APPENDIX N SOILS AND WATER ADDENDUM REPORT

Hills of Gold Wind Farm Pty LTD

Developed by Clean Energy Partners Pty Limited

Hills of Gold Wind Farm Amendment Report

Soil and Water Addendum Report

21 December 2021

Project No.: 0550690

The business of sustainability

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Hills of Gold Wind Farm Amendment Report

Soil and Water Addendum Report

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1. INTRODUCTION

This report is an addendum to the Soils and Water Assessment, being Appendix O of the Hills of Gold Windfarm Environmental Impact Statement (EIS). This addendum report is a supporting document for the Hills of Gold Wind Farm Amendment Report. This addendum report includes the outcomes of additional site survey and data analysis, as well as considering proposed Project amendments described in the Amendment Report and addressing relevant comments included in submissions received following the exhibition of the EIS. The Amendment Report provides support to the responses to specific comments provided in the Response to Submissions Report (ERM, 2021).

A table referencing submission comments on soils from HoGPI and identifying where addressed in the addendum report is provided as Appendix B.

The addendum report has the following structure:

- Section 2 provides additional geological information including extracts and summaries of relevant results provided in the Preliminary Geotechnical & Geophysical Interpretive Report (Coffey Services, 2021).
- Section 3 provides additional slope analysis.
- Section 4 provides a site specific analysis of the NSW Land and Soil Capability Scheme.
- Section 5 reviews soil and water management requirements including catchment characteristics, and outcomes of the additional survey data, slope analysis and Revised Universal Soil Loss Equation (RUSLE) calculations.
- Section 6 provides updated mitigation measures to address potential soil and water impacts.
- Section 7 summarises the report findings.

2. GEOTECHNICAL AND GEOPHYSICAL INVESTIGATION

In order to respond to comments received following the exhibition of the EIS primarily concerned with the appropriateness of information currently available regarding the site ground and hydrology conditions and the overall suitability of the proposed site for the location of a wind farm, Coffey Services Australia (Coffey) undertook a geotechnical and geophysical investigation in February 2021 to obtain information on ground conditions across the Development Footprint. The scope of this investigation comprised:

- Desktop review of available site/regional information;
- Intrusive geotechnical investigation comprising the drilling of eight boreholes and excavation of 22 test pits together with geotechnical index testing of selected recovered soils and rock samples; and
- Initial site geophysical investigations including Land Seismic Refraction (LSR), Multichannel Analysis of Surface Wave (MASW) and Earth Resistivity Testing (ERT).

2.1 Regional Geology

The Project Area is almost entirely underlain by the Mount Royal Volcanics, comprising olivine basalts with some intrusions of theralite and teschenite. The Mount Royal Volcanics are part of the Liverpool Ranges Group, formed during the Paleogene Period.

The basalts are underlain by the Devonian Yaromine Formation, that primarily consists of siltstones though also includes pockets of the Crawney Limestone to the west and the Timor Limestone to the south of the Development Footprint. Karsts are known to exist in the limestone, including the Travelling Stock Route Cave at Crawney Pass and the more extensive Timor Caves located in the lower slopes east of Crawney Timor Road over 6 km to the south of the nearest turbine.

Environmental Geosurveys (2021) investigated potential for microbat habitats in the vicinity of the Project and concluded:

> *"outcrops of fractured basalt may provide localised habitat, however, terrain and geology of this precinct provides limited opportunity for extensive habitat. While several large solution caverns in limestone and basalt occur in surrounding terrain, these are localised and there is a low probability that similar unreported large habitat sites occur. It is extremely unlikely there are basalt caverns of the dimension to accommodate a large colony. There is also a low possibility that unknown caves occur in the Devonian crystalline limestone, as these outcrops have been searched on several occasions."*

Excavations for the construction of the Project are relatively shallow within the basalts and above the underlying limestone deposits.

The western extent of the Project, around the area of the Switching Station site, is situated within sedimentary sequences of the Namoi Formation. The Namoi Formation was formed during the Carboniferous Period and is characterised by thinly bedded siltstones and sandstones with localised bands of conglomerate, calcareous sandstone, bioclastic limestone and tuff.

2.2 Groundwater

Water bore drilling records supplied by a landowner indicates that the depth to ground water bearing zones on the ridgeline is between 30 m to 36 m below ground level (bgl), and depth to ground water bearing zones at the base of the hills is recorded as between 16 m to 20 m bgl. The wells on the ridge tops are regarded as being in groundwater recharge areas, not supply areas.

Site observations by Coffey confirmed there was no indication of shallow groundwater. However, discussions with local landowners revealed that many onsite dams were fed by nearby springs.

Of the eight boreholes drilled by Coffey, groundwater observation standpipes were installed in three to depths of 14 m to 20 m bgl targeting the main access track and Wind Turbine Generators (WTG) 58 and 67. Observed peisometric water level in two of the standpipes was recorded at 4.06 m bgl and

12.43 m bgl, indicating the water bearing zones are confined aquifers under some pressure, hence the potential for springs at the surface of the ridgeline and side slopes.

It is expected that at the Project Area groundwater would exist both as localised seepage and transient flows within the soil and extremely weathered rock profiles from rainwater infiltration, and as a much deeper groundwater table from rainwater accumulation within the rock mass defects.

Current site information suggest that the existing bores may be able to supply low volume of waters, but there is no information as to what length of time these flows may be maintained. Typically for bores in basalt the flow rate and amount of water that can be extracted is a function of how much water is stored in the rock mass jointing and over the longer period how quickly it can be recharged.

Additional detailed investigation and site assessment will be undertaken if it is deemed necessary that a sustained groundwater supply is a requirement for the purposes of construction.

2.3 Site Observations

2.3.1 Soils and Geology

The approximately 23 km long ridgeline of turbines and access tracks is characterised by highly variable soil depths, observed between 0.3 m to upwards of at least 5.0 m. The soils are typically silty or clayey, medium to high plasticity, with high to very high strength basaltic cobbles and corestones, up to 1.5 m in diameter. Soils display frequent cracking and rutting indicating moderate to high reactivity and shrink swell characteristics with seasonal changes in moisture content. These characteristics will be incorporated into the engineering design of turbine footings and foundations for site structures.

Rock outcropping is rare across the Project Area, with only one outcrop noted during the site walkover by Coffey in an existing small landowner borrow pit. No rock outcropping has been observed within the preliminary Development Footprint for the wind farm. Cuttings and excavation activities on the site indicate bedrock consists of a variable weathered zone, very low to low strength basalt with high strength bands. The weathered basalt was observed at the borrow pit to be underlain by high to very high strength basalt.

The topography around the switching station located at the western extent of the Project was observed as steeply to rolling hills. A nearby unnamed creek to the north of the switching station, exposed rock of the Namoi Formation sedimentary sequence. Distinct beds of siltstone and sandstone were observed; the siltstone was dark grey, thinly laminated, moderately weathered, and high strength. The sandstone beds were sub-horizontally bedded and laminated, fine grained, medium to high strength and highly to moderately weathered.

2.3.2 Erosion and Land Slips

Soils in the vicinity of the ridgeline appeared to be somewhat erodible. Undercutting around tree roots was frequently observed by Coffey.

Several relatively small soil slips were observed along the western portion of the ridgeline on the existing access tracks as well as the access track at the north of the eastern portion of the ridgeline. Slips with slip scarps of less than 1.5 m, were generally translational, less than 10 m^3, stabilising with a slope angle of 10°-15°. However, it is possible larger unobserved landslips may be present on the steeper slopes of the ridgeline. An area of boulder colluvium was observed along the eastern portion of the ridgeline (refer Figure 2.1). The slope was measured with a laser rangefinder to be approximately 38 m high at an angle of 35°. The boulders were basalt, typically 200-800 mm diameter, sub-rounded to angular and high to very high strength. This area is outside the location of wind turbines.

Further, basaltic boulders are present on other steep upper slopes across the Project Area and hence the nature and extent of rock-fall hazards will need to be considered in the design of access road cuttings and locations at the base of the hills including the Transverse Track that links turbines WP 18 to WP40, which follows contours on moderately steep land below the steep upper slopes of the ridgeline.

Section 6.1.1 provides details of design measures recommended to address slope instability.

2.4 Investigation Results

2.4.1 Encountered Surface Conditions

The encountered ground conditions across the Project Area are highly variable and differed between each investigation location. This great variability is a function of the varying geology (basalts, siltstones, sandstones and mudstones), topography (ridgelines with flat and sloping plateaus, upper and lower slopes and river flats), and in-ground weathering conditions both across and with depth. An inherent characteristic of dominant basalt geology is that due to both deep preferential weathering along the vertical joints, and differences between individual flows that make up a deposit, bedrock conditions with depth can be quite variable. It is noted that the wind farm Development Footprint is generally on the plateaued ridgeline with deep basalt soils, a resulting landform that has encouraged historical grazing activities that are recognised as a compatible land use to wind farm developments.

The majority of the Project Area is underlain by basalt bedrock and in general terms, due to prolonged weathering, near surface ground conditions comprise of a deeply weathered profile with thick sequences of residual soil overlying extremely weathered basalt to depths of between 10 m to 20 m below ground surface levels. This deeply weathered profile often contains intact basalt corestones which represent unfractured areas of the rock mass away from joints and fractures that were less susceptible to weathering. Corestones are expected to be typically 0.1 m to 1 m in size but may be as large as 2 m to 3 m at some locations.

Less weathered, relatively intact high to very high basalt bedrock was only encountered in boreholes on the ridgelines, at depths of 11 m to 15.5 m bgl.

