APPENDIX 23

Sapphire Wind Farm Soils Assessment

Eco Logical Australia Pty Ltd

SAPPHIRE WIND FARM

Soils Assessment

Prepared for
Wind Prospect CWP

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Soil and Erosion Assessment

This report provides a desktop soils assessment for the Sapphire Wind Farm Proposal. This assessment describes the soil and geological landscapes of the study area to identify and address potential issues arising from the project and any soil erosion concerns.

1 Regulatory Context

The regulatory context for soil management in NSW is provided in the *Water Management Act 2000* (WM Act) and the *Protection of the Environment Operations Act 1997* (POEO Act).

Standard soil and related water quality objectives for development sites as they relate to the above typically include:

- No pollution of waters (s120 of the POEO Act);
- Revegetation of all areas disturbed during construction;
- All activities to be carried out with due diligence, duty of care and according to best management practices;
- Environmental assessment to describe measures to control erosion and sedimentation;
- All personnel should be made aware of their responsibilities in this regard; and,
- Application of the guideline: *Managing Urban Stormwater: Soils and Construction, 4th Edition* (Landcom 2004) commonly referred to as the "Blue Book".

This soils assessment provides the technical basis to identify and address any sedimentation and erosion impacts related to the proposal.

2 Methodology

This assessment was conducted using:

- A desktop assessment and review of published soils and geology data and reports;
- GIS mapping of existing mapping relevant to soil associations in the proposed wind farm area; and,
- Linking soil characteristics to erosion potential and mitigation measures.

3 Existing Environment

3.1 LANDSCAPE AND TOPOGRAPHY

The Sapphire proposal is located along the spines of the ridges within the Kings Plains district of the northern New England Tableland. The turbines extend over a 10km span north-south and 15km span east-west. The landscape is a basin dominated by undulating to steep hills in the eastern, southern and western sections, and Kings Plains nestled between these ridge-lines and heading north. The locality is of moderate to high elevation (750 to 1100 metres above sea level; Australian Height Datum). The individual turbine positions are located on land with elevations ranging from approximately 750m to 1,100m AHD.

Slopes within the study area range from high (>30%) along the ridges of the southern portion of the proposal, down to gently undulating and rolling slopes (Figure 1).

Mitchell Landscapes mapping (DECCW 2008) shows that the study area is located predominantly on Glen Innes – Guyra Basalts. Small sections of the proposal (very northern and western extents) lie on the Inverell Plateau Granites and the Ashford Mole Valleys (Figure 2).

The Glen Innes – Guyra Basalts landscapes are a typically undulating to stepped hilly plateau with broad ridges, wide shallow valleys and high rounded peaks on Tertiary basalt, with a general elevation ranging from 700 to 1510m. Soils on slopes are generally brown structured stony loam and clay loam, while occasional red structured loam with gradational profiles and deep dark self-mulching sticky clays are found on the valley floors (DECC 2002).

A small section on the northern and western arms of the proposal lie on the Inverell Plateau Granites, described as undulating plateaus with domed peaks on Permian New England granites and granodiorites (DECC 2002). Shallow gritty loam is found at high elevations within the unit, which thickens to red or yellow earthy sand and red, red-yellow and yellow texture-contrast soil on the lower slopes and valley floors. A small portion of the western extent of the proposal extends onto the Ashford Mole Valleys Mitchell Landscape, which is characterised by wide valleys and low rolling hills with rock outcrops on upper slopes.

A number of small creeks and gullies drain the ridges of the project site. Drainage to the south is via Swan Brook into the Macintyre River. The east, north and west drain into the Seven River catchment via one of five creeks; Kings Plains Creek, Spring Valley, Frazers Creek, Horse Gully and Wellingrove Creek. The Severn River is a principal tributary of the Macintyre River in the Border Rivers Basin. The Macintyre River forms part of the headwaters of the Barwon River.

