is likely to be a snapshot in time rather than providing an overview of the potential outcomes of a wildfire impact. Also, radiant heat analysis does not accurately quantify potential fire intensities, nor can it identify likely fire paths that are likely to be experienced within the study area. If the above parameters are to be investigated Covey recommends undertaking a dynamic and/or probabilistic bushfire behaviour analysis.

3.6 Limitations of the Study

Fire weather and behaviour are, by nature, difficult to predict with certainty. It, therefore, follows that those limitations exist when predicting bushfires and designing for bushfire mitigation. The following limitations are noted:

- Fuel loads are based on State dataset and not site-specific fuel measurements;
- Fire behaviour at high fire danger ratings and under the influence of fire-induced winds driven by strong convection rates becoming erratic beyond the bounds of prediction models (Cruz et al., 2012);
- Human-induced climate change may exacerbate fire behaviour and affect vegetation structure and floristics in different ways than those assumed in this study (A. J. Dowdy, 2018);
- The available digital elevation model LiDar data is relatively coarse (1s) and, therefore may provide locally inaccurate modelling results however is deemed sufficient for relative risk ratings across the study and meeting the primary study objective; and
- The assessment is desktop-based and relies on various data inputs, some of which may be outdated.

Also, radiant heat modelling methodology:

- Assumes an omni-directional head-fire approaching the asset. As detailed in section 3.5, westerly wind signatures are typically associated with hazardous fire weather days. Therefore, large wildfires are likely to be approaching the proposed WF from those directions.
- Adopts older iterations of fire rate of spread models (per statutory standards).
  Most of these were formulated based on experiments undertaken in Victoria, in areas with fuel loads and structures vastly different from the ones for the study area. It is therefore hard to determine how accurately these models predict local fire behaviour.
- Disregards interaction between weather parameters with topography and fuels, such as:
  - Rainfall and its interaction with fuels;
    High rainfalls lead to increased vegetation growth and hence fuel loading. Different vegetation communities also dry out at varying rates, with grasslands curing faster than forests. This leads to fuel availability differentials after wet periods.
  - Wind and its interaction with topography;
    Winds tent to channel and create eddies in high rugosity areas, such as hills, valleys, and slopes, leading to local conditions that can be significantly different from predicted prevailing wind directions and speeds. This in turn may lead to 'unpredictable' fire behaviour within those areas.

4 BUSHFIRE MITIGATION MEASURES

Bushfire hazard mitigation measures are to ensure that the WF facility is sufficiently protected from bushfire impact, while also being well-designed and constructed to avoid igniting a bushfire. The following mitigation measures must be incorporated into the development design and operating model by the WF developers and managers.

4.1 Asset Protection Zone

Wind farm infrastructure (wind turbine generators, substations, switching boards, offices, on-site accommodation buildings, BESS) must:

1. Be located at a distance of at least 20m from bushfire hazard vegetation; and
2. Be subject to radiant heat levels lower than 29 kW/m2, under design bushfire scenario detailed in chapter 3.4.

These setback areas, classified as Asset Protection Zones (APZ), should be established and maintained in perpetuity.

The APZ is to be maintained as a non-vegetated area or as low-threat vegetation per AS 3959 s2.2.3.2. Any critical infrastructure (e.g., electrical safety components such as BESS sensors, shut-down/disconnection switches, isolators, etc.) within the development is to be constructed to withstand 40 kW/m^2 of radiant heat and ember penetration into the structure and associated infrastructure (i.e., BAL-40). Subject to assessment with design team engineers.

Note that, Wind Turbine Generators will be predominantly constructed of non-flammable materials; and as such, their vulnerability to fire damage is relatively low.

4.2 Landscaping guidelines

Any landscaping should not exacerbate potential bushfire risk. This may be achieved through aligning landscaping with Bushfire Resilient Landscaping (CSIRO, 2020) and Low Threat exclusion clauses defined in AS 3959, S2.2.3.2. Examples include:

3. Landscaping design within the low fuel zone is consistent with AS 3959 S2.2.3.2(f) to ensure vegetation does not create vertically and horizontally continuous fuel structures that may contribute to bushfire intensity (Figure 4-1);
4. Where areas of bushland are to be included as part of landscaping design in the low fuel zone, ensure they are consistent with AS 3959 S2.2.3.2, being less than 0.25 ha in area and not within 20 m of each other or proposed dwellings (Figure 4-2);
5. Utilise non-vegetated areas within the development consistent with AS 3959 S2.2.3.2 (e) to provide enhanced separation between buildings and vegetation identified as a bushfire threat external to the site boundaries; and,
6. Utilise 'Fire-Wise' plant species resistant to fire effects (guidance can be found at http://www.cfa.vic.gov.au/plan-prepare/landscaping-for-bushfire).

Figure 4-1. Low Threat vegetation (left) and Low Threat public open space (right).

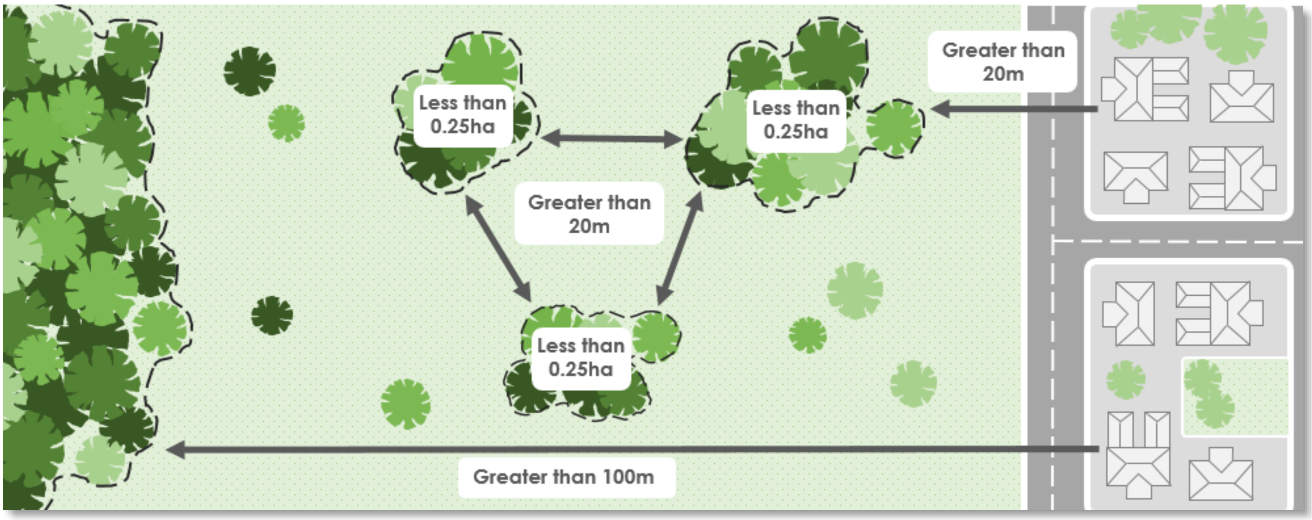

Figure 4-2. AS 3959 Exclusions—Low threat vegetation and non-vegetated areas.

4.3 Access

The proposed development will see the construction of vehicular access tracks connecting to all proposed wind turbine, switchboard, substation, BESS and building. Access to the facility's infrastructure must be suitable to two-wheel drive emergency vehicles in all weather conditions.

Vehicular access tracks should follow 'Design Guidelines and Model Requirements for Renewable Energy Facilities' (Country Fire Authority, 2023) and be informed by 'Fire hydrant and vehicle access guidelines' (Queensland Fire and Emergency Services, 2019b). Roads are to:

1. Provide suitable emergency services access to all areas of the facility, including turbines, substation, BESS, switching board, buildings and fire service infrastructure.
2. Be a minimum of four metres in trafficable width with a four-metre vertical clearance.
3. Have grades, and dips, as per 'Unsealed roads best practice guide' (Australian Road Research Board, 2020).
4. Incorporate passing opportunities for vehicles across the site where achievable; general requirement for vehicular passing opportunities are to have a minimum trafficable width of six metres of which can be a combination of the formed gravel access road of nominal width combined with a flat grassed shoulder to achieve the 6m required width for passing. It is

recommended that discussions be undertaken with the local Rural Fire Brigades to understand vehicular access requirements.

All internal roads and trails should be sign-posted. A road network map should be developed incorporating state and local roads, WF access tracks, existing farm trails, fire trails, and Queensland Parks and Wildlife Services access tracks and the associated spatial data should be shared with Queensland Fire and Emergency Services.

4.4 Water dedicated to firefighting

Firefighting water supply points of at least 45,000 L effective capacity are to be provided at each vehicle entrance to the facility (refer to Figure 2-2), indicating the direction to the nearest static water tank(s) and/or dam(s) per Renewable Energy and Fire Safety Design guidelines (Country Fire Authority, 2023). Static water points should follow Design Guidelines and Model Requirements for Renewable Energy Facilities (Country Fire Authority, 2023). They must be:

1. Clearly signed and should display the tank capacity.
2. Above-ground, constructed of concrete or steel.
3. Located at vehicle access points to the facility and located at least ten metres from any infrastructure, including wind turbines, battery energy storage systems, and site compounds.
4. Located near a hardstand, maintained to a minimum of 15 tonne gross vehicle mass, eight metres long and six metres wide.
5. Installed to comply with AS 2419.1-2021: Fire hydrant installations – System design, installation and commissioning.
6. Capable of being completely refilled automatically or manually within 24 hours, with an external, visible water level indicator.
7. Have a hard-suction point
    a. Ideally provided with rural fire brigade tank fittings of a 50-millimetre ball valve and male camlock coupling (or appropriate connectors are stored in the vicinity of the water tank) (Queensland Fire and Emergency Services, 2019b; Appendix D);
    b. Positioned within 4.5 metres to a hardstand area and provide a clear access for emergency services personnel.
    c. Protected from mechanical damage (e.g., bollards) where necessary.

4.4.1 BESS

Ideally the BESS should be located near one of the entrances to the site that has a proposed static water supply of 45,000L. If the BESS is to be installed away from one of the site entrances and at a location well within the site boundary, then an additional static water supply tank of 45,000L capacity shall be installed within 120m of the BESS location

4.5 Measures Specific to Wind Farms

Certain weather and terrain conditions can present challenges for aerial firefighting operations within wind energy facilities. As such it is recommended that:

1. Wind turbine generators must be located no less than 300 metres apart.
2. Wind turbine generators must be provided with automatic shut-down, and the ability to be completely disconnected from the power supply in the event of fire.
3. Nacelles must be equipped with automatic fire detection, alarm and fire suppression systems.
4. The installation of weather monitoring stations and wind turbine generators of 110m or more above ground must be notified to the Civil Aviation Safety Authority.
5. All guy wires and monitoring towers must be clearly marked, even where marking is not required by Civil Aviation Safety Authority.