Ground conditions at the Switching Station site are very different to the rest of the Project Area as this site is approximately 10 km west of the Wind Farm site and at lower elevation. Here the Switching Station site is underlain by sedimentary bedrock of the Namoi Formation with a ground profile comprising shallow residual soils between 0.4 m to 1.1 m deep over siltstone bedrock. The residual soil comprises clays and silts of firm to hard consistency. The upper 0.5 m to 1 m of siltstone was assessed as being highly weathered and very low strength; it is then underlain by fresh siltstones and sandstone of medium to high strength.

Figure 2.1 Boulder Colluvium (source (Coffey Services, 2021)

2.4.2 Soil Profile

The soil profiles logged from the bores and test pits have been summarised for the Wind Farm Development Footprint and the Switching Station footprint and are provided in Table 2-1 and Table 2-2 respectively.

Table 2-1 Soil Profile Summary Wind Farm Ridgeline

Unit	Description	Indicative Thickness (m)
Topsoil/Slope Wash	Sandy silt	0.0 – 0.3
Residual Soil	Gravelly clay/silt and clay, medium to high plasticity, stiff to hard consistency, with high strength basalt cobbles and corestones	1.5 – 5.0
Extremely Weathered Basalt	Basalt, very low to low strength, extremely weathered, with occasional high strength basalt gravel, cobbles, and corestones	5 - 10
Slightly Weathered to Fresh Basalt	Basalt, slightly weathered to fresh basalt, high to very high strength	-

Table 2-2 Soil Profile Summary Switching Station Site

Unit	Description	Indicative Thickness (m)
Topsoil	Sandy silt	0.0 – 0.1
Residual Soil/Extremely Weathered Siltstone	Sandy clay/silt, low to medium plasticity, very stiff to hard consistency	1.0 – 1.5
Interlaminated Siltstone & Sandstone	Medium to high strength, slightly weathered to fresh	-

The site investigations confirm the wind farm site has relatively deep basalt derived soils underlain by low strength weathered grading to high strength fresh basalts, whereas the switching station site has minimal topsoil and shallow residual siltstone overlaying the sedimentary bedrock.

2.4.3 Soil Erodibility

Based on the results of Emerson Class testing and site observations by Coffey, the silts and clays encountered onsite are highly dispersive and will be readily eroded where they are disturbed or exposed. As a result, any exposed soil in stockpiles, temporary works or permanent works will require erosion protection such as covering, vegetation or a permanent capping, together with effective sediment control measures incorporated into the site drainage.

Soil erodibility is one factor in the determination of erosion hazard and hence the basis for development of appropriate erosion and sediment controls that meet site conditions. Further factors addressed in this addendum report include slope analysis (Section 3), catchment conditions (Section 5) and outcomes of the Revised Universal Soil Loss Equation (RUSLE) (Appendix A). These factors and the calculated erosion hazard at the location of construction activities provide input to identifying relevant recommendations of 'The Blue Book' (Landcom, 2004) for the development of site specific erosion and sediment control plans.

Section 6.1.2 provides details of construction measures recommended to address erosion and sediment control.

2.4.4 Earthwork Batters

Appropriate permanent cut batter slopes should be assessed on an individual basis with reference to cutting ground conditions. In the soil strength Residual Soils and Extremely Weathered Basalts, and Engineering Fill slopes, permanent batter slopes of 2H:1V or shallower are considered appropriate for the concept design of slopes up to 10 m in height. Benches will be required for stability purposes for higher cut slopes. In summary the following is recommended:

- For slopes 2H:1V or shallower, individual vertical batter heights may be up to 10 m;
- Minimum bench width of 4.5 m;
- The unreinforced slopes must be designed with the following Long-term FOS ≥ 1.5;
- No temporary or permanent surcharges loads may be placed on batter crests; and
- Surface rainwater flows must also be diverted away from batter crests and faces.

If steeper, or relatively high batter slopes are required, then engineering design and support / stabilisation will be required. Permanent soil nailing and shotcrete support may be considered for such cases.

Given the relatively steep and exposed nature of much of the Project Area, and assessed high dispersity/erodibility of site soils, consideration needs to be given during design to the use of appropriate cut/fill batter protection and effective site surface water management and drainage to prevent the mobilisation of sediments to natural water courses. This may include vegetation or shotcreting batter faces together with effective catch drains above batters and the construction of contour banks, sediment ponds and silt traps within the surface water drainage system.

To minimise the ongoing maintenance of any cut and fill slopes, batters should be vegetated with grass as soon as possible following construction, and be protected from overland surface water flows by the construction of appropriate permanent surface drainage measures.

The recommendations above have been incorporated into the updated mitigation measures detailed in Section 6.

3. SITE SLOPES

A detailed analysis of slopes at the wind farm site has been prepared using ArcGIS software. The mapping presented as Figure 3.1 and Figure 3.2 provide a colourised representation of slope, generated dynamically using the ArcGIS function ‘Terrain’ using 1 m contour data. The percent of slope steepness is depicted by light to dark colours - flat surfaces as blue, shallow slopes as grey, moderate slopes as yellow, steep slopes as brown, with slopes greater than 50 percent coloured with red. This breakdown represents the classes used in the derivation of NSW Land and Soil Capability (LSC) mapping (refer Table 3.1), which is further discussed in Section 4. For ease of interpretation shallow slopes i.e. under 10% representing Classes 1 to 3 have been depicted as the single colour blue in Figure 3.1 and Figure 3.2.

Table 3-1 Slope Class for each LSC Class Used to Determine Water Erosion Hazard [1]

NSW Division	Slope Class (%) for each LSC Class							
	1	2	3	4 [3]	5 [4]	6	7	8
Eastern and Central Division	<1	1 to <3	3 to <10 [2]	10 to <20	10 to <20	20 to <33	33 to < 50	>50

Source: OEH 2012

Notes: 1. Slope classes also used for Mass Movement Hazard

2. 1 to <3 with slopes >500 m length

3. No gully erosion or sodic/dispersible soils are present

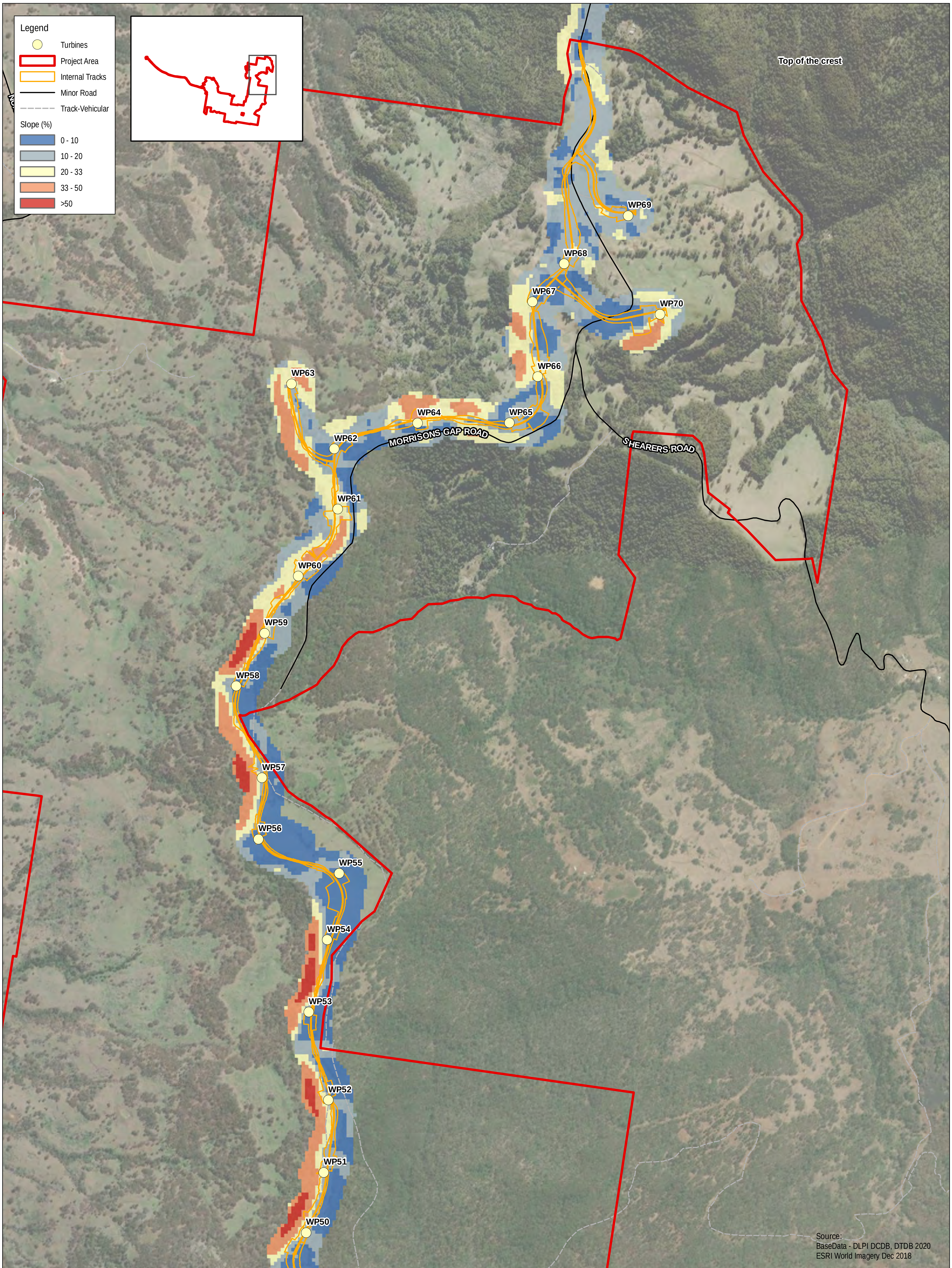
4. Gully erosion and/or sodic/dispersible soils are present

The Project Area is located along the upper ridgeline that is exposed to prevailing wind directions. These ridgelines and plateaus are flanked in most directions by very steep and rugged terrain. The slope analysis confirms that the majority of the Development Footprint which follows the top of the cleared ridgeline generally has slopes from 0-20 percent, mainly falling in Slope Classes 3, 4 and 5, with some sections of access tracks with longitudinal slopes or batters within steeper areas.