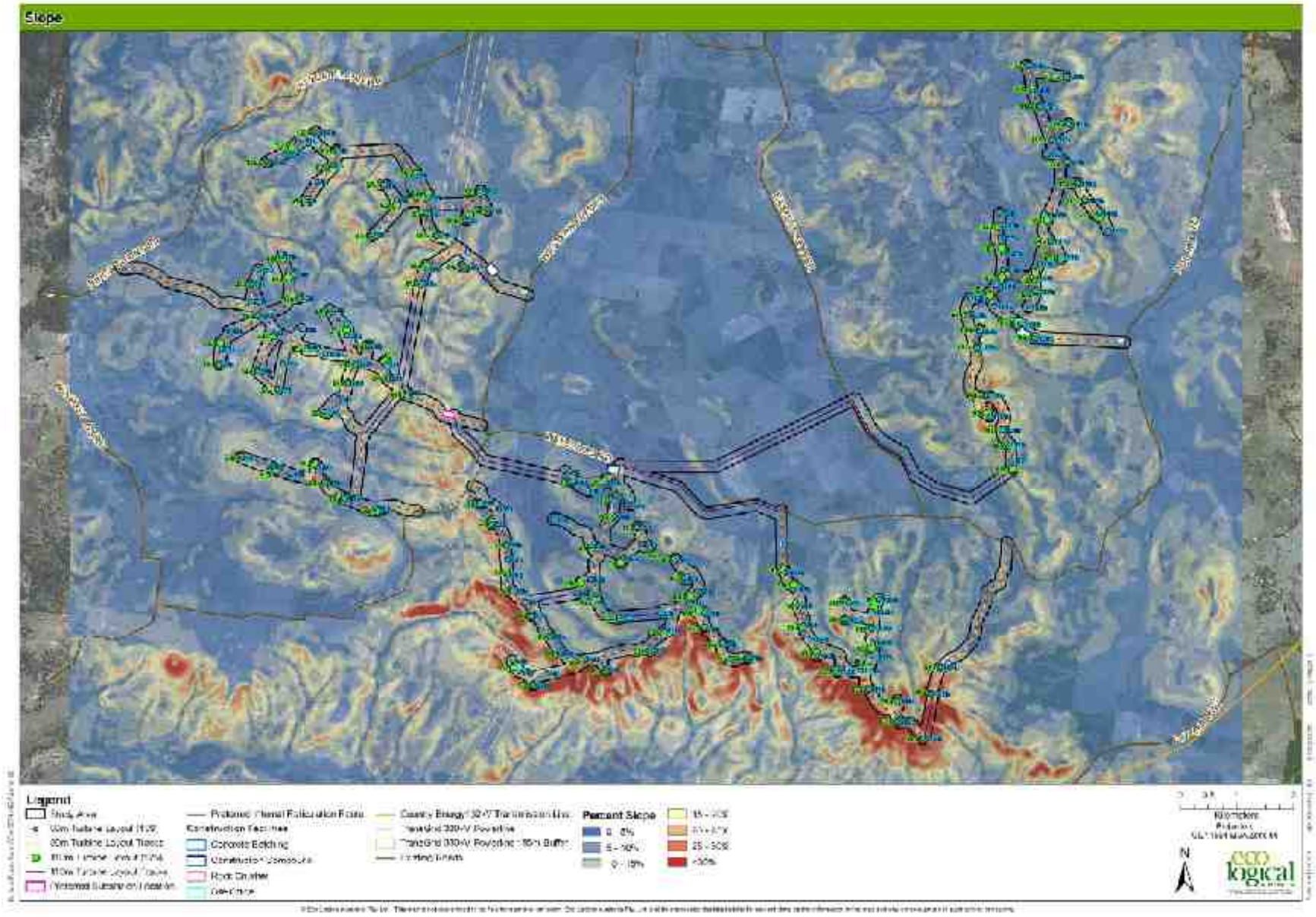

Figure 1: Slopes of the project area

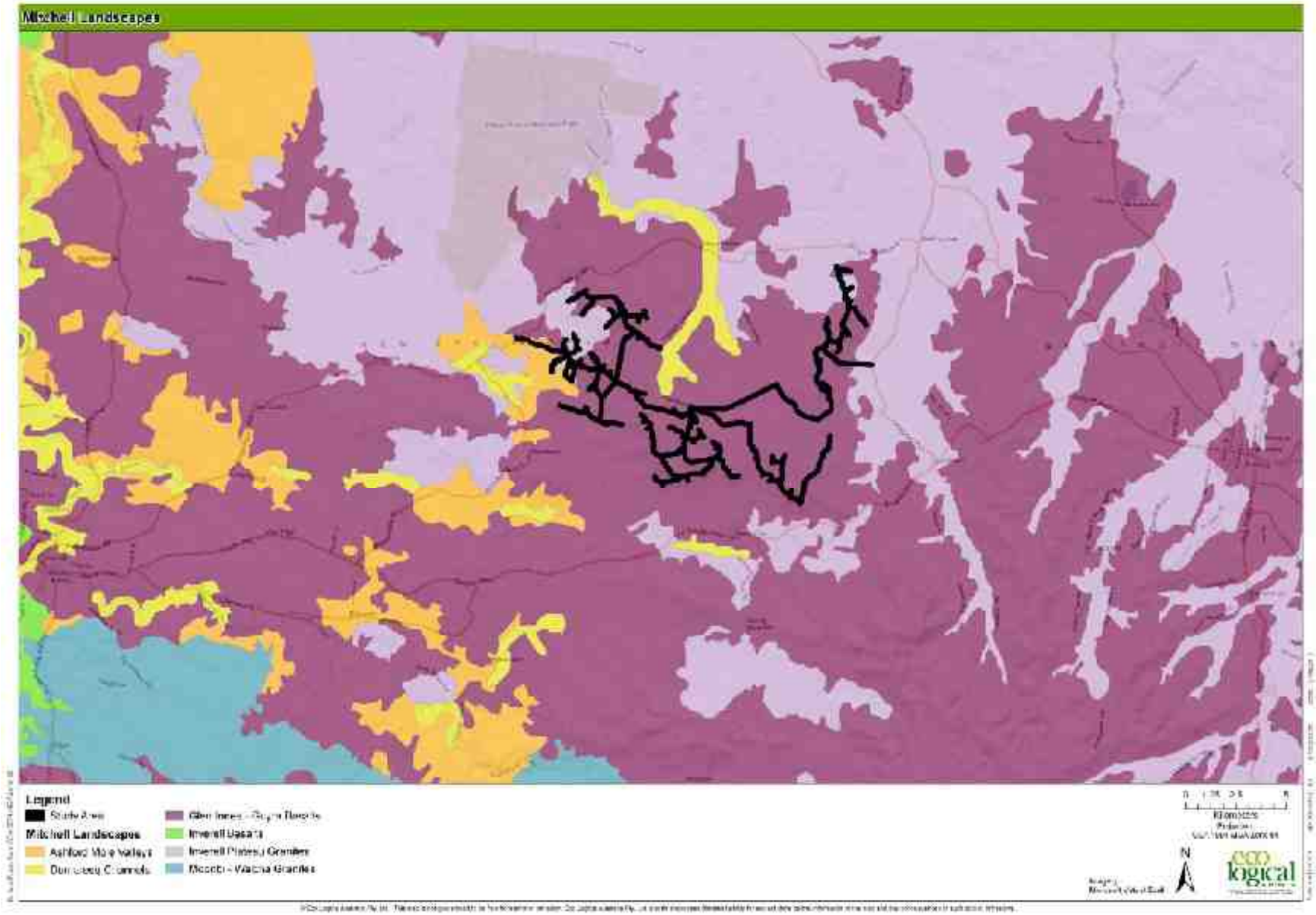

Figure 2: Mitchell Landscapes of the project area

The waterways within the locality are typified by low-flows and dry creek-beds. Some farm dams occur within the locality. The development area is mostly confined to the ridges of the locality with limited direct impact on waterways.