4.6 Measures Specific to BESS

BESS is designed to reduce the potential for ignition and the consequences of fire should it occur, with the ultimate goal to be of fire prevention. BESS design should incorporate:

1. A separation distance that prevents fire spread between battery containers/enclosures and other site elements.
2. A fire break around the battery energy storage system and related infrastructure, of a width of no less than 25 m or of greater width to achieve less than RHF 10kW/m^2 based on the results presented in Table 3-7.
3. The separation and fire break around the BESS shall be in the form of a non-vegetated Asset Protection Zone.
4. A layout of site infrastructure that:
    d. Considers the safety of emergency responders.
    e. Minimises the potential for grassfire and/or bushfire to impact the battery energy storage system.
    f. Minimises the potential for fires in battery containers/enclosures to impact on-site and offsite infrastructure.

Battery energy storage systems must be:

1. Located so as to be reasonably adjacent to a site vehicle entrance (suitable for emergency vehicles).
2. Located so that the site entrance and any fire water tanks are not aligned to the prevailing wind direction (therefore least likely to be impacted by smoke in the event of fire at the battery energy storage system.)
3. Provided with in-built fire and gas detection systems.
4. Provided with explosion prevention via sensing and venting, or explosion mitigation through deflagration panels.
5. Provided with suitable ember protection.
6. Installed on a non-combustible surface.
7. Provided with suitable ventilation.
8. Provided with suitable impact protection.
9. Provided with enclosed wiring and buried cabling, except where required to be above-ground for grid connection.
10. Provided with spill containment that includes provision for management of fire water runoff.

4.7 Emergency Plan

An Emergency Plan must be developed for the construction, commissioning and operational phases of the facility.

4.8 Facility Operation

4.8.1 Operational Bushfire Management Plan

A detailed Bushfire Management Plan to be prepared and implemented for the site WF to treat residual landscape bushfire risk. The bushfire management plan is to be prepared in conjunction with the landholder by a suitably qualified person, and should considers the following:

1. Adopting integrated land management principles including grazing, prescribe burning, weed control, and mechanical options. In particular, grazing and prescribed burning are key tools to manage fuels, that are mutually beneficial under well formulated plans.
2. Implementing periodic controlled burns reduce fuel load within the site retained areas of vegetation and have positive effect on new growth grass nutritional value as well as biodiversity.
3. Cooperation with adjoining landowners, Queensland Parks and Wildlife Services, Queensland Rural Fire Service and cultural heritage / traditional land managers.
4. Recommended ecological guidelines for fire management.
5. Annual fuel monitoring by qualified / trained staff to:
    i. Maintain and promote dynamic bushfire risk assessment; and
    ii. Learn and /or improve ‘reading country’, i.e., understanding the best time to undertake prescribed burns.

4.8.2 Facility Monitoring

Appropriate monitoring for facility infrastructure must be provided, to ensure that any shorts, faults or equipment failures with the potential to ignite or propagate fire are rapidly identified and controlled.

4.8.3 Maintenance

Inspection, maintenance, regular and ad/hoc repair and replacement activities must be conducted for all infrastructure, equipment and vehicles at the facility. Maintenance must be in line with any relevant Australian Standards and the manufacturer's requirements. A maintenance checklist is developed for implementation before each fire season to ensure the WF is well prepared for bushfires during each fire season.

4.8.4 Preparedness

Basic firefighting tools are available on-site during routine maintenance activities that have a chance of creating an ignition (example, mowing) to rapidly extinguish ignitions before they become larger threatening fires;

4.8.5 Hazardous Materials

Flammable materials or hazardous materials are stored within a secure structure away from any unmanaged native vegetation so as to have an RHF exposure <10 kW/m^2 on the storage structure.

5 COMPLIANCE ASSESSMENT

Appendix E contains an assessment against the Banana Shire Council Rural Zone Code Performance Outcome 52 to Performance Outcome 59. The proposed development is deemed to comply with the code's requirements subject to the bushfire mitigation measures detailed in Section 4 being implemented in the design and operation of the proposed development.

6 CONCLUSION

The SPP Bushfire Prone Area mapping indicate that the WF site and surrounding area is subject to Medium and High Potential Bushfire Intensity around areas of woody vegetation with Very High Potential Bushfire Intensity typically observed in more rugged terrain. The fire season typically extends between August and January, peaking in October (seasonally dependant). Historical fire weather analysis indicates that the more severe fire weather conditions are typically associated with westerly winds. The fire season for the area is also influenced by rainfall, with wet years usually leading to an increase in fuel loading (especially in the grass layer), and dry years resulting in reduced grass growth and lower fuel loads.

Desktop analysis of indicates that grasslands and dry to moist eucalypt woodlands and open forests (VHC 40.4 VHC 13.2, respectively) constitute more than 85% of the landscape vegetation for the study area. Indicative fuel loads within 150 m from the WF footprint vary between 9 t/ha and 20 t/ha for forest communities, with grasslands having a prescribed fuel loads of 5 t/ha (Queensland Fire and Emergency Services, 2019a).

A potential radiant heat flux analysis was undertaken per Method 2 of AS 3959. The bushfire design scenario incorporated site-specific fuel loads and FFDI to satisfy State Planning Policy. The required setback distances between wind farm infrastructure (including wind turbine generators, site offices/compounds, on-site accommodation, switchboards, substations, BESS, and static water supply) and vegetation prone to bushfire hazards must adhere to the specifications outlined in Table 4.1, ensuring a minimum separation of 20 meters. The development disturbance footprint has a sufficient area to allow the required APZ widths to be implemented within the design layout. From a radiant heat level perspective, the bushfire hazard and risk to the proposed development is considered to be acceptable, subject to compliance with the prescribed APZ widths.

The chances of wildfire impacting the WF are considered likely throughout its expected operational life. Measures detailed in section 4 detail how to mitigate bushfire risk impacting and originating from the development. An operational Bushfire Management Plan will be required for the WF to treat residual landscape bushfire risk.

Provided that the bushfire mitigation measures detailed in Section 4 of this report and Banana Shire Council Rural Zone Code response (Appendix E) are adopted, the proposed development does not increase the vulnerability of people, assets and environment to potential bushfire impact, per applicable policy and planning requirements.

This NHRA focused on radiant heat flux risk level, and related hazards, and further investigations might be required to support a development application, e.g., bushfire behaviour analysis, Engineering Services Report, electrical transmission line compliance, ecological assessments, etc.

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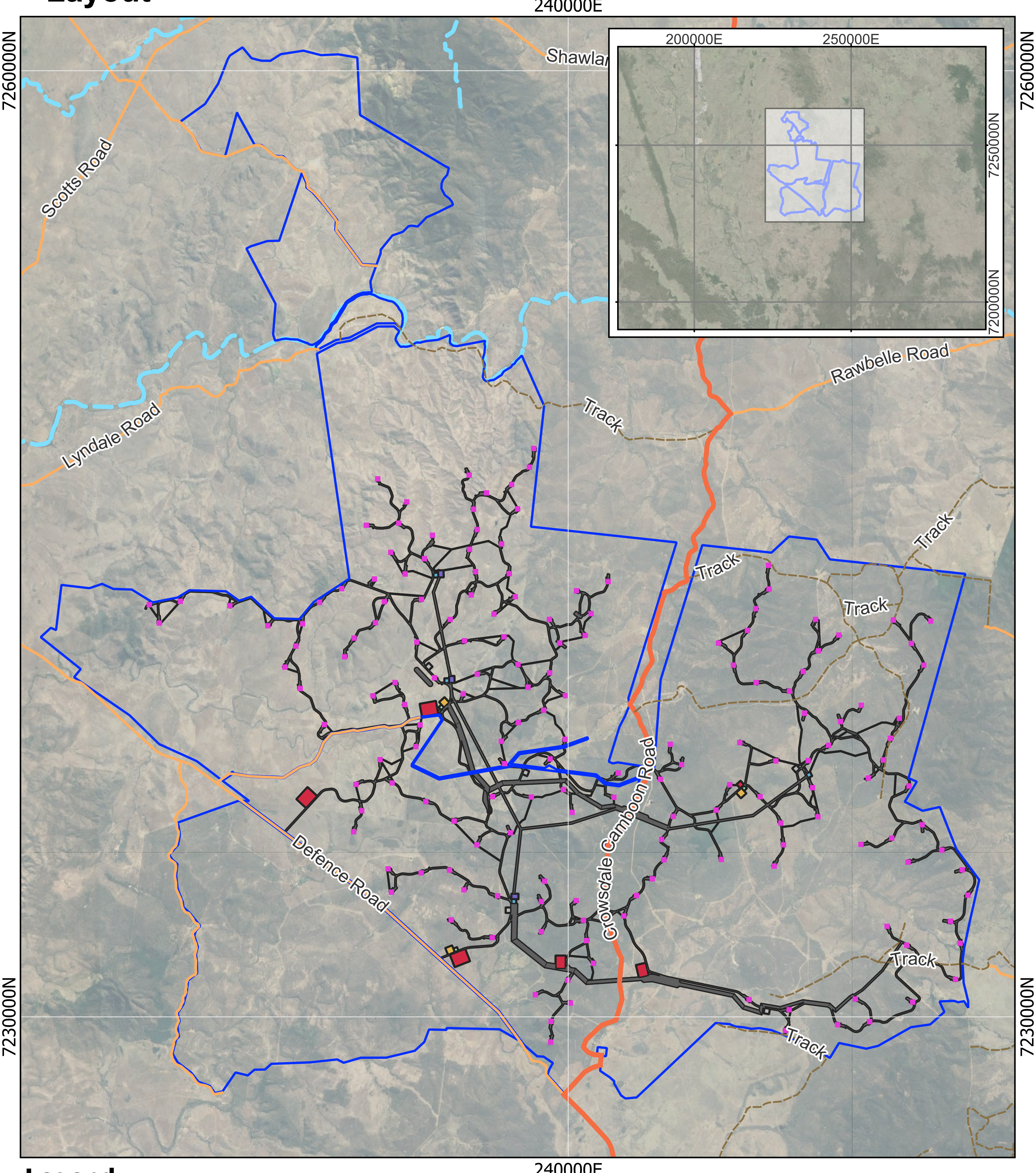
APPENDIX A
Thedore Wind Farm Layout

Layout



Legend

Wind Turbine Generator

Disturbance Corridor

Laydown

OM Compoud

Site Compound

Substation

Switching Station

Concrete Batching Plant

Disturbance Corridor

Site

Roads

Connector

Local

Track

5,000 10,000 15,000 m

CRS: GDA2020 / MGA zone 56
Scale: 1:160,000
Date created: 01/08/2024
Author: Marzia Coslan