By locating the Development Footprint along the ridgetop, primarily avoids the steeper upper slopes to the ridgeline of 33 to >50 %. The Transverse Track generally follows existing topographic contours at the base of these steep upper slopes on slopes of 10-33 % with some sections crossing steeper sections of >33 %. No turbines are located in slopes above 33 %.

The Development Footprint has been developed to minimise bulk earthworks and associated disturbance to soils and biodiversity. The current Project design is preliminary and will be refined further during detailed design to optimise infrastructure grades and hence reduce overall earthworks.

Suitable measures for soil erosion and sediment control are presented in Section 5.2 of this document. The Transverse Track avoids steep rock outcrops and with suitable controls proposed in this document can be managed to avoid soil erosion. The substation, BESS and O&M Facility is situated primarily on a 0-10 percent slope and present a minimal soil erosion risk with suitable controls.



Wind Farm Site Slope Analysis East End

F3-1

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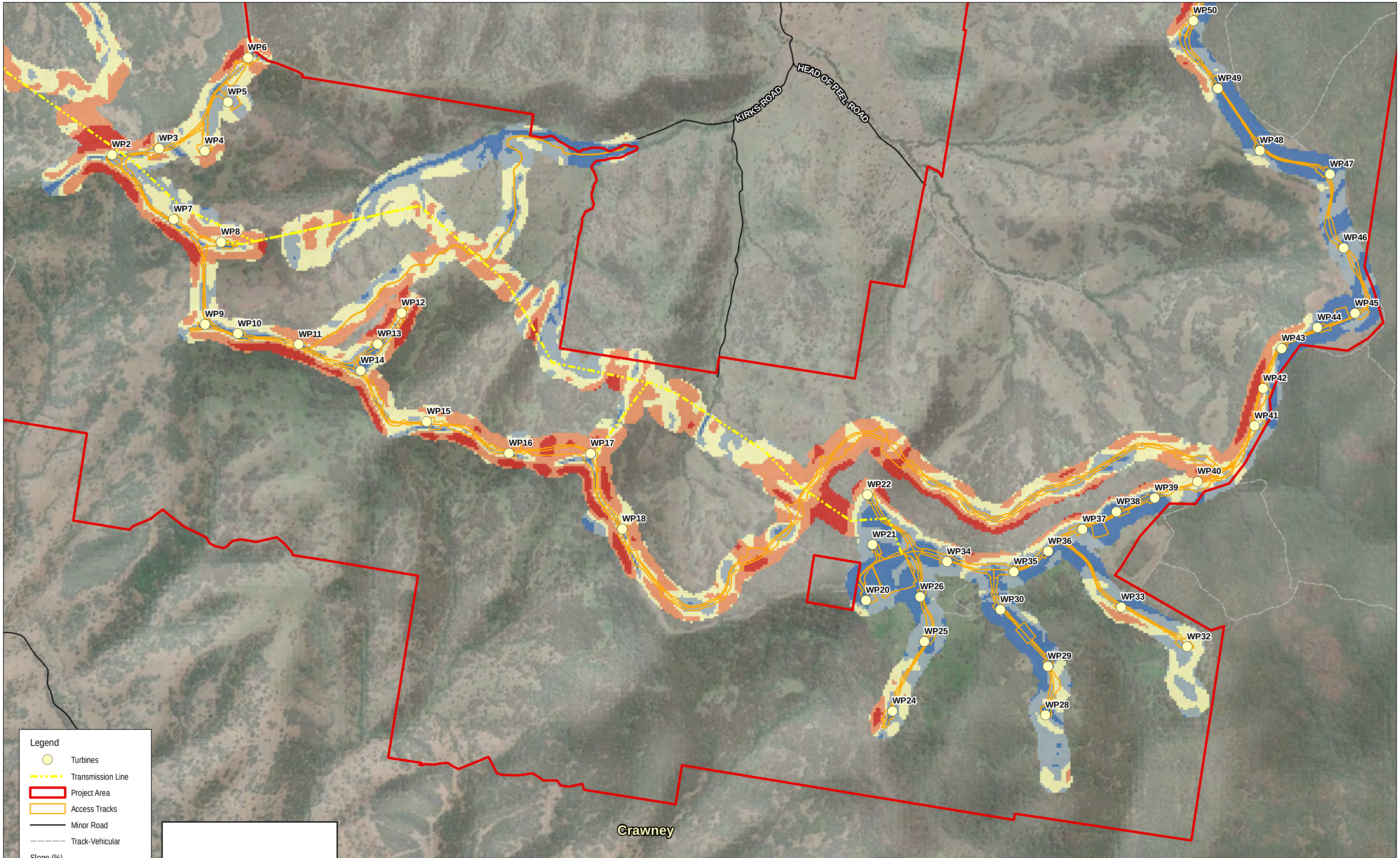

Wind Farm Site Slope Analysis West End

F3-2

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Coordinate System: GDA 1994 MGA Zone 56

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4. LANDSCAPE AND SOIL CAPABILITY MAPPING

The Land and Soil Capability Assessment Scheme (OEH, 2012) established the land and soil capability (LSC) mapping to inform the inherent physical capacity of the land to sustain a range of land uses and management practices in the long-term without degradation to soil, land, air and water resources. It provides information using an eight class system representing the broad agricultural land uses most physically suited to an area. The context and application of the LSC assessment scheme is largely for:

- regional assessment of land capability; and
- the assessment of land capability for broad-scale, dry-land agricultural land use.

The LSC assessment scheme uses biophysical features of the land and soil, including landform position, slope gradient, drainage, climate, soil type and soil characteristics, to derive detailed rating tables for a range of land and soil hazards. These hazards include water erosion, wind erosion, soil structure decline, soil acidification, salinity, waterlogging, shallow soils and mass movement.

OEH (2012) states that "*The mapping is broad-scale and should only be used at the scale of the soil map datasets that underpin the maps. These maps are not suitable for site assessment at the property scale."*

Further, OEH (2012) states that *"It is important to recognise that the scheme provides guidance only on the physical capability of the land to support different agricultural land uses."*

The LSC classes are grouped into four types of land uses with land capability decreasing from Class 1 to Class 8:

- Class 1 – 3: Land capable for a wide variety of land uses (cropping, grazing, horticulture, forestry, nature conservation);
- Class 4 – 5: Land capable of a variety of land uses (cropping with restricted cultivation, pasture cropping, grazing, some horticulture, forestry, nature conservation);
- Class 6: Land capable for a limited set of land uses (grazing, forestry and nature conservation, some horticulture); and
- Class 7 – 8: Land generally incapable of agricultural land use (selective forestry and nature conservation).

It is noted that a submission in response to the EIS identified an error in the published LSC mapping over the Project Area, in particular areas to the south of the ridgetop west of the proposed BESS/O&M/Substation mapped as Class 7 (very low capability land) were in fact Class 8 (extremely low capability land) and that this mapping was to be updated by DPIE. The DPIE online mapping tools (SEED, eSPADE) continue to reflect the mapping as provided as Figure 4-2 in Appendix O of the EIS.

In general, the regional LSC mapping has mapped LSC Class 7 and Class 8 as the dominant classes across the Project Area, generally from the 800 m contour at the base of the upper slopes to the ridgetop at approximately 1400 m AHD and varies in width from approximately 1 km to over 5 km. OEH (2012) defines LSC Class 7 as:

Very low capability land: Land has severe limitations that restrict most land uses and generally cannot be overcome. On-site and off-site impacts of land management practices can be extremely severe if limitations not managed. There should be minimal disturbance of native vegetation.

OEH defines LSC Class 8 as:

Extremely low capability land: Limitations are so severe that the land is incapable of sustaining any land use apart from nature conservation. There should be no disturbance of native vegetation.

A summary of the LSC decision tables for individual hazards that trigger Classes 7 & 8 is provided as Table 4-1. The summary data confirms that the Development Footprint itself does not represent Class 7 or Class 8 land.