3.2 GEOLOGY

The study site is within a geological domain that comprises a large area of tertiary basalts (Lea et al. 1977a). Alluvial sediments are present along water courses in the valleys. Outcrops of Palaeozoic Volcanics (granite) can also be found. The key geological unit that underlies the study site is an unnamed unit of Basalt Flows (Figure 3), with a small area underlain by Emmaville Volcanics in the north and west (Mineral Resources NSW 2003). While Emmaville Volcanics have a minor distribution within the study area (Sapphire Cluster and Wellingrove Cluster only), it is the dominant geological unit of the area that boarders the northern and western portions. An unnamed unit (comprised of Quaternary alluvial, residual or colluvial deposits of sand, silt, clay and gravel) is found in the central portion of the Swan Vale Cluster, and extends northward along the Kings Plains Creek.

3.3 SOILS

No recent soil landscape mapping has been published for the Glen Innes locality (personal communication with DECCW, 14 March 2011). Soil characteristics provided here for the project site are based on soil mapping published in the 1970s (Lea et al. 1977a; Lea et al. 1977b).

A generalized map of soil associations (using the earlier Great Soil Groups classification) was reviewed in an attempt to determine dominant soil/s of the project area. Historical soils mapping shows Chocolate-Prairie soils are found on the upper slopes of the eastern portion of the study area, while Black Earth-Euchrozem soils make up the western portion. Black Earth-Prairie soils are mapped along the valleys and major drainage lines (mainly Kings Plains Creek, Wellingrove Creek and Swan Brook). Based on visual observations of the study study and review of literature, chocolate-prairie soils are the dominant soils of the project area.

Key characteristics of these soil landscapes are provided in are provided in Table 1.