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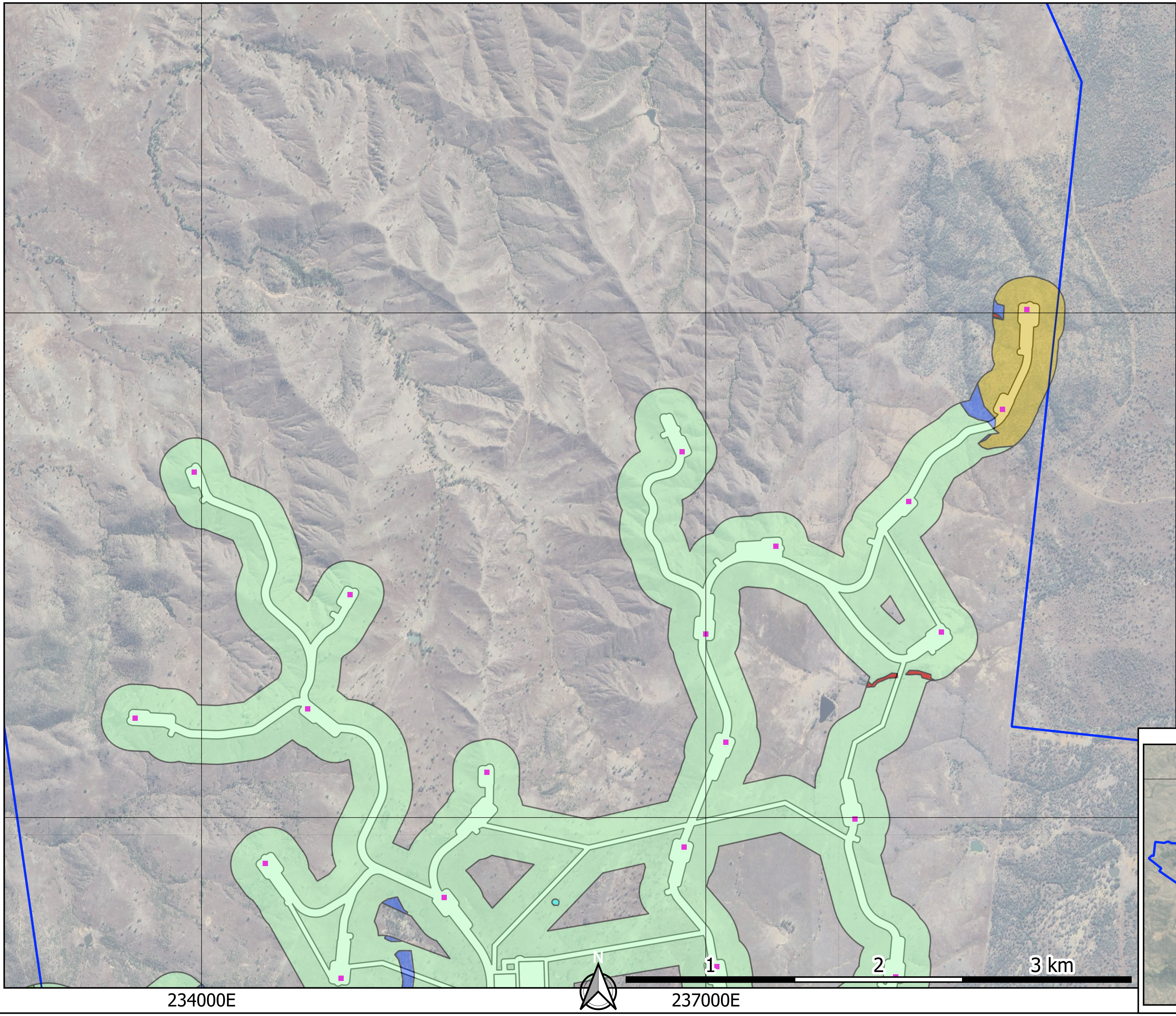
COVEY ASSOCIATES PTY LTD Consulting Engineers

233609_0008_Layout.pdf

APPENDIX B

Vegetation Hazard Class within 150 m of Theodore Wind Farm disturbance corridor

Vegetation Hazard Class within 150 m of disturbance corridor



Legend

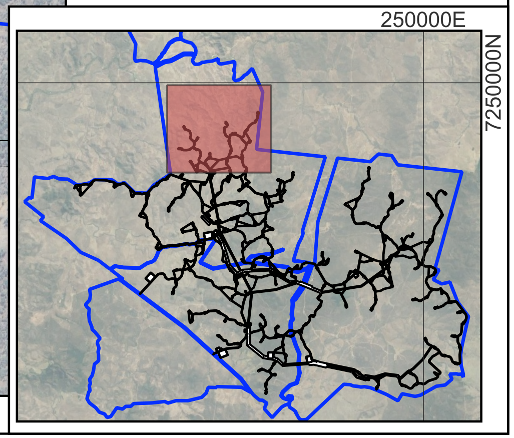
- Wind Turbine Generators

Vegetation Hazard Class to 150m buffer

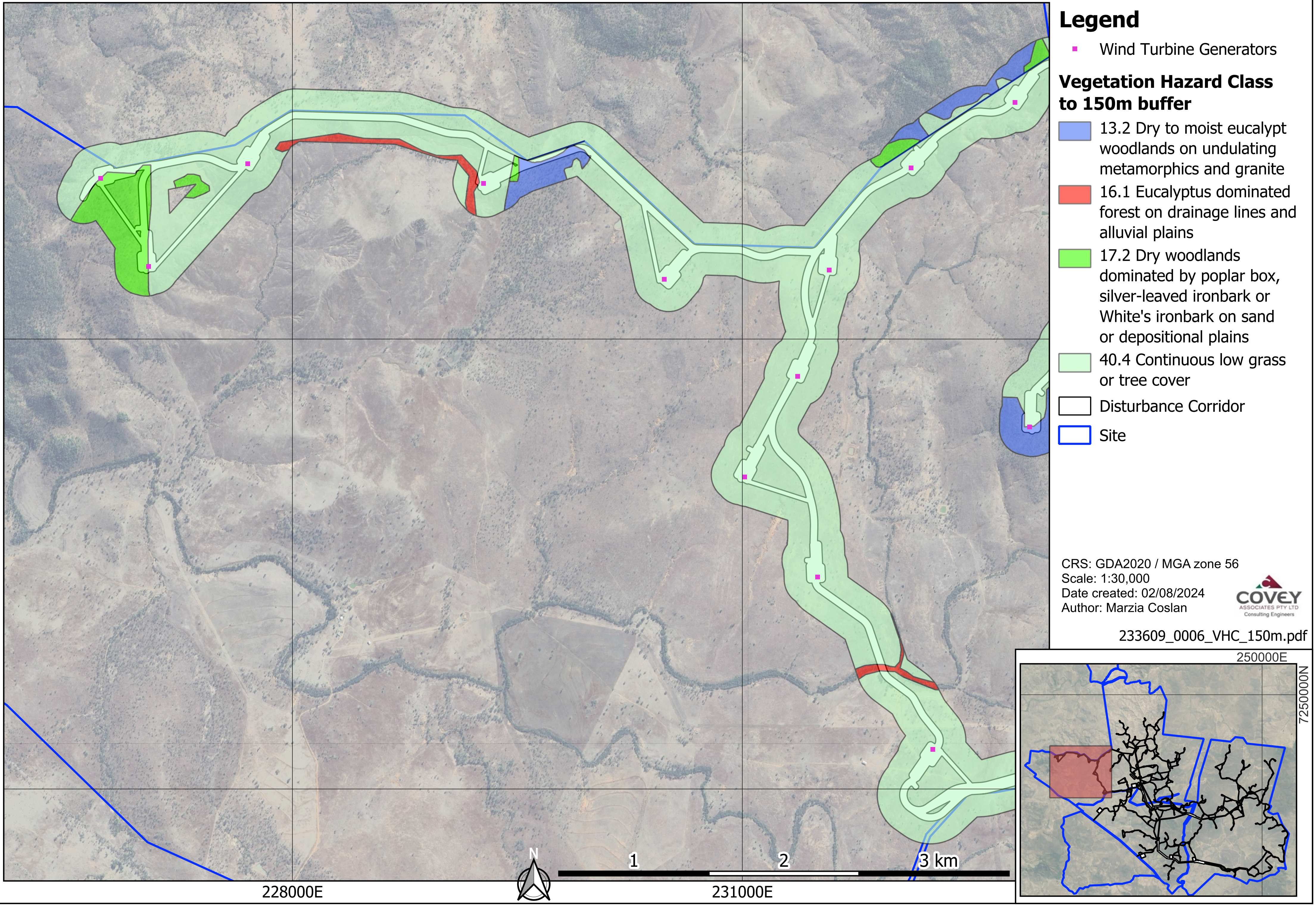
- 10.1 Spotted gum dominated open forests
- 13.2 Dry to moist eucalypt woodlands on undulating metamorphics and granite
- 16.1 Eucalyptus dominated forest on drainage lines and alluvial plains
- 40.4 Continuous low grass or tree cover
- 43.6 Water bodies
- Disturbance Corridor
- Site

CRS: GDA2020 / MGA zone 56
Scale: 1:30,000
Date created: 02/08/2024
Author: Marzia Coslan

233609_0006_VHC_150m.pdf



Vegetation Hazard Class within 150 m of disturbance corridor



Legend

- Wind Turbine Generators

Vegetation Hazard Class to 150m buffer

- 13.2 Dry to moist eucalypt woodlands on undulating metamorphics and granite
- 16.1 Eucalyptus dominated forest on drainage lines and alluvial plains
- 17.2 Dry woodlands dominated by poplar box, silver-leaved ironbark or White's ironbark on sand or depositional plains
- 40.4 Continuous low grass or tree cover
- Disturbance Corridor
- Site

CRS: GDA2020 / MGA zone 56
Scale: 1:30,000
Date created: 02/08/2024
Author: Marzia Coslan