Table 4-1 Data requirements for determining LSC Classes 7 & 8

Hazard	Data Requirement	Class 7	Class 8	Comment
Water Erosion	Slope Class % Eastern and Central Divisions	33% - <50%	>50%	Development Footprint generally on slopes of 0-33%
Wind Erosion	Wind Erodibility Class of surface soil Wind Erosive Power Exposure to Wind (>500mm average annual rainfall)	High High High	NA	Site surface soils are classed as Low Wind Erodibility Class (loams, clay loams, or clays)
Soil Structure Decline	Field Texture Modifier (degree of sodicity)	Clay/ Strongly Sodic Surface Soils Highly Organic/Peat Soils	NA	Surface soils generally Sandy Silts overlaying Gravelly Clay/Silt and Clay
Soil Acidification	Texture/Buffering Capacity pH (>900mm mean annual rainfall)	NA	NA	Soils are acidic to slightly acidic
Salinity Hazard	Recharge potential Discharge Potential Salt Store	High Moderate/High High	NA	Site is mapped as Low Salt Store Class
Waterlogging	Waterlogging Duration Return Period Soil Drainage	NA	Almost Permanently Every Year Very Poorly Drained	Site is not subject to waterlogging of any significant duration
Shallow Soils & Rockiness	Rocky Outcrops Soil Depth	<30% with 0-<25cm soil depth	>70% rocky outcrops	Negligible Rocky Outcrops in Development Footprint Soil depth from 0.3m to 5m

Source: OEH 2012

The description of LSC classes states that: *Class 7 land includes slopes of 33–50% (except on basalt soils which could still be Class 6) and that Class 8 land includes precipitous slopes (>50% slope) and cliffs, areas with a large proportion of rock outcrop (>70% area), or areas subject to regular inundation and waterlogging (swamps, lakes, lagoons, stream beds and banks).* The descriptions state that these LSC classes have such severe limitations that they are unsuitable for agricultural activities including grazing.

As shown in Figure 3.1 and Figure 3.2, the Development Footprint follows the ridgetop and avoids the steep upper side slopes of the ridge. The proposed Transverse Track to provide access to WTGs 1-18 is located generally along a topographic contour below the steep upper slopes to the ridgeline.

The majority of the Development Footprint is on basalt soils and is used for grazing operations. The groundcover in the Development Footprint is mostly dense exotic grassland consistent with grazing and with negligible rock outcrops, though small floating basalt cobles are evident throughout the Development Footprint. Some erosion and minor landslips (<1.5 m) are evident where upper soil horizons have been exposed by tracks and other disturbance, though results of mass movement events are not evident. During detailed design, turbine and infrastructure locations will be further refined to avoid the adjacent steeper slopes and areas of significant rocky outcrops.

OEH (2012) provides photographic examples of LSC Class 8 and 7 lands which are reproduced as Figure 4.1 and Figure 4.2 respectively.

A number of photographs of the proposed Development Footprint following the existing access track along the ridgetop are provided as Figure 4.3 and are in contrast to the landforms depicted in the photographs that OEH (2012) interpret as LSC Classes 7 and 8.

Figure 4.1 Class 8 Land – Precipitous hills with little or no soil, abundant cliffs and boulders and severe mass movement (rock fall) hazard (OEH, 2012)

Figure 4.2 Class 7 Land – Steep hills with shallow, rocky soils which are generally unsuitable for agricultural use (OEH, 2012)

Figure 4.3 Photographs of the Development Footprint along the existing access track

As noted above, LSC mapping is for use in the context of broad-scale agricultural purposes.

The LSC scheme acknowledges that a mapped class may in fact contain a range of LSC classes and are intended to be interpreted at the underpinning scale and are not intended for use at property scale, including for wind farm developments, where actual site conditions can override the mapped classes.

Table 4-1, the LSC class descriptions including photographic examples, site based investigations, current land use, and geotechnical assessments confirms that the overall Development Footprint at the Wind Farm site does not meet the data requirements for LSC Class 7 or Class 8, which are generally land that is incapable for agricultural land use.

The historical grazing land use on dense groundcover across the Development Footprint confirms the land is capable for land uses such as grazing and forestry.

5. SOIL AND WATER MANAGEMENT

5.1 Peel River Catchment

5.1.1 Affected Catchment Areas

Section 4.2.3 of the Soil and Water Assessment provided as Appendix O of the EIS discussed the hydrology of the Project Area. Given the dominant characteristic of the Wind Farm site is a ridgeline, the hydrology consists of the headwaters of three main river catchments being the Namoi, Hunter and Manning Rivers (refer Figure 4.4 Appendix O of the EIS). With the alternate access via an upgraded Head of Peel Road no longer being proposed, the Development Footprint on the ridgeline only directly impacts first order ephemeral watercourses, primarily tributaries of the Peel River within the Namoi River catchment. The Transmission Line alignment has also been amended (refer Amendment Report) and no longer spans Woodleys Creek. No other second order or higher watercourses are affected by the route realignment.

The Project Area incorporates only 0.00123% of the Namoi River Catchment. The Peel River, a major system of the Namoi River Catchment, flows from its headwaters at the ridgeline meandering some 46 km through agricultural land passing the village of Nundle to Chaffey Dam. The catchment of Chaffey Dam is reported by WaterNSW as 420 km^2 with an operating capacity of 100.5 GL and on 8th June 2021 its dam level was at 58.1% (https://www.waternsw.com.au/supply/visit/chaffey-dam).

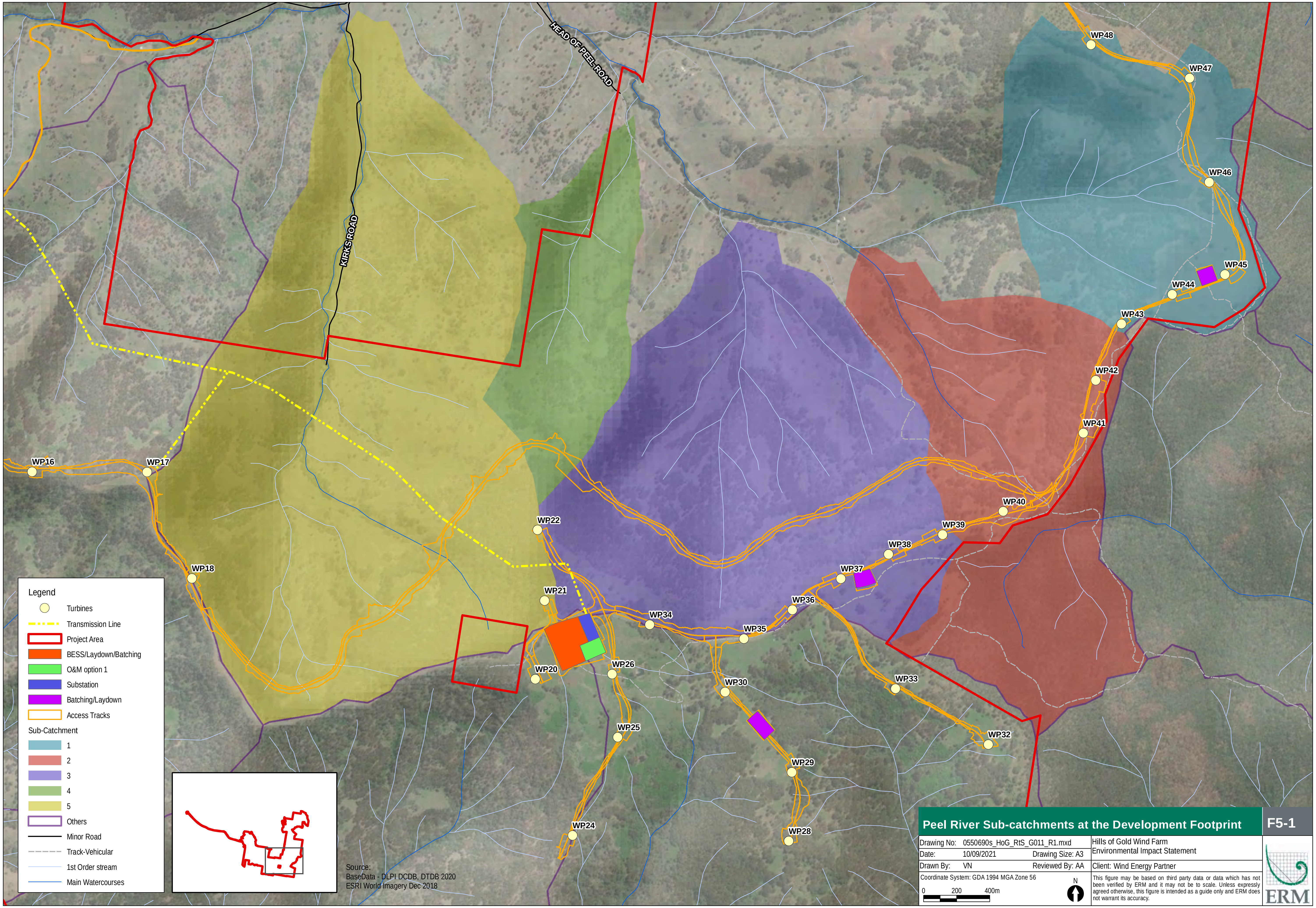
At the headwaters to the Peel River below the ridgeline there are many small catchments feeding the numerous tributaries, some named (Oakey Creek, Woodleys Creek and Talbots Creek) and many unnamed. Figure 5.1 depicts a number of sub-catchments in the central portion of the Project Area. The Development Footprint is shown within six of the Peel River sub-catchments with the figure confirming its relatively minor area within these small tributary sub-catchments. The area of Development Footprint and the percent affected in each of the shown sub-catchments are provided in Table 5-1.

Table 5-1 Area of Disturbed Footprint within Peel River Sub-Catchments occurring within Project Area

Sub-Catchment	Sub-Catchment Area (ha)	Development Footprint within Sub-Catchment (ha)	Development Footprint as % of Sub-Catchment Area
1	235.06	9.12	3.9 %
2	295.28	12.26	4.2 %
3	416.10	27.73	6.7 %
4	124.75	5.56	4.5 %
5	643.71	20.20	3.1 %

Note: Sub-catchments as numbered in Figure 5.1.