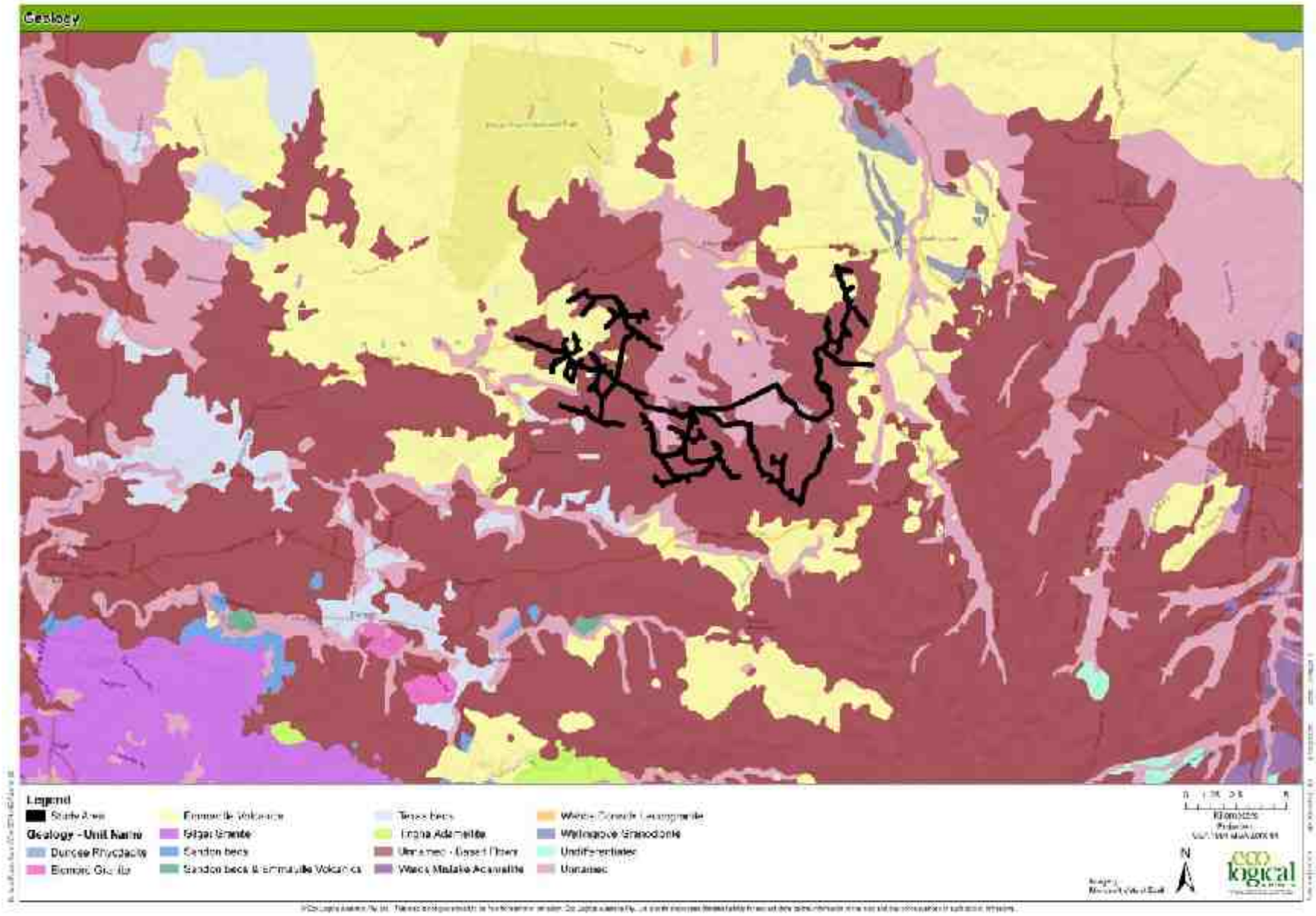

Figure 3: Geology of the project area

Table 1: Soil association characteristics*

Great Soil Group	Rock Type	Characteristics	Australian Soil Classification	Erosion Potential#
Chocolate - Prairie soils	Basalt	Chocolate soils - Red/Chocolate in colour; shallow on ridges and upper slopes (<1m); clay content increases with depth; surface soils usually clay loams or silty clay loams to light clays	Chocolate - Dermosols	Moderate to high depending on slope and groundcover
		Prairie soils - found on lower colluvial slopes and valley drainage lines; typically deeper with higher organic matter content; clay loam-clay texture	Prairie – Dermosols	Moderate to high depending on slope and groundcover
Black earth-prairie soils	Basalt	Found in valley plains where basalt makes up large portion of the watershed; typically well drained; uniform texture and cracking characteristics.	Black earth - Vertosols Prairie - Dermosols	Low; although this potential increases on cleared slopes
Black Earth-Euchrozem soils	Basalt	Euchrozems - are typically red and moderately deep (1-2m)	Euchrozems - Dermosols	Low to moderate depending on slope and groundcover
		Black earth - Chocolate soils are a more common association than black earths around Wellingrove; typically more friable; uniform profile	Chocolate/Black earth – Dermosol/Vertosol	Low to moderate (increasing particularly on cleared slopes)

* As mapped by Lea et al.1977a

based on Australian Soil Classifications – general soil characteristics

4 Assessment

The dominant soil associations of the proposed site are generally stable when in a natural condition (vegetation and uncultivated). Vegetation clearing will take place during construction, and further soil disturbance may result from activities such as the creation of access tracks, reticulation trenching, foundation construction, ancillary works and vehicle movement.

This section of the report addresses soil and water management principles as they are identified in the 'Blue Book' (Landcom 2004). This section of the report does not take the place of a detailed Soil and Water Management Plan (SWMP) or Erosion and Sediment Control Plan.

4.1.1 Rainfall Erosivity

Rainfall Erosivity (also called the R-Factor) is a measure of the ability of rainfall to cause erosion, and is calculated based on total energy and maximum 30 minute storm intensity (Landcom 2004).