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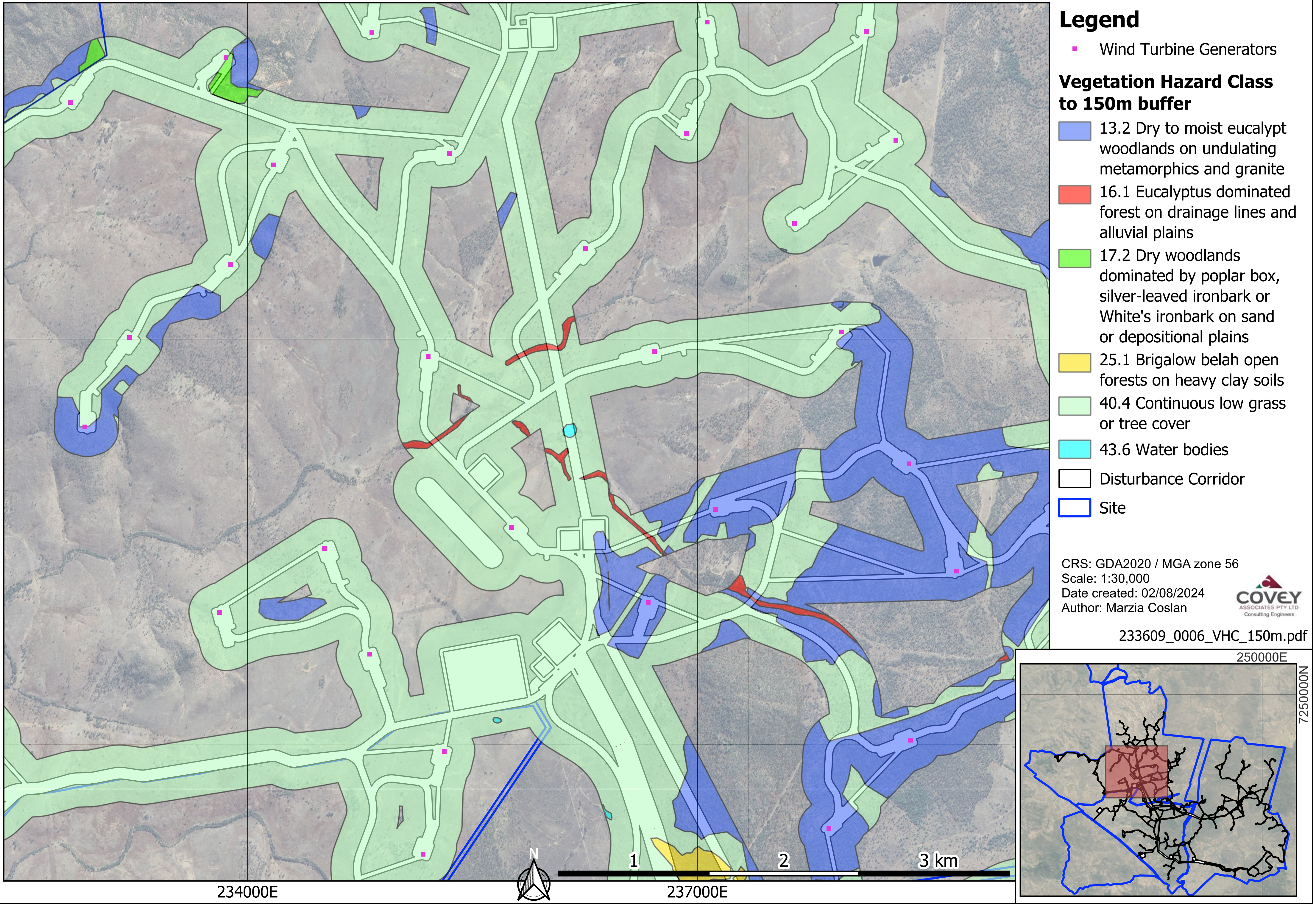
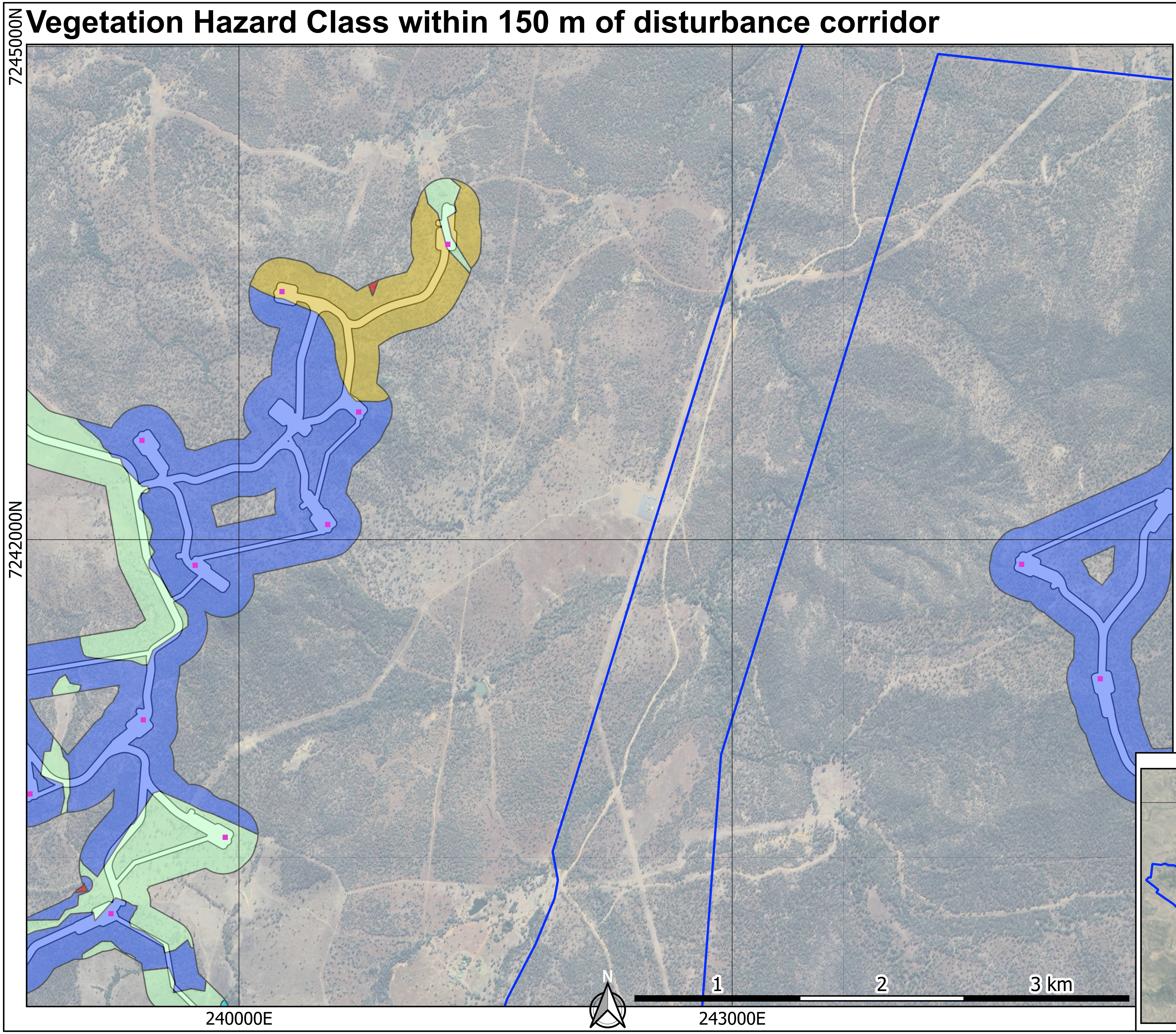
233609_0006_VHC_150m.pdf

Vegetation Hazard Class within 150 m of disturbance corridor



Vegetation Hazard Class within 150 m of disturbance corridor



Legend

- Wind Turbine Generators

Vegetation Hazard Class to 150m buffer

- 10.1 Spotted gum dominated open forests
- 13.2 Dry to moist eucalypt woodlands on undulating metamorphics and granite
- 16.1 Eucalyptus dominated forest on drainage lines and alluvial plains
- 40.4 Continuous low grass or tree cover
- Disturbance Corridor
- Site

CRS: GDA2020 / MGA zone 56
Scale: 1:30,000
Date created: 02/08/2024
Author: Marzia Coslan

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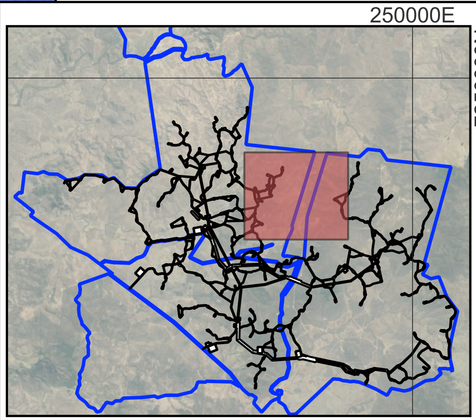
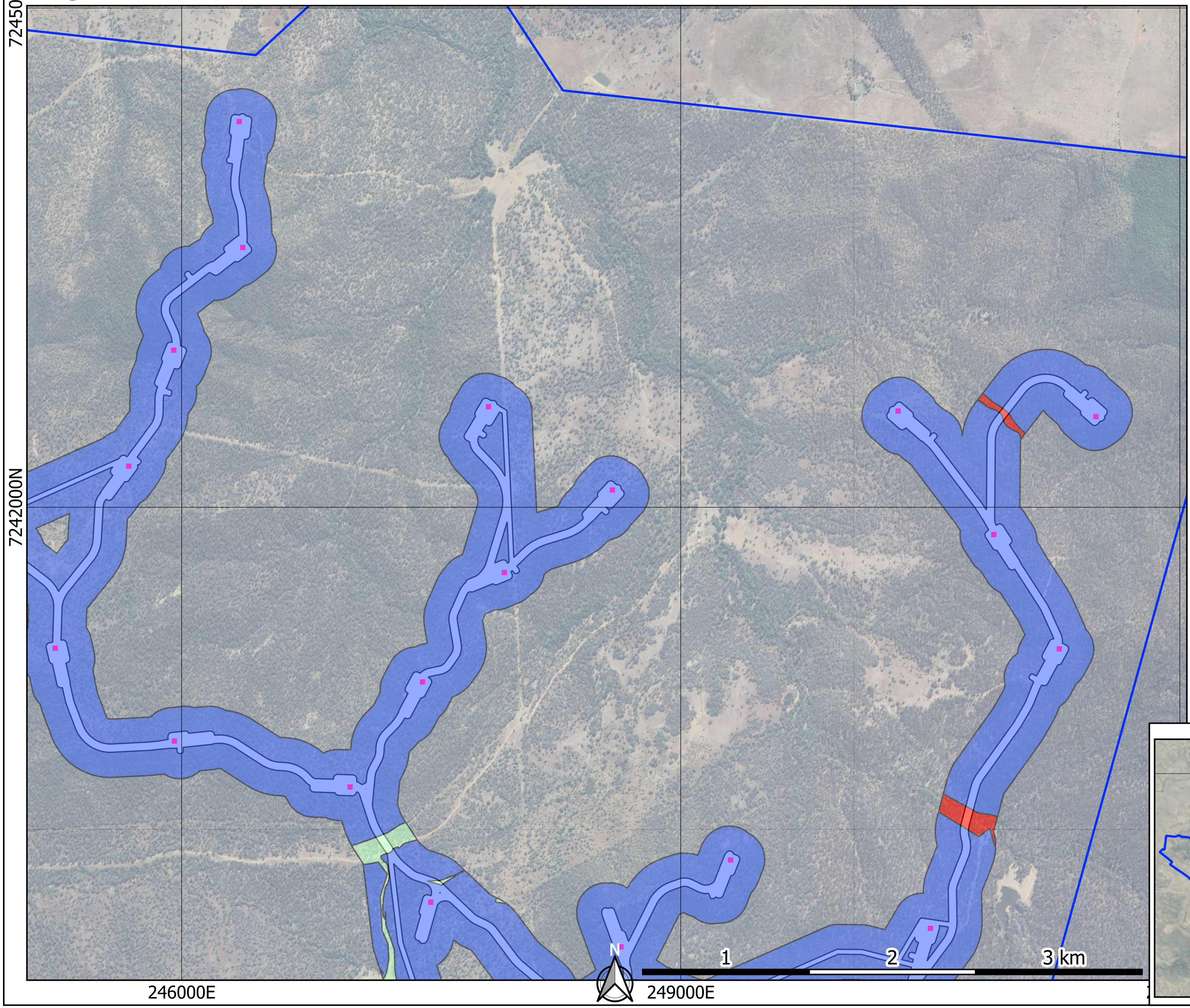
233609_0006_VHC_150m.pdf