The extent of the total Development Footprint within the Peel River catchment upstream of Chaffey Dam is 216 ha, representing only 0.51% of its 420 km^2 sub catchment area. These small catchments are primarily located up-gradient of first order streams. Disturbance activities during construction of the Project will require management to ensure runoff is directed to down-gradient watercourses through appropriate water quality controls and continue to reach the Peel River and onto Chaffey Dam.



Peel River Sub-catchments at the Development Footprint **F5-1**

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Date: 10/09/2021 Drawing Size: A3
Drawn By: VN Reviewed By: AA
Coordinate System: GDA 1994 MGA Zone 56

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Environmental Impact Statement
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5.1.2 Transverse Track

The Transverse Track provides a relatively low gradient link from WTG40 to WTG18 that generally follows existing topographic contours at the base of the northern side of the ridgeline. The Transverse Track passes through four of the Peel River sub-catchments (refer Figure 5.1) crossing a number of first order ephemeral watercourses. To ensure that flows from the up-gradient catchment, including rainfall runoff or any identified springs, reach down-gradient watercourses and the Peel River, options including drainage rock blankets installed for seepage and culverts installed at key watercourse crossing points will be confirmed at the detailed design phase. Figure 5.3 provides indicative locations for culverts along the Transverse Track to ensure surface flows pass safely down-gradient.

5.1.3 Conclusion

Water quality management will be achieved using specific erosion and sediment controls based on The Blue Book (Landcom, 2004) and developed by an experienced Certified Practitioner in Erosions and Sediment Control (CPESC). The Blue Book provides comprehensive guidelines to mitigate land disturbance impacts on the basis that *'are based on the premise that land degradation associated with land disturbance activities can be avoided or minimised, largely through appropriate planning before commencement of earthworks and by applying the best management practices (BMPs) available.'* The Blue Book provides a range of BMPs for various activities and landforms and allows for enhanced controls to be implemented when working in sensitive catchments and challenging landforms. The Blue Book was developed in cooperation of NSW EPA and is referenced in Environment Protection Licences as the required guidance for major developments.

Given the Development Footprint is located at the very upper reaches some 46 km from Chaffey Dam, the implementation of enhanced erosion and sediment controls during construction and the incorporation of appropriate civil structures to allow ongoing flows to pass through Project infrastructure during operation, the Project will not have a material impact on Peel River and Chaffey Dam.

5.2 Runoff Management

Changes to the catchment runoff characteristics due to project activities primarily relate to upgrading existing access tracks and replacing open vegetated ground cover with hardstand (all weather) access tracks, crane pads and turbine footings as well as construction of sealed areas for the O&M building and a mix of sealed and gravel areas within the BESS and substation.

5.2.1 Construction

Section 5 of the Soils and Water Assessment (Appendix O of the EIS) provides a Conceptual Soil and Water Management Plan that details the proposed approach to water quality management during construction and subsequent site rehabilitation. Section 6 of the Assessment details recommended mitigation measures.

Mitigation measures in addition to those recommended in the Soil and Water Assessment include:

- the drainage design for hardstand and access track infrastructure will aim to direct runoff from all hardstands and access tracks to appropriate sediment control facilities such as sediment basins, grassed filter strips or swales to trap sediments and filtered off before being discharged (to appropriate vegetated areas or drainage lines);
- installation of geotextile silt fences (with sedimentation basins where appropriate) on all drainage lines from the site which are likely to receive runoff from disturbed areas;
- installation of appropriate sediment traps or sediment ponds near waterways to contain surface water contaminated with sediment runoff entering the waterway;
- procedures to ensure that steep batters are treated appropriately for sediment control;
- a process for overland flow management to prevent the concentration and diversion of water onto steep or erosion prone areas; and
- thorough visual inspections following significant rain events with a requirement for immediate remediation of localised erosion caused by runoff (within specified response times).

NPWS has identified two small catchments in the headwaters of Ben Halls Creek and Brayshaws Creek within the Ben Halls Gap National Park as sensitive waterways and require no sediment to drain to the National Parks. Schematic examples of potential runoff management at the Development Footprint are provided as Figure 5.2 and Figure 5.3.

The schematics confirm that in the vicinity of the Ben Halls Gap National Park, the Development Footprint design is primarily in cut, meaning that clean run-on from undisturbed areas can be diverted away from disturbed areas by catch drains/bunds (flow paths in aqua) to a stabilised discharge location (green dots), either to the south to the receiving watercourses and the National Park or to the north through stable structures to the small sub-catchments of the Peel River.

'Dirty' runoff from disturbed areas will be graded away where possible from the National Park catchment to collection drains (flow paths in blue) that convey flows via outlet water quality controls (blue dots). Where it is not possible to grade away, runoff from fill batters facing towards the National Park can be retained as sheet flows utilising vegetated filter strips or concentrated in collection drains diverted either via culverts beneath the access tracks to join the northern drainage network or to enhanced sediment controls prior to release.

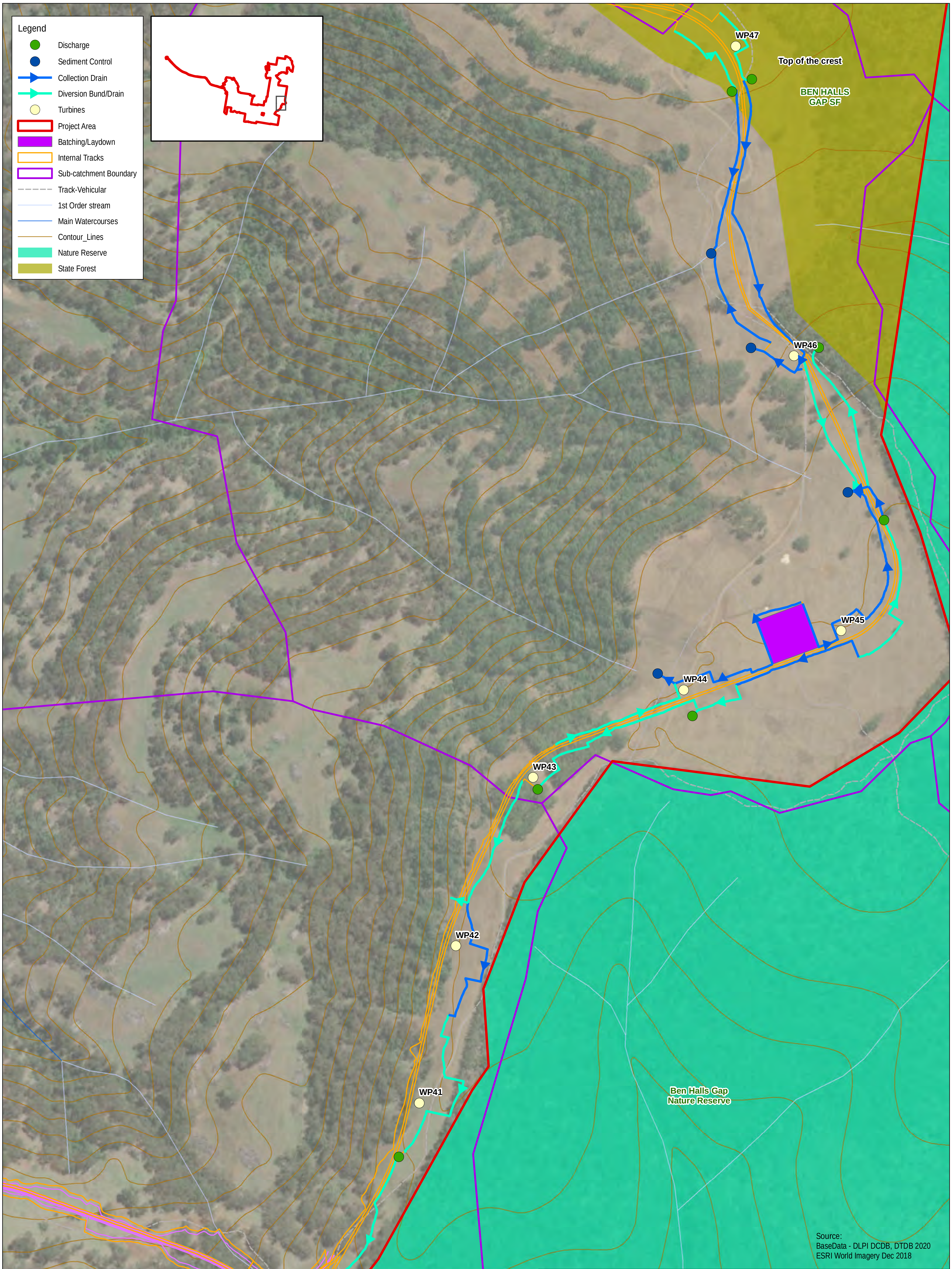
The separation of 'clean' and 'dirty' runoff is the first principle of best management practices in erosion and sediment control and minimises flows to be subject to water quality controls and will be implemented throughout the Project.

Mitigation measures will be included in site specific Erosion and Sediment Control Plans developed by an experienced CPESC.

5.2.2 Operation

Runoff from Project infrastructure will be at a higher velocity with less infiltration compared to existing conditions. However, this will be somewhat offset by the capture of runoff in rainwater tanks at the O&M building to provide supply for amenities and use of controls such as grass swales with regular rock checks in access track and other constructed drainage lines, level spreaders onto naturally vegetated areas at flow outlets to reduce velocities and encourage infiltration.