The Rainfall Erosivity for the proposed wind farm is approximately 1,700 – 1,800 based on *Map 3: Rainfall Erosivity of the Grafton 1: 250,000 Topographic Sheet in Appendix B* of the 'Blue Book' (Landcom 2004). The R-Factor varies between 600 in parts of western NSW to over 10,000 on the far north coast of NSW. Given this range the Rainfall Erosivity for the site can be considered low.

Monthly mean rainfall data collected by the Bureau of Meteorology from Glen Innes Agricultural Research Station (Station No. 056013) and Inverell Research Station (Station No. 056018) recorded the highest levels of rainfall in Disremember through to February. Consideration may be given to higher rainfall months in planning of construction schedules.

4.1.2 Soil Erodibility and Dispersibility

Table 1 above indicates the erodibility of the soils based on soil types. The Revised Universal Soil Loss Equation, a tool used to predict the long term, average annual soil loss under specified management conditions (Landcom 2004), includes a soil erodibility factor (also called the K-Factor). The K-factor is a measure of the susceptibility of individual soil particles to detach and be transported by rainfall and runoff (Landcom 2004). While soil texture is the primary driver of the K-factor, soil structure and organic matter also influence the value. The K-Factors generally ranges from 0.005 (very low) to 0.075 (very high) (Landcom 2004).

Due to the lack of published and current mapping of soil landscape information for the study site, it is recommended that the K-Factor be derived from site specific laboratory data (such as particle size distribution and Atterberg Limits). Emerson aggregate and dispersion percentage testing should also be undertaken. Samples from each of the major soil landscapes should be collected and analysed as part of the geotechnical assessment proposed for footing design.

4.1.3 Soil Erosion Hazard

Soil erosion hazard refers to the susceptibility of a parcel of land to the prevailing agents of erosion and is typically described as high or low erosion hazard (Landcom 2004). Sites with high erosion hazard may require control measures beyond the normal suite of erosion control measures applied to construction sites.

The gradient of the slopes on site range from gently undulating and rolling hills to steep gullies associated with the primary waterways in the area. The slope characteristics of each soil landscape have been summarised in Table 2, to the extent of available information.

Table 2: Soil landscape units – slope characteristics

Soil Landscape	Erosion Potential	Slope Range (%)
Chocolate-prairie soils	Moderate to high depending on slope and groundcover	5-30%
Black earth-prairie soils	Low; although this potential increases on cleared slopes	5-30%
Black earth-euchrozem soils	Low to moderate depending on slope and groundcover	<5%

Based on the above information, including the R-Factor (1,700 to 1,800) and upper slope gradient of >30%, the predominant soil association (chocolate-prairie soils) and Black earth-prairie soils) is classified as having a potentially high erosion hazard when assessed against Figure 4.6 of the 'Blue Book'. If the slope of the work sites is less than around 12% (i.e. approximately 1(V):8(H)) then the potential erosion hazard is low.

Land with slopes greater than around 30% are likely to be affected by soil erosion and land degradation if subjected to inappropriate clearing and activities. The development area encompasses areas with steep gradients, particularly in drainage valleys and along the southern portion, although work sites are mostly confined to the ridges of the locality with limited direct impact on waterways. The works within steep gradient land and/or highly erosive soil types will be managed during construction and operations and is addressed elsewhere in this report.

4.1.4 Expansion or Reactive Soils

Most soils will shrink or swell depending on changes in their moisture content. Soils that shrink significantly are called expansive or reactive soils and may be problematic in structures such as sediment basins and roads (Landcom 2004). Chocolate, prairie and black soils all typically exhibit shrink-swell properties (or 'cracking') to varying degrees. Laboratory testing of soil samples should also include the measure of surface movement potential (such linear shrinkage and volume expansion) and should be considered both in subsequent design and the during the development of a site specific Soil and Water Management Plan (SWMP) that includes measures to address soil and water management.

4.1.5 Depth to Watertable

The design of erosion and sediment controls may be influenced by the presence of watertables near the surface, whether seasonal or permanent (Landcom 2004). The SWMP should consider scheduling in relation to seasonal fluctuations for access road construction and footings. Further investigations regarding local groundwater elevation forms part of the Riparian Assessment.