Vegetation Hazard Class within 150 m of disturbance corridor



Legend

- Wind Turbine Generators

Vegetation Hazard Class to 150m buffer

- 13.2 Dry to moist eucalypt woodlands on undulating metamorphics and granite
- 16.1 Eucalyptus dominated forest on drainage lines and alluvial plains
- 40.4 Continuous low grass or tree cover
- Disturbance Corridor
- Site

CRS: GDA2020 / MGA zone 56
Scale: 1:30,000
Date created: 02/08/2024
Author: Marzia Coslan

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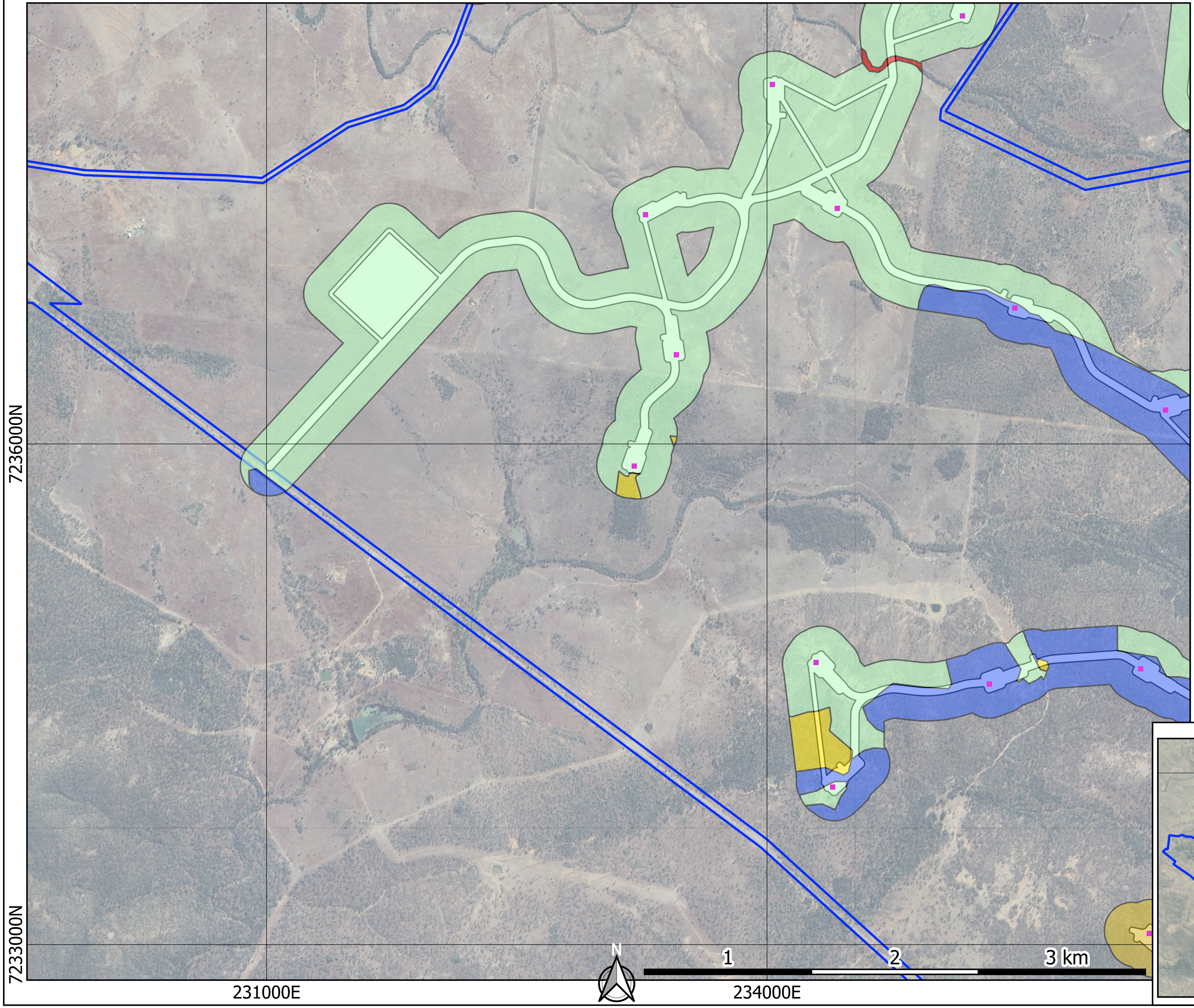
233609_0006_VHC_150m.pdf

Vegetation Hazard Class within 150 m of disturbance corridor



Legend

- Wind Turbine Generators

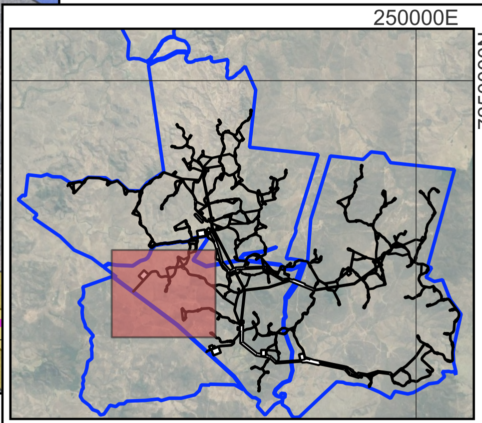
Vegetation Hazard Class to 150m buffer

- 10.1 Spotted gum dominated open forests
- 13.2 Dry to moist eucalypt woodlands on undulating metamorphics and granite
- 16.1 Eucalyptus dominated forest on drainage lines and alluvial plains
- 25.1 Brigalow belah open forests on heavy clay soils
- 40.4 Continuous low grass or tree cover
- Disturbance Corridor
- Site

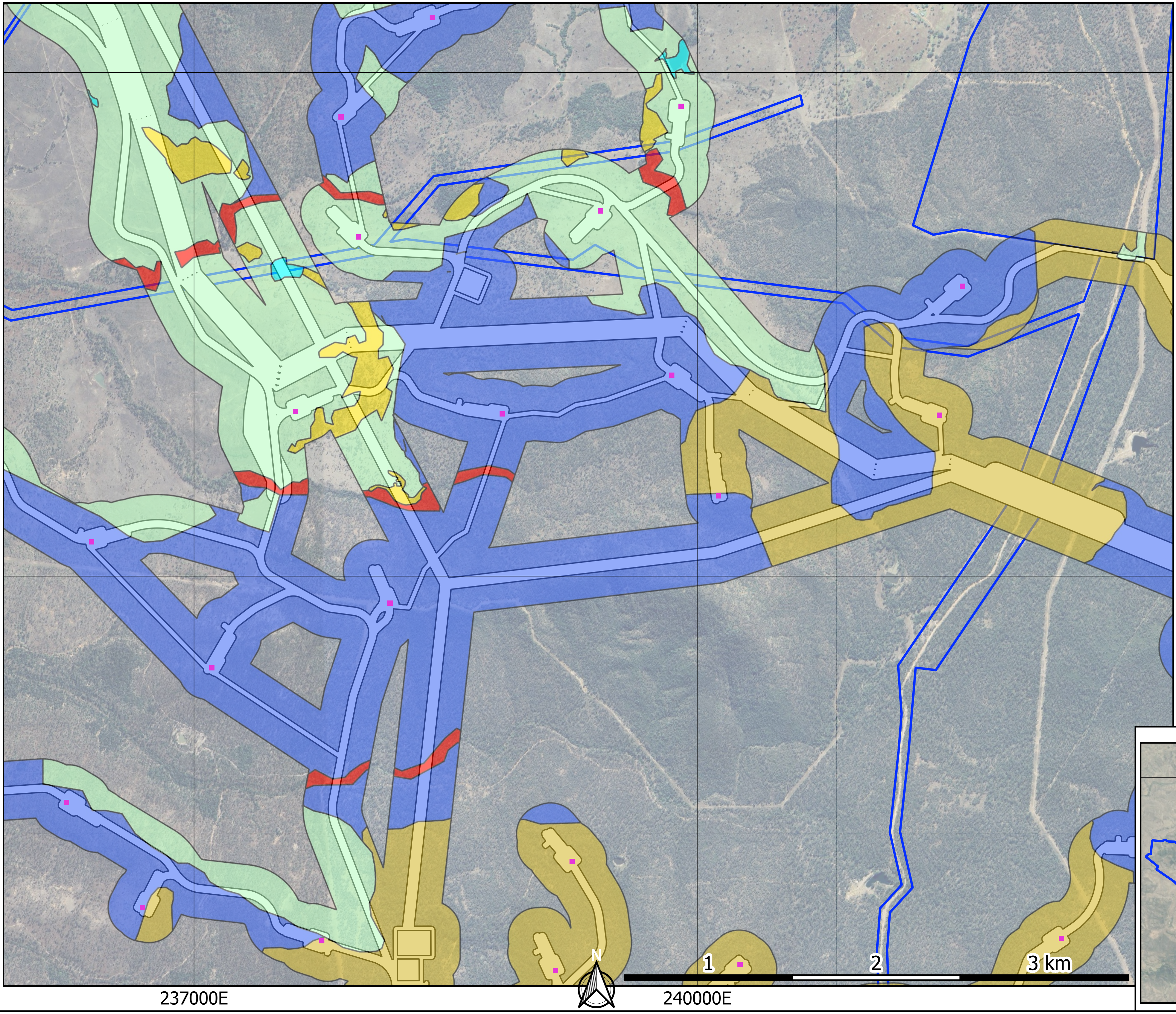
CRS: GDA2020 / MGA zone 56
Scale: 1:30,000
Date created: 02/08/2024
Author: Marzia Coslan

COVEY ASSOCIATES PTY LTD Consulting Engineers

233609_0006_VHC_150m.pdf



Vegetation Hazard Class within 150 m of disturbance corridor



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- Wind Turbine Generators

Vegetation Hazard Class to 150m buffer

- 10.1 Spotted gum dominated open forests
- 13.2 Dry to moist eucalypt woodlands on undulating metamorphics and granite
- 16.1 Eucalyptus dominated forest on drainage lines and alluvial plains
- 25.1 Brigalow belah open forests on heavy clay soils
- 40.4 Continuous low grass or tree cover
- 43.6 Water bodies
- Disturbance Corridor
- Site