Engineered designed and constructed hardstand areas graded to perimeter drains have minimal available fine materials on surfaces and limited potential to erode and hence the potential to generate sediment. Erosion risk is primarily during construction when working on disturbed surfaces and constructing cut and fill batters prior to completion of permanent stabilising works. Erosion risk also continues after construction in concentrated flow paths such as access track drainage lines, however these can be managed using appropriate controls as noted above.



Runoff Infrastructure adjacent Ben Halls Gap Nature Reserve

F5-2

Drawing No:	0550690s_HoG_RtS_G009_R3.mxd		Hills of Gold Wind Farm Environmental Impact Statement
Date:	10/09/2021	Drawing Size: A3	
Drawn By:	VN	Reviewed By: AA	Client: Wind Energy Partner
Coordinate System: GDA 1994 MGA Zone 56			This figure may be based on third party data or data which has not been verified by ERM and it may not be to scale. Unless expressly agreed otherwise, this figure is intended as a guide only and ERM does not warrant its accuracy.

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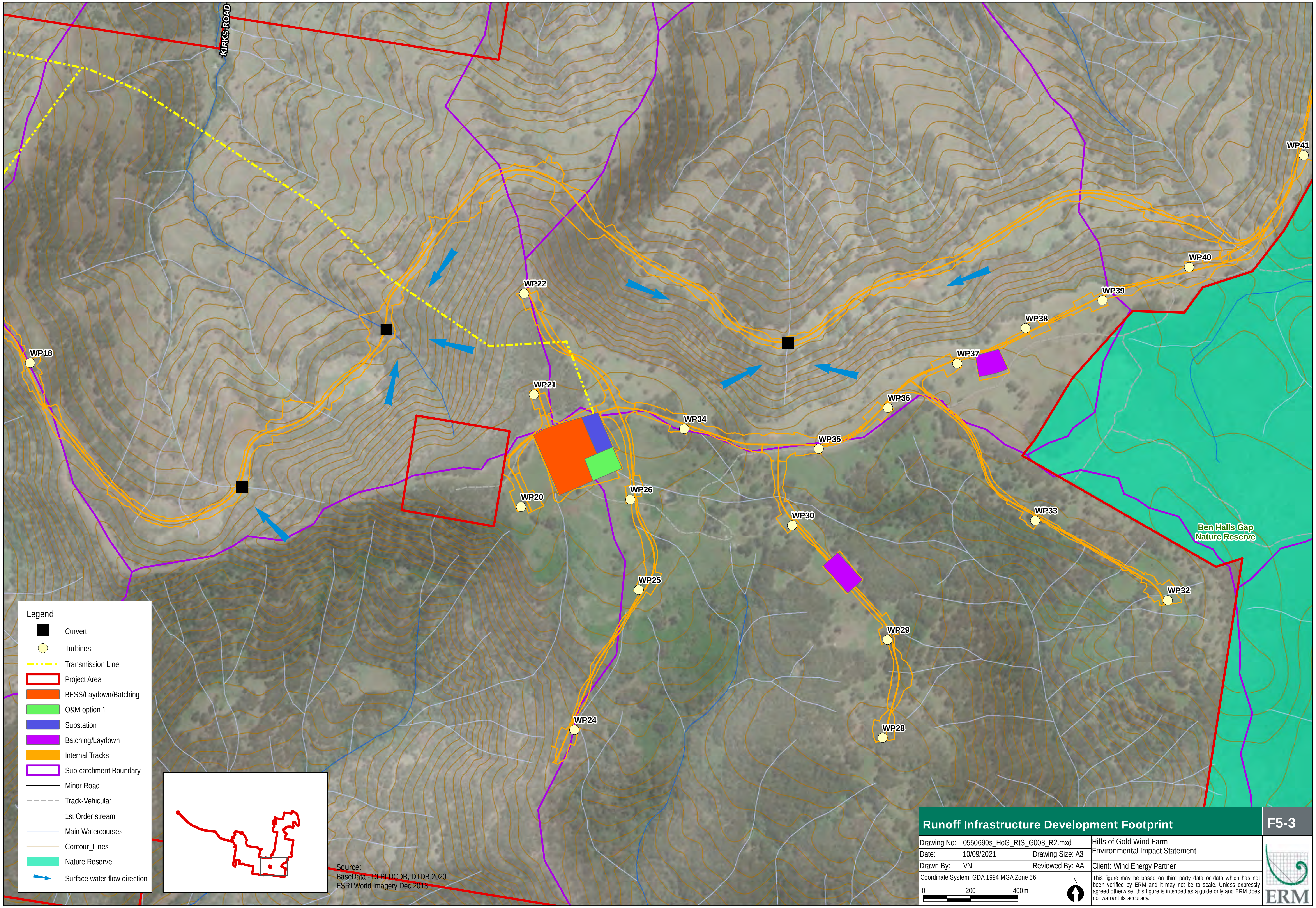

KIRKS ROAD
WP18
WP20
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WP34
WP35
WP36
WP37
WP38
WP39
WP40
WP41
Ben Halls Gap Nature Reserve
Legend
Curvert
Turbines
Transmission Line
Project Area
BESS/Laydown/Batching
O&M option 1
Substation
Batching/Laydown
Internal Tracks
Sub-catchment Boundary
Minor Road
Track-Vehicular
1st Order stream
Main Watercourses
Contour_Lines
Nature Reserve
Surface water flow direction
Source:
BaseData - DLPI DCDB, DTDB 2020
ESRI World Imagery Dec 2018
Runoff Infrastructure Development Footprint
F5-3
Drawing No: 0550690s_HoG_RtS_G008_R2.mxd
Date: 10/09/2021
Drawing Size: A3
Drawn By: VN
Reviewed By: AA
Hills of Gold Wind Farm
Environmental Impact Statement
Client: Wind Energy Partner
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5.3 Erosion Hazard and Assessment

Managing Urban Stormwater: Soils and Construction, Volume 1 (Landcom, 2004) provides guidance on appropriate erosion and sediment controls for various environments and challenges including for highly dispersive readily eroded subsoils derived from the Mount Royal Volcanics as confirmed by Emmerson Aggregate testing (Coffey Services, 2021) and where receiving environments are considered highly sensitive such as the adjacent Ben Halls Gap National Park.

As noted in Section 2.4.3, the site soils are highly erodible. The approach to managing such soils is to first confirm the erosion hazard at a specific site using the Revised Universal Soil Loss Equation (RUSLE). Based on the use of appropriately conservative Project site factors, updated erosion hazards based on a range of scenarios were estimated using the RUSLE, as provided in Appendix A. The RUSLE provides a quantitative estimation of erosion hazard based on five factors: rainfall erosivity; soil erodibility; slope length and gradient; soil cover and management practices. A detailed description of the RUSLE equation and its contributing factors is provided in Landcom (2004).

The majority of the Development Footprint's erosion hazard has been assessed as moderate based on disturbance of slopes averaging 15%. This is a consequence of relatively high rainfall erosivity, high soil erodibility and a moderate slope gradient at managed slope lengths where disturbance will occur on the longitudinal slopes of the ridgeline, which limit the generation of high velocity, erosive run-off.

The sensitivity analysis using a range of scenarios determined that flat areas of slopes less than 10% also have moderate erosion hazard class. Localised areas with steeper slopes (20%) were assessed in the high erosion hazard class and for the potential that some very localised areas along edges of the Development Footprint have slopes approaching 33% were assessed in the very high erosion hazard class.

Consequently, a standard suite of erosion and sediment controls may be widely employed throughout the majority of the Development Footprint, being moderate erosion hazard areas. Specialised techniques using enhanced control measures will be required in high and very high hazard areas, such as steep slopes and areas of concentrated flow. A CPESC will be engaged by the project during detailed design and particular attention to erosion control should be applied in these areas of the final Development Footprint.

6. UPDATED MITIGATION MEASURES

Section 6 of the Soils and Water Assessment, Appendix O of the Hills of Gold Windfarm EIS, provided mitigation measures that will be implemented to manage soils and water impacts. The studies incorporated into this addendum report have identified additional mitigation measures to further minimise Project impacts. Below provides updated details of soil and water mitigation measures to be implemented into the Project.

6.1.1 Design Mitigation Measures

During detailed design, turbine and infrastructure locations will be further refined to avoid the adjacent steeper slopes and areas of significant rocky outcrops. In addition, appropriate permanent cut batter slopes will be assessed on an individual basis with reference to cutting ground conditions. Benches will be implemented into areas of higher cut slopes or wherever deemed necessary for stability purposes.

An additional recommended mitigation measure includes earthwork batter design, as follows:

- For slopes 2H:1V or shallower, individual vertical batter heights may be up to 10 m;
- Minimum bench width of 4.5 m;
- The unreinforced slopes must be designed with the following long-term factor of safety ≥ 1.5;
- No temporary or permanent surcharges loads may be placed on batter crests; and
- Surface rainwater flows must also be diverted away from batter crests and faces.

If steeper, or relatively high batter slopes are required, then engineering design and support / stabilisation will be required. Permanent soil nailing and shotcrete support will be considered for such cases during detailed design.

Given the relatively steep and exposed nature of much of the Development Footprint, and assessed high dispersity/erodibility of site soils, detailed design will assess the need for the use of appropriate cut/fill batter protection and effective site surface water management and drainage techniques to prevent the mobilisation of sediments to natural water courses. This may include vegetation or shotcreting batter faces. Drainage design will aim to direct runoff from all hardstands, access tracks and Project infrastructure to appropriate sediment control facilities such as sediment basins, grassed filter strips or swales to trap sediments and filtered off before being discharged (to appropriate vegetated areas or drainage lines).