4.1.6 Salinity

Salt accumulation in soils can have adverse impacts on developments including damage to building foundations, breaking up of road pavements and corrosion of underground pipes and services (Landcom 2004). Desktop assessment indicates that the site's soils are well drained and not at risk of salt accumulation.

4.1.7 Acid Sulphate Soils

Acid Sulphate Soils when exposed to air can release sulphuric acid, which is harmful to human and fauna health. Acid Sulphate Soils are typically associated with low lying coastal areas and are not expected to be present within the proposed wind farm site.

4.1.8 Soil Contamination/ Toxicities/ Pollution in Soils

Exposure to contaminated soils presents a health risk to construction personnel, landowners and site visitors. At the time of preparation of this risk analysis no assessment of contaminated soils had been undertaken for the proposed site. Potentially contaminating activities associated with agricultural activities include sheep dips, import of fill material, demolition of old buildings and stockpiling of wastes.

Wind Prospect should seek information from landowners regarding details of known areas of potential land contamination based on current and past activities and review against the proposed site layout. Additional soil investigations to contamination levels may be required; alternatively the relocation of facilities, roads or other infrastructure may be necessary.

4.1.9 Mass Movement

Identifying areas with the potential for mass movement is critical to managing soil and water during construction such that these areas can be avoided or stringent controls put in place.

Mass movement generally only occurs on slopes above 25% where there is little vegetation cover and annual rainfall is over 900mm, although on unstable soils movement can occur on less steep slopes. The potential for mass movement increases where there is a high rainfall frequency. Some instances of minor mass movement have been recorded in the area (for example, see Inverell Shire Council 2009).

The potential for mass movement and the subsequent impacts (such as increased potential of soil erosion on dispersed soils) should be considered during the preparation of a SWMP.

4.1.10 Wind Erosion

Given the frequent high winds in the locality of the proposed wind farm, consideration should be given to the potential for wind erosion of soil and mitigation measures to address this within the SWMP. The hard setting clays found in the vicinity of the project site are prone to wind erosion.

4.2 LIMITATIONS

This study was conducted using published soil and geological maps and reports. It is acknowledged that a published detailed soil landscape map is not available for the project site; consequently additional soil physical testing should be undertaken as part of the geotechnical investigation. This information regarding soil properties can then be used to develop a site specific SWMP to provide detailed mitigation measures will allow further recommendations for construction phase management.

Normal engineering practice of regular inspection and maintenance of operational areas should be carried out in accordance with the SWMP and geotechnical report.

4.3 POTENTIAL IMPACTS

Based on the above understanding of the site, the following potential impacts from the development have been identified in terms of soil and erosion:

- The removal of vegetation and soil disturbance associated with earthworks has the potential to increase erosion, particularly on steep slopes. Vegetation clearing will be restricted primarily to a narrow linear pathway. Appropriate erosion controls should be implemented during clearing and construction, with particular care given to steep slopes and in the vicinity of drainage lines. Where possible, progressive revegetation is to take place.
- Consideration should also be given to the location and design of access tracks to minimise the grade and include suitable drainage to avoid erosion during both construction and operation.

- Minor creeks and tributaries pass through or occur adjacent to the study area, with some waterway crossing required. Therefore, if appropriate control measures are not implemented, there is the potential for both direct and indirect impacts on these water bodies during and following construction from runoff, erosion. Measures to control soil erosion and sedimentation should be detailed in a SWMP.
- The hard-setting nature and mobility of soils within the study area, and the elevation and occurrence of strong winds means that the potential for dust generation should be considered. Exposure of soils during earthworks, and the formation of stockpiles, may cause dust issues. Appropriate dust suppression measures should be implemented.

5 Soil and Water Management

This report is not intended to act as detailed management plan for erosion and sediment control. Rather, this section of the report addresses the principles of the 'Blue Book' (