CRS: GDA2020 / MGA zone 56
Scale: 1:30,000
Date created: 02/08/2024
Author: Marzia Coslan

COVEY ASSOCIATES PTY LTD Consulting Engineers

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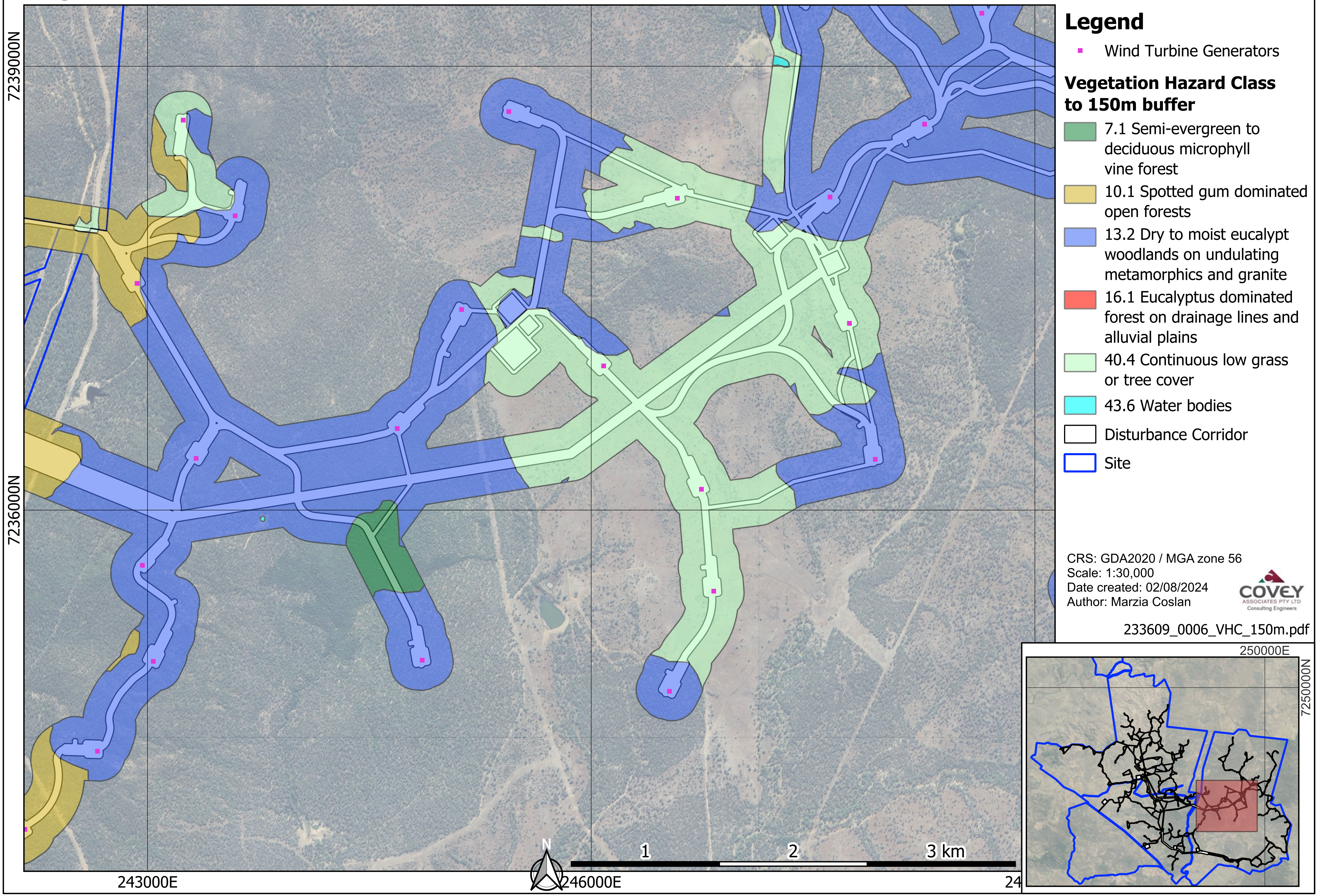
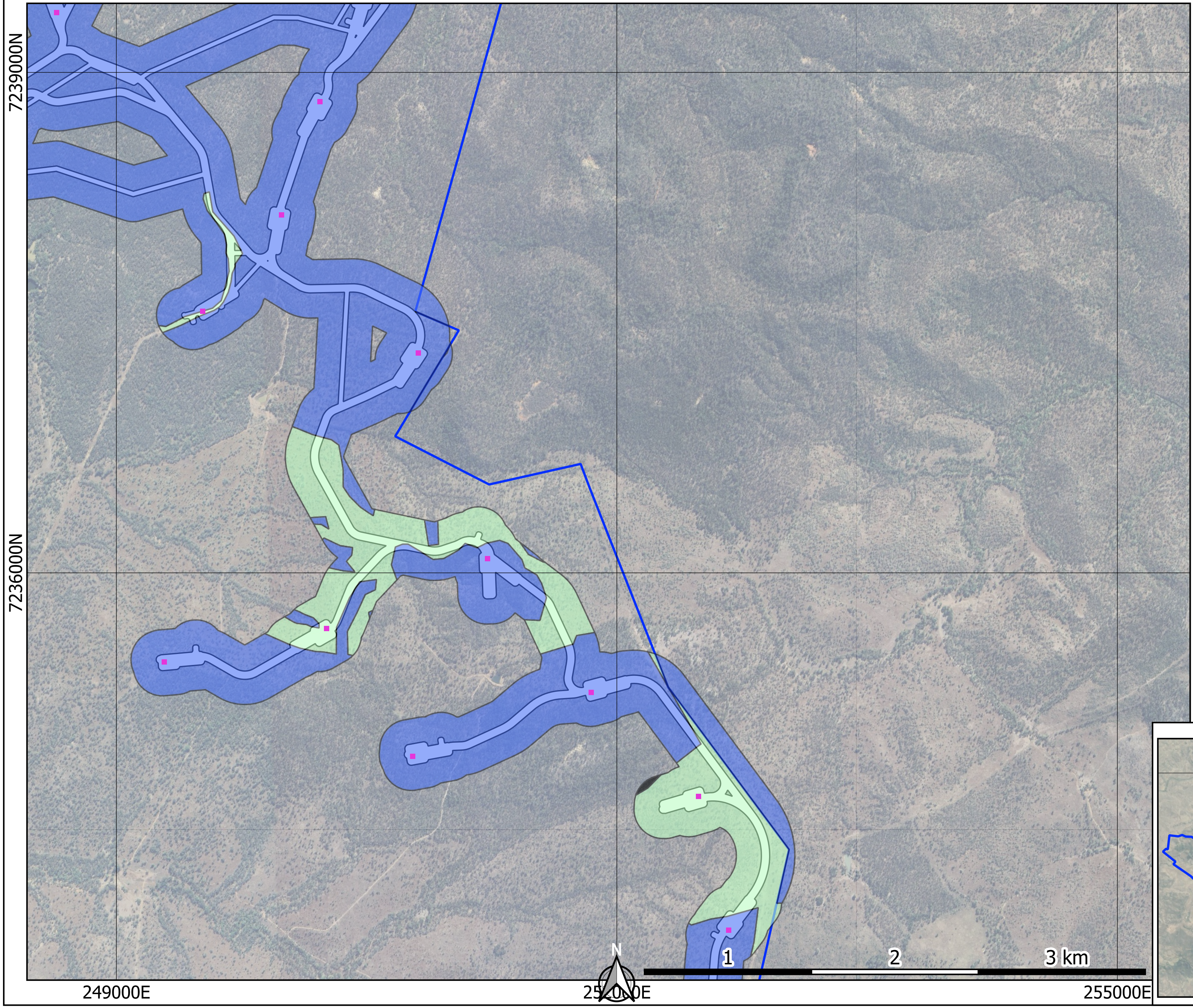
Vegetation Hazard Class within 150 m of disturbance corridor



Vegetation Hazard Class within 150 m of disturbance corridor



Legend

Wind Turbine Generators

Vegetation Hazard Class to 150m buffer

- 12.2 Dry eucalypt woodlands on sandstone and shallow soils
- 13.2 Dry to moist eucalypt woodlands on undulating metamorphics and granite
- 40.4 Continuous low grass or tree cover