To minimise the ongoing maintenance any cut and fill slopes, batters will be vegetated with grass as soon as possible following construction, and be protected from overland surface water flows by the construction of appropriate permanent surface drainage measures.
Any exposed soil in stockpiles, temporary works or permanent works will require erosion protection such as covering, vegetation or a permanent capping, together with effective sediment control measures incorporated into the site drainage.

Runoff from fill batters facing towards the National Park can be retained as sheet flows utilising vegetated filter strips or concentrated in collection drains diverted either via culverts beneath the access tracks to join the northern drainage network or to enhanced sediment controls prior to release. To ensure that flows from the up-gradient catchment reach the Peel River culverts will be installed at key watercourse crossing points confirmed at the detailed design phase.

6.1.2 Construction Mitigation Measures

The following measures will be implemented to address potential soil and water impacts:

- undertake a further geotechnical study prior to construction commencement including soil characteristics to inform the development of appropriate erosion and sediment controls;

- prepare a detailed Soil and Water Management Plan (SWMP) prior to construction commencing, outlining measures for the management and monitoring of surface water quality and hydrology during construction. The plan would also address any requirements for the management of pollutants or contaminated lands during construction so as to minimise impacts to terrestrial and aquatic habitats. The SWMP should be prepared by a suitably qualified person, such as a soil conservationist;
- Progressive Erosion and Sediment Control Plans (PESCPs) within the SWMP as the Project progresses to address management requirements at individual work sites to be developed by an experienced CPESC;
- SWMP & PESCP will be prepared based on 'The Blue Book' (Landcom, 2004) utilising a range of BMPs for the various construction activities and landforms including the adoption of enhanced controls/higher level of protection for activities in sensitive catchments and challenging landforms such as increased capacity of controls, shortening lengths between controls and use of soil binders and other proprietary products;
- design and construct the Project to minimise land disturbance and therefore reduce the erosion hazard;
- stage construction activities to minimise the duration and extent of land disturbance;
- manage topsoil resources to minimise the risk of erosion and sedimentation, and maximise reuse of topsoil during rehabilitation;
- divert upslope (clean) stormwater around the disturbed sites and capture sediment-laden run-off from within the disturbed site for diversion to sediment control devices;
- installation of geotextile silt fences (with sedimentation basins where appropriate) on all drainage lines from the site which are likely to receive runoff from disturbed areas;
- installation of appropriate sediment traps or sediment ponds near waterways to contain surface water contaminated with sediment runoff entering the waterway;
- procedures to ensure that steep batters are treated appropriately for sediment control;
- a process for overland flow management to prevent the concentration and diversion of water onto steep or erosion prone areas;
- rehabilitate the site promptly and progressively as works progress;
- inspect and maintain erosion and sediment control devices for the duration of the Project construction stage including thorough visual inspections following significant rain events with a requirement for immediate remediation of localised erosion caused by runoff (within specified response times);
- avoid land disturbance beyond that identified in the assessment within 20 m of minor streams (first and second order watercourses) and 40 m of third order or higher watercourses;
- ensure appropriate procedures are in place for the transport, storage and handling of fuels, oils and other hazardous substances, including availability of spill clean-up kits;
- construct required access tracks at any early stage to minimises disturbance during construction;
- obtain all necessary water access licences; and
- ensure appropriate stormwater, collection, treatment and recycling at the concrete batch plant, in accordance with good practice and any requirements of the NSW Environmental Protection Authority.

6.1.3 Sensitive Areas Mitigation Measures

The Ben Halls Gap Nature Reserve is located adjacent to the Project Area, immediately to the east of the ridgeline. In portions of the National Park, a rare moss has been identified as requiring additional consideration to ensure activities associated with the Project do not impact on the integrity of the rare moss. The primary risk to impact upon the "sensitive location" is associated with runoff and sediment deposits.

Additional measures are able to be effectively implemented to appropriately mitigate impacts associated with the identified sensitive location in the adjacent National Park. Measures are to be included in the progressive ESCP to either;

- direct disturbed runoff away from the catchment area identified to contain the sensitive location; or
- process runoff through additional sediment controls (e.g. sumps and/or sediment basins) and discharge at a low, non-erosive velocity.

A monthly water quality monitoring program will be developed in consultation with NPWS for the two sensitive receiving waters. The monitoring program will include trigger parameters that can be measured insitu such as pH and turbidity along with visual observations for hydrocarbons. Monitoring would be undertaken during dry periods and post rainfall.

These measures are to be included in any environmental management plans to be implemented across the site, to protect the identified sensitive locations.

7. CONCLUSION

The Project is located along the upper ridgeline that is exposed to prevailing wind directions. These ridgelines and plateaus are flanked in most directions by very steep and rugged terrain. The majority of the Development Footprint is used for grazing operations. By their very nature, wind farms are located at high elevations typically along ridgelines and hill tops. A number of constructed NSW wind farms incorporate some narrow ridgelines in their development, including Sapphire, White Rock, Crudine Ridge and Cullerin Range wind farms.

In order to respond to comments received following the exhibition of the EIS primarily concerned with the appropriateness of information currently available regarding the site ground and hydrology conditions and the overall suitability of the proposed site for the location of a wind farm, Coffey (2021) undertook a geotechnical and geophysical investigation in February 2021 to obtain information on ground conditions across the Development Footprint and comprised:

- Desktop review of available site/regional information;
- Intrusive geotechnical investigation comprising the drilling of 8 boreholes and excavation of 22 test pits together with geotechnical index testing of selected recovered soils and rock samples; and
- Initial site geophysical investigations including Land Seismic Refraction (LSR), Multichannel Analysis of Surface Wave (MASW) and Earth Resistivity Testing (ERT).

Overall, it was found that the ridgeline of turbines and access tracks is characterised by highly variable soil depths which are typically silty or clayey, medium to high plasticity, with high to very high strength basaltic cobbles and corestones. The soils also display frequent cracking and rutting. Cuttings and excavation activities on the site indicate that the bedrock consists of a variable weathered zone, very low to low strength basalt with high strength bands. Distinct beds of siltstone and sandstone were also observed in the investigation.

In addition, site observations confirmed there was no indication of shallow groundwater. Borehole drilling and excavation found water level in two standpipes, with piesometric head recorded at 4.06 m bgl and 12.43 m bgl. Additional detailed investigation and site assessment will be undertaken if it is deemed necessary that a sustained groundwater supply is required for the purposes of construction.

A slope analysis prepared using ArcGIS software (refer Figure 3.1 and Figure 3.2) confirms that the majority of the Development Footprint which follows the top of the cleared ridgeline generally has slopes from 0-20 %, mainly falling in LSC Slope Classes 3, 4 and 5, with some sections of access tracks with longitudinal slopes or batters within steeper areas. The Development Footprint avoids the steeper upper slopes to the ridgeline of 33 to >50 %. The Transverse Track generally follows existing topographic contours at the base of these steep upper slopes on slopes of generally 10-33 % with some sections crossing steeper sections of >33 %. No turbines are located in slopes above 33 %.

It should be noted that the LSC scheme provides guidance only on the physical capability of the land to support different agricultural land uses at a regional level. Nevertheless, Table 4-1, the LSC class descriptions including photographic examples, site based investigations, current land use, and geotechnical assessments confirms that the overall Development Footprint at the Wind Farm site does not meet the data requirements for LSC Class 7 or Class 8, which are generally land that is incapable for agricultural land use.

The historical grazing land use on dense groundcover across the Development Footprint confirms the land is capable for land uses such as grazing and forestry.

The Development Footprint is primarily located along the top of a ridgeline that is bounded by three major river catchments. The majority of the Development Footprint is within the headwaters of the Peel River catchment which flows to Chaffey Dam. The Development Footprint covers a small proportion of the total Chaffey Dam catchment and through detailed design of access track, hardstand and project infrastructure drainage there will be negligible change to received inflow volumes at Chaffey Dam.

Whilst the soils have been assessed as having high erodibility, based on the RUSLE assessment in Appendix A, the erosion hazard for the majority of the Development Footprint has been assessed as moderate as a consequence of relatively high rainfall erosivity, high soil erodibility and a moderate slope gradient where disturbance will occur on the longitudinal slopes of the ridgeline, which limit the generation of high velocity, erosive run-off. Localised areas of greater erosion hazard will exist, for example where steeper slopes occur and in areas of concentrated water flow, such as along watercourses and table drains. Consequently, a standard suite of erosion and sediment controls may be widely employed. Specialised techniques using enhanced control measures will be required in high and very high hazard areas, such as steep slopes and areas of concentrated flow, if further refinement of the Development Footprint through detailed design cannot avoid these areas.

The additional studies and results provided in this addendum report recommend a suite of measures to be incorporated into the detailed design to address site conditions including works on the steeper portions of the Development Footprint. The slope analysis and updated RUSLE calculations confirm a range of erosion hazards exist across the Development Footprint; however, these fall within the guidance and recommended management measures in ‘The Blue Book’ (Landcom, 2004) which is referenced in NSW EPA Environment Protection Licences (EPL). The Hills of Gold Wind Farm will be subject to the requirements of an EPL.

8. REFERENCES

Coffey Services. (2021). *Hills of Gold Windfarm: Preliminary Geotechnical & Geophysical Interpretive Report.* Chatswood, NSW: Prepared for Hills of Gold Windfarm Pty Ltd.

Environmental Geosurveys Pty Ltd. (2021). *Geomorphology and Geology & Potential Microbat Roosting Habitat.*

ERM. (2021). *Hills of Gold Wind Farm: Response to Submissions.*

Hutchinson, M. H. (2002). *ANUCLIM, Version 1.6.* Canbrra: ANU.