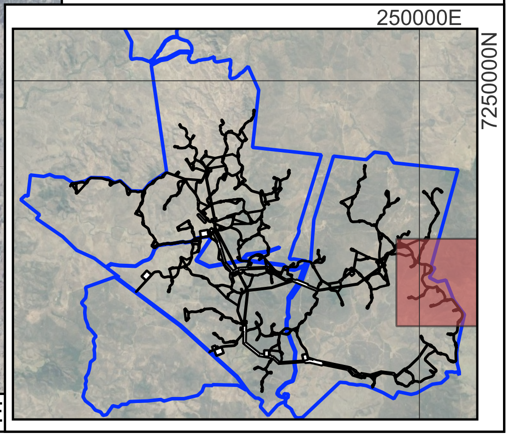
Disturbance Corridor

Site

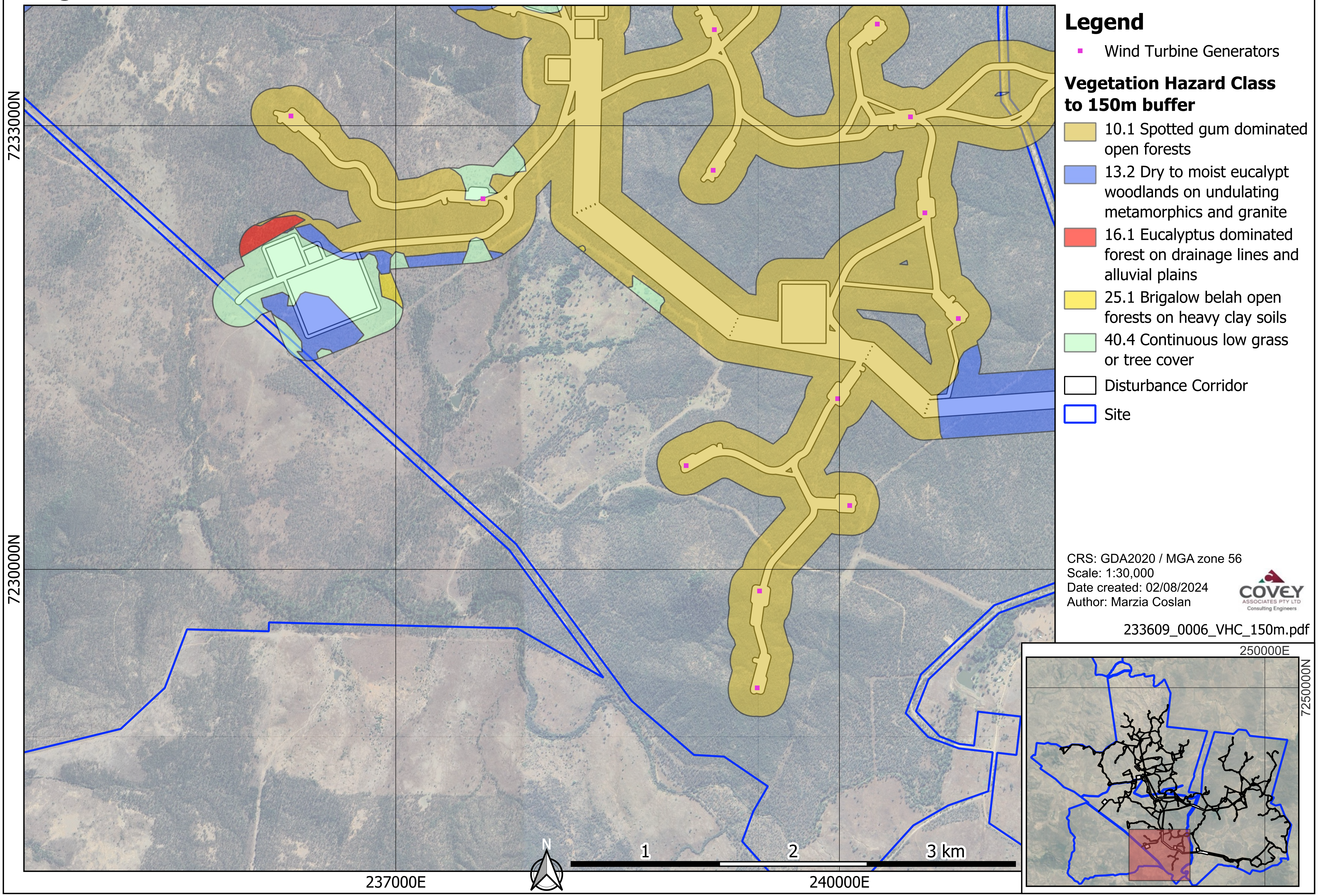
CRS: GDA2020 / MGA zone 56
Scale: 1:30,000
Date created: 02/08/2024
Author: Marzia Coslan

COVEY ASSOCIATES PTY LTD Consulting Engineers

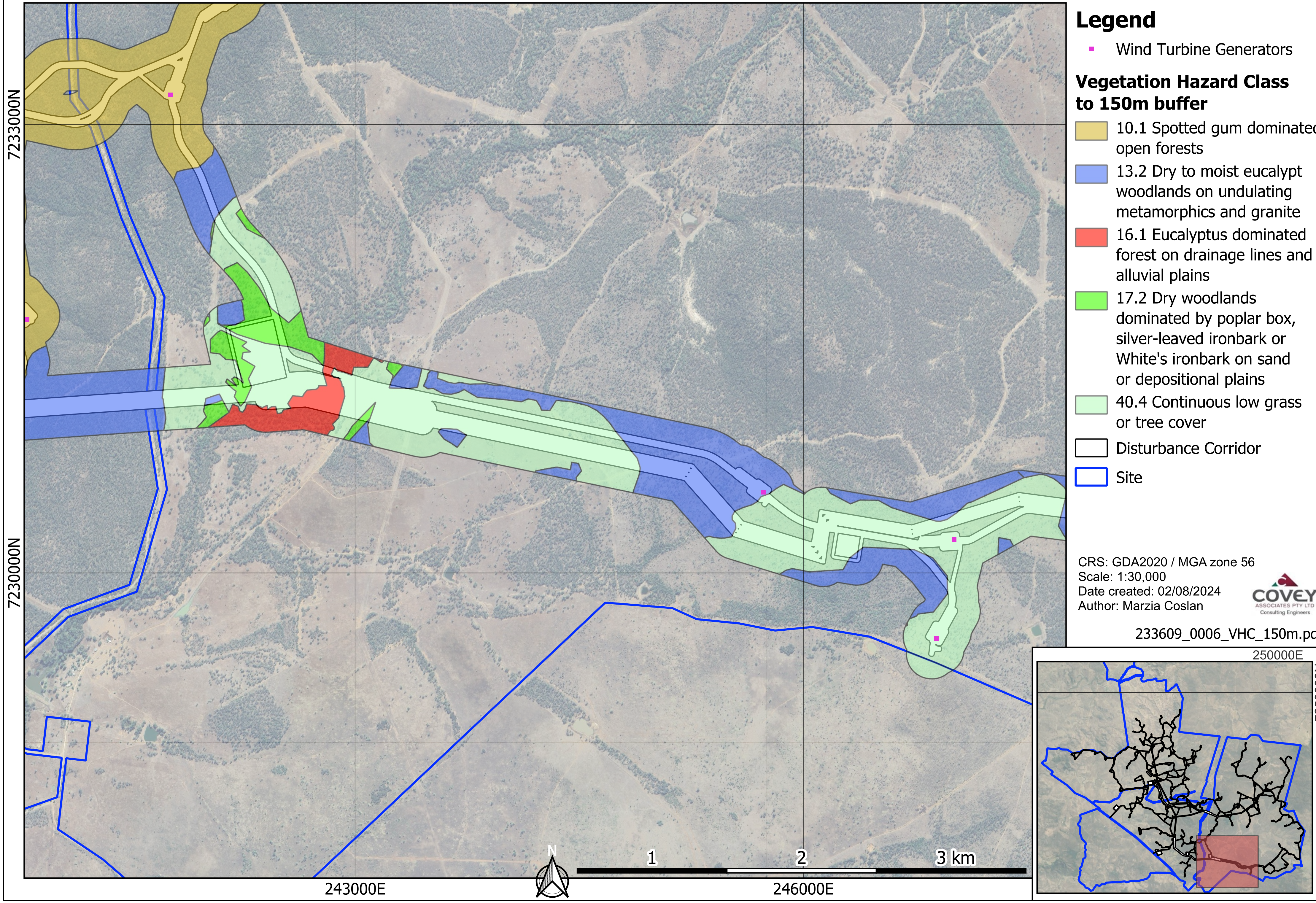
233609_0006_VHC_150m.pdf



Vegetation Hazard Class within 150 m of disturbance corridor



Vegetation Hazard Class within 150 m of disturbance corridor



Legend

- Wind Turbine Generators

Vegetation Hazard Class to 150m buffer

- 10.1 Spotted gum dominated open forests
- 13.2 Dry to moist eucalypt woodlands on undulating metamorphics and granite
- 16.1 Eucalyptus dominated forest on drainage lines and alluvial plains
- 17.2 Dry woodlands dominated by poplar box, silver-leaved ironbark or White's ironbark on sand or depositional plains
- 40.4 Continuous low grass or tree cover
- Disturbance Corridor
- Site

CRS: GDA2020 / MGA zone 56
Scale: 1:30,000
Date created: 02/08/2024
Author: Marzia Coslan

COVEY ASSOCIATES PTY LTD Consulting Engineers

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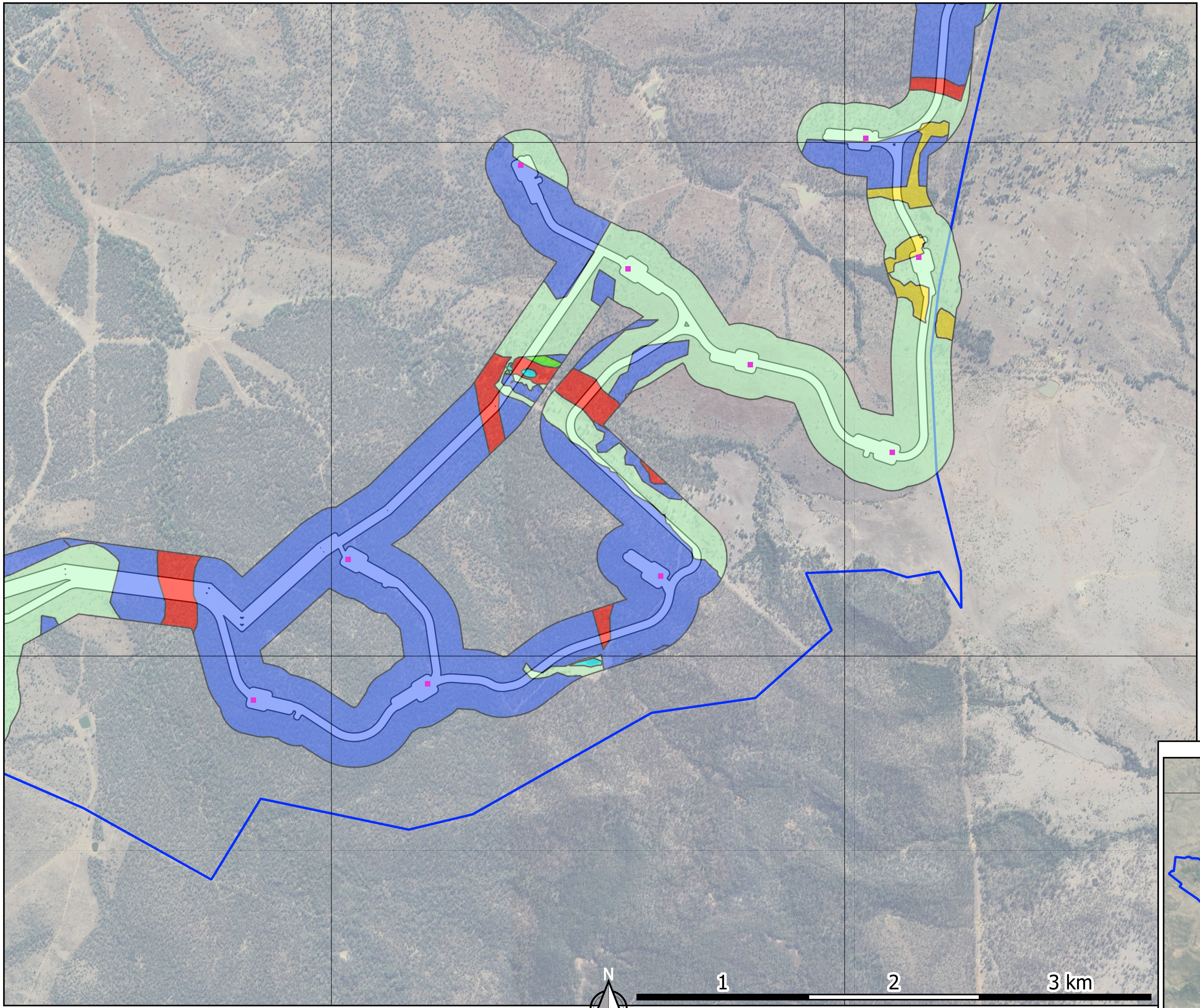
Vegetation Hazard Class within 150 m of disturbance corridor



Legend

- Wind Turbine Generators

Vegetation Hazard Class to 150m buffer

- 13.2 Dry to moist eucalypt woodlands on undulating metamorphics and granite
- 16.1 Eucalyptus dominated forest on drainage lines and alluvial plains
- 17.2 Dry woodlands dominated by poplar box, silver-leaved ironbark or White's ironbark on sand or depositional plains
- 25.1 Brigalow belah open forests on heavy clay soils
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CRS: GDA2020 / MGA zone 56
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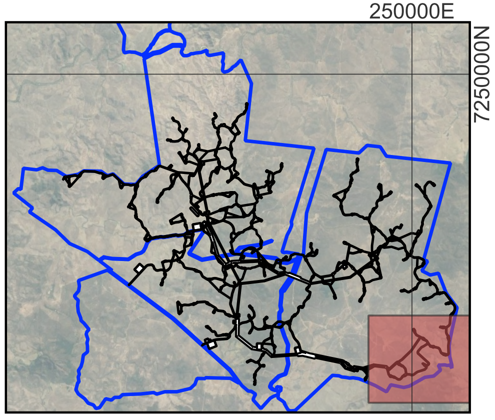

APPENDIX C

Radiant Heat Flux Model Input and Assumptions

Table 1. Radiant Heat Flux model input values.