Landcom. (2004). *Managing Urban Stormwater: Soils and construction (Blue Book) - Volume 1, 4th Edition.* NSW Government. Retrieved from https://www.environment.nsw.gov.au/research-and-publications/publications-search/managing-urban-stormwater-soils-and-construction-volume-1-4th-editon

OEH. (2012). *The Land and Soil Capability Assessment Scheme.* Sydney, NSW: State of NSW and Office of Environment and Heritage . Retrieved from https://www.environment.nsw.gov.au/-/media/OEH/Corporate-Site/Documents/Land-and-soil/land-soil-capability-assessment-scheme-120394.pdf

APPENDIX A UPDATED EROSION HAZARD ASSESSMENT

A.1 REVISED UNIVERSAL SOIL LOSS EQUATION

Managing Urban Stormwater: Soils and Construction, Volume 1 (Landcom 2004) describes a method for assessing erosion hazard using the revised universal soil loss equation (RUSLE). The RUSLE is designed to predict the long-term, average, annual soil loss from sheet and rill erosion at nominated sites under specified management conditions. It is used to assess erosion hazard at construction sites and estimate sediment flux to sediment traps.

The RUSLE equation is represented by:

A = R K LS P C

where,

A = computed soil loss (tonnes/ha/yr)

R = rainfall erosivity factor

K = soil erodibility factor

LS = slope length/gradient factor

P = erosion control practice factor

C = ground cover and management factor.

R-Factor

The rainfall erosivity factor, *R*, is a measure of the ability of rainfall to cause erosion. It is the product of two components; total energy (E) and maximum 30 minute intensity for each storm (I_{30}). Rosewell and Turner (1992) identified a strong correlation between the R-factor and the 2-year ARI, 6-hour storm event (denoted S) and proposed the following equation:

$R = 164.74\ (1.1177)^{S}\ S^{0.6444}$

Where S = 9.36 mm/h.

The IFD chart for the location of Hills of Gold confirms S = 7.49 mm/h. A submission in response to the EIS identified modelled rainfall of 865 – 1150 ML/ha of the Nundle/Hanging Rock region, peaking along the ridgeline of the Project Area, using output from ANUCLIM ((Hutchinson, 2002)). This model appears to not be publically available and the modelled output appears to be an annual rainfall depth and is not related to R-Factor, which utilises rainfall intensity for a specified rainfall event (2-year ARI, 6-hour). Nevertheless to conservatively allow for potential increased rainfall intensity due to localised topographical factors the IFD based value has been increased by 25%.

Using the above conservative value for S = 9.36 mm/h at Hills of Gold Wind Farm **R = 1,980.**

K-Factor

The soil erodibility factor, K, is a measure of the susceptibility of soil particles to detachment and transport by rainfall and run-off. Texture is the principle component affecting K, but structure, organic matter and permeability also contribute. In the RUSLE, it is a quantitative value that is normally experimentally determined.

Soil K-factor data was estimated with reference to the soil descriptions provided in Coffey Sciences (2021) and soil landscape tables in Appendix C of Landcom (2004). Review of the soil landscapes and the erodibility of the topsoil and subsoils allowed for the estimate of the average erodibility to be high-very high and thus a conservative estimate for the K-factor of 0.06 is considered appropriate. Generally, K-factor ranges from 0.005 (very low) to 0.075 (very high) (Landcom 2004).

Therefore, **K = 0.06**.

LS-Factor

The slope length-gradient factor, LS, describes the combined effect of slope length and slope gradient on soil loss. It is the ratio of soil loss per unit area at any particular site to the corresponding loss from a specific experimental plot of known length and gradient. The LS factor can be read from Table AI in Landcom (2004). It should be noted that an increase in slope gradient has a proportionately greater effect on LS, compared with an increase in slope length.

The Project Area has variable gradients: generally, the Development Footprint is on slopes at about <10-20%, with the majority of the remainder on steeper slopes to 33%. Actual turbine locations are commonly on gently sloping with gradients less than 20 %. Slope lengths in disturbed areas would be typically less than 80 m. Under the combination of 80 m slope length and 10 % gradient the LS Factor is 2.81. On steeper slopes it is assumed that slope lengths would be kept shorter through the use of appropriate stormwater controls. Under the combination of 40 m slope length and 15 % gradient the **LS Factor is 3.05; at 20% is 4.32; and at 33 % is 7.305.**

P-Factor

The erosion control practice factor, P, is the ratio of soil loss with a nominated surface condition ploughed up and down the slope. It is reduced by practices that reduce both the velocity of run-off and the tendency of run-off to flow directly downhill. At construction and mining sites, it reflects the roughening or smoothing of the soil surface by machinery. The **P-factor used here is 1.3** that is normally assigned to compacted and smooth construction sites and is worst case where no roughening of surfaces has occurred.

C-Factor

The cover factor, C, is the ratio of soil loss from land under specified crop or mulch conditions to the corresponding loss from continuously tilled, bare soil. The most effective method of reducing the C-factor is maintenance, or formation of a good ground cover. The best practices are those that reduce both the amount of soil exposed to raindrop impact and the erosive effects of run-off.

The C-factor assigned here during mining operations is 1.0, typical of that for bare, compacted soil. Table A3 in Landcom (2004) provides estimated C-factors for various cover types. It is worth noting that the C-factor is the factor that can be most readily manipulated to affect a change in erosion hazard. For example, changing the soil surface from a condition of bare, compacted earth (C = 1.0) to one with 70% cover of grasses (C = 0.05) leads to a proportionate reduction in soil loss, i.e. 20 times lower erosion hazard. Other temporary erosion controls such as use of chemical soil binders also significantly reduce the C-factor and hence the use of 1.0 is worst case.

C-Factor = 1.0

A.2 PREDICTED SOIL LOSS

Much of the Development Footprint has slopes in the 0-20 % range. The predicted soil loss for the majority of the Project has been calculated for 15 % with slope lengths managed at 40 m, providing the following soil loss prediction:

A = R K LS P C where:

R = 1,980

K = 0.06

LS = 3.05

P = 1.3

C = 1.0

Therefore, A = 471 tonnes per hectare per year.

Using the RUSLE, using this worst case scenario the predicted annual soil loss is 471 tonnes/hectare/year under the combination of 40 m slope length and 15 % gradient. This is Soil Loss Class 4 (351 to 500 tonnes/ha/yr) which is rated moderate (refer Table 4.2 in Landcom 2004).

A sensitivity analysis based on the combinations of 80 m slope length and 10 % gradient; 40 m slope and 20% gradient; and 40 m slope and 33% gradient predicted annual soil loss of 434 tonnes/hectare/year - Soil Loss Class 4 (moderate); 667 tonnes/hectare/year - Soil Class 5 (high); and 1,128 tonnes/hectare/year - Soil Class 6 (very high), respectively.

Based on this assessment, it is concluded that the overall site erosion hazard will vary across the site. The majority of the Development Footprint has been assessed as moderate erosion hazard class, with steeper areas in the high erosion hazard class and possibly on very localised areas into the very high erosion hazard class. Consequently, a standard suite of erosion and sediment controls may be widely employed. Specialised techniques using enhanced control measures will be required in high and very high hazard areas, such as steep slopes and areas of concentrated flow.

APPENDIX B CROSS REFERENCE TO SUBMISSION COMMENTS

Reference No.	Theme	Comment	Reference
HOGPI_1	**Soil and Water**	Redo Soil and Water Assessment based on correct Land and Soil Capability mapping, paying particular attention to Class 8 soil, high erosion and mass movement risk.	Section 4, Appendix A
HOGPI_1		Conduct on site soil survey and use results in modelling of erosion hazards.	Section 2, Appendix A
HOGPI_1		Use Hanging Rock rainfall modelling (up to 50% higher than Nundle Post Office) and use figures to inform runoff and erosion mitigation.	Appendix A
HOGPI_1		Address potential for moving soil and water-based pathogens between sites (including Ben Halls Gap Nature Reserve).	Section 5
HOGPI_1		Incorporate wash down facilities to avoid contamination or rare and endangered flora and fauna, weed spread and fungus movement affecting frogs.	Refer RtS Report
HOGPI_1		Address potential impacts of flooding, particularly on floodplain crossings needed for heavy transport vehicles.	Refer RtS Report
HOGPI_1		Take into account the gradient of the site in engineering of road realignment, internal access roads, wind turbine and associated infrastructure construction.	Section 5
HOGPI_1		Modify wind turbine and site layout based on high erosion and mass movement risk.	Section 5 and refer Amendment and RtS Reports
HOGPI_1		Incorporate Class 8 soil high erosion and mass movement risk implications for road and wind turbine, and other infrastructure, into Capital Investment Value Report.	The CIV valuation has been prepared by a Quantity Surveyor in accordance with the requirements of the E&A Act.
HOGPI_19		A thorough Hydrological and Geotechnical Analysis (on ground study) to determine the potential impact on groundwater flow.	Refer RtS Report
HOGPI_20		Determine potential impact on Tamworth water supply & Hunter / Manning catchments.	Refer RtS Report
HOGPI_21		To insist on a thorough investigation into potential impacts on surface and groundwater flows into the Peel River, as people rely on springs for domestic and stock water.	Section 5 and refer RtS Report
HOGPI_22		Note that in the EIS flooding has not been covered at all.	Refer RtS Report
HOGPI_23		Include hardstands and compacted surfaces such as internal access roads in runoff modelling and mitigation.	Section 5

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