FFDI	Vegetation Criteria				Rate of spread
	Vegetation Class	Vegetation Type	SFL (t/ha)	TFL (t/ha)	
67	VHC 10.1	Forests	19.3	20.8	R = 0.0012 * FFDI * SFL
67	VHC 13.2	Woodlands	12.8	14.4	R = 0.0012 * FFDI * SFL
67	VHC 16.1	Forests	13.8	16	R = 0.0012 * FFDI * SFL
67	VHC 17.2	Woodlands	9	9.6	R = 0.0012 * FFDI * SFL
67	VHC 25.1	Forests	13.1	15	R = 0.0012 * FFDI * SFL
67	VHC 40.4	Grassland	4.5	5	R = 0.13 * GrassFDI

Table 2. Radiant Heat Flux model assumptions – modified Method 2 of AS 3959.

Calculation Parameters					Flame Properties	
Emissivity	Heat of Combustion	Relative Humidity	Ambient temperature	Transmissivity	Flame Temperature	Head Fire width
0.95 ε	18600° K	25%	308° K	0.775	1090° K	100 m

APPENDIX D
Specifications for tank supply points

Specifications for tank supply points

This applies to tank supply points of hydrant systems, sprinkler systems and combined hydrant/sprinkler systems.

Where a site requires the inclusion of tank suction points to support QFES operations, the following points should be incorporated into the site design.

Location of Booster Installations and Tank Suction Points

- Connections to water storage tanks should be compatible with the equipment and procedures employed by QFES.
- QFES interpret that the maximum litres per second (L/S) from any suction point to be 40 L/S. If hydrants and/or sprinklers draw from onsite tanks and the building's water demand is over 40 L/S, additional suction points may be required in order to satisfy the 40 L/S per suction point ratio as referenced in AS 2419.1:2017 Appendix J3. Whilst not yet referenced by the National Construction Code (NCC), QFES supports the requirements of the 2017 standard. It is recommended that system designers consult with the QFES regional referral agency.
- If the design of the system requires more than one suction point, then the equivalent number of booster inlets (calculated @ 10 L/S per inlet) should be provided to facilitate the design flow required.
- Where the required hydraulic flows for the installation dictate more than one tank suction point is required to be provided, those tank suction points should be separated from each other by a minimum distance of 10 m, to allow multiple appliances (where required) to be simultaneously connected to the installation.
- Each tank suction point should be located within 10 m of the relevant booster inlet connections.
- Each tank suction point should be located within 4.5 m of hardstand for QFES appliances.
- Large bore suction connections should not have any inline reducers or couplings attached, which restricts or narrows the opening to less than the 115 mm internal diameter. (see photos below).
- Where the storage tank is located below ground level, the tank suction connection should be designed for hard suction.
- All pipework diameters and associated installation fittings should be in accordance with AS 2419.1 – 2005.
- The maximum length of dry pipe work from non-gravity fed tank/s to the suction point in a booster cabinet should be no more than 15 m inclusive, with a lift of no more than 4 m from the low water mark in order to not overtax QFES pump primer. In an on-site gravity tank fed system the length may be more than 15 m provided performance is met for the full duration of the systems performance requirements.
- The large bore tank suction connection point should be no more than 20 m below the high-water mark of the elevated firefighting water storage tanks due to head pressure. Static pressure at the suction point should not exceed 200 kPa as this exceeds the capability of QFES suction hose.
- Roof-top tanks may have to be designed with standard hose connections instead of hard suction outlets.
- Tank contents indicator should be installed and compliant to the prescribed standard.

These suction points are not considered compatible with QFES equipment and procedures

APPENDIX E
Banana Shire Council Rural Zone Code

5.10.2 Rural Zone code

5.10.2.1 Application

(1) This code applies to development where the code is identified as applicable in the Categories of Assessment Table. When using this code, reference should be made to Section 1.5.2 and, where applicable, Section 1.6.1.

5.10.2.2 Purpose

(1) The purpose of the Rural Zone Code is to

(a) provide for rural uses and activities; and

(b) provide for other uses and activities that are compatible with:

(i) existing and future rural uses and activities; and

(ii) the character and environmental features of the Zone; and

(c) maintain the capacity of rural land for rural uses and activities by protecting and managing significant natural resources and processes;

(2) The purpose of the Code will be achieved through the following overall outcomes:

……

(j) and where affected by an overlay for:

………

(iii) bushfire or flood risk:

(A) the use and works support and do not unduly burden disaster management response or recovery activities, providing for access for evacuation resources and efficient evacuation of sites during emergency events;

(B) development minimises the exposure of people or property to unacceptable risk from exposure to natural hazards and environmental constraints affecting the land through consideration of location, siting, design, construction and operation;

(C) development that intensifies occupancy of a site in Theodore responds to the elevated flood risk hazard by ensuring that emergency management plans allow appropriate responses to emergency measures having consideration to the numbers and capabilities of existing and future users of the development;

(D) works do not contribute to an increase in the severity of natural hazard events and are designed, located and operated to minimise risk to people and damage to property, disruption to development function and re-establishment time following an event;

(E) development involving the manufacture or storage in bulk of hazardous materials does not adversely impact on public safety or the environment;

(F) works retain the natural processes and protective function of landforms and vegetation in natural hazard areas;

5.10.2.3 Requirements for accepted development or assessment benchmarks

Table 5.10.3 For assessable development

Performance Outcomes	Complies Y/N	Comments
For development affected by one or more overlays		
Bushfire Risk		
PO 52 Development avoids any areas mapped on Overlay Maps OM-0301 - OM-0304 as a Bushfire Prone Area, does not increase the extent or severity of bushfire or exposure to the identified risk, taking into consideration: (a) vegetation type; (b) slope; (c) aspect; (d) bushfire history; (e) ecological values of the site; (f) ongoing maintenance; and (g) on-site and off-site fire hazard implications; and	**Yes**	WF site and surrounding area is subject to Medium and High Potential Bushfire Intensity around areas of woody vegetation with Very High Potential Bushfire Intensity typically observed in more rugged terrain. However, Wind Turbine Generators, Battery Energy Storage Systems, Substations, temporary and permanent site offices and accommodation are to be located such that they will be subject to less than 29 kW/m^2 (calculated in accordance with Method 2 of AS 3959-2018 Construction of buildings in bushfire-prone areas). Development infrastructure will achieve a minimum of 20 m setback from bushfire prone vegetation or as per Table 3-7, whichever is greater. This will mitigate the level of bushfire risk assets are exposed to an acceptable level, in case of bushfire under current planning legislation and guidance material. Any critical infrastructure within the development is recommended to be constructed to withstand 40 kW/m^2 of radiant heat and ember penetration. The development must not increase the amount of fine fuel load present on site. Generally, the WF will have 10 to 15 personnel upon completion. An emergency evacuation plan should be implemented to minimize likelihood of personnel being on site in case of wildfire impacting the site.
PO 53 Essential community infrastructure in any area mapped on Overlay Maps OM-0301 - OM-0304 as a Bushfire Prone Area is able to function effectively during and immediately after bushfire events. and	**Not Applicable**	The proposed development does not involve the construction of essential community infrastructure.
PO 54 Public safety and the environment are not adversely affected by the detrimental impacts of bushfire on hazardous materials manufactured or stored in bulk. and	**Yes/ to be included in design**	Any flammable materials (diesel and transformer oil) will only be stored in small quantities in storage facility. Hazardous materials (e.g., BESS) will be located at a setback distance of at least 20 m from flammable vegetation.
PO 55 Adequate water storage is provided for firefighting purposes that is safely located, accessible at all times and fitted with the standard rural fire brigade fittings. and	**Yes**	Firefighting water supply points are to be provided at each vehicle entrance to the facility, indicating the direction to the nearest static water tank(s) and/or dam(s). Static water points should follow Design Guidelines and Model Requirements for Renewable Energy Facilities. Additional Static Firefighting Water supply should be established for the proposed BESS. Refer to section 4.4 of this report.

Performance Outcomes	Complies Y/N	Comments
PO 56 Bushfire hazard mitigation avoids impacts on matters of environmental significance such as fragmentation, habitat loss and edge effects.	**Yes**	This report assumes that all relevant biodiversity and ecological issues will be addressed by a suitably qualified person. ERM are in the process of preparing an Ecological Impact Assessment evaluating the potential development impact.
For reconfiguring a lot by subdivision only		
PO 57 Subdivision design incorporates a perimeter road that: (a) is located between the boundary of the proposed lots and the bushfire hazard area; (b) has a minimum cleared width of 20m and a constructed minimum road width of 6m; (c) has a maximum gradient of 12.5%; (d) is constructed to an all-weather standard and ensures any culverts and bridges have a minimum load bearing of 15 tonnes; and	**Not Applicable**	Development does not involve lot reconfiguration. All proposed WF infrastructure will be accessible via internal roads and tracks. These are to be constructed per section 4.3.
PO 58 Fire trails are provided to: (a) mitigate against bushfire hazard; (b) enable access for fire fighters, residents and equipment; and (c) allow access for hazard reduction management programs; and	**Yes**	All proposed WF infrastructure will be accessible via internal roads and tracks. These are to be constructed per section 4.3 A Bushfire Management Plan should be prepared by a suitably qualified person and implemented in conjunction with the landholder. The bushfire management plan should adopt integrated land management principles including grazing, prescribe burning, weed control, and mechanical options. In particular, grazing and prescribed burning are key tools to manage fuels, which are mutually beneficial under well formulated plans.
PO 59 Development does not create additional lots in any areas mapped on Overlay Maps OM-0301 - OM-0304 as a Bushfire Prone Area.	**Not Applicable**	Development does not involve lot reconfiguration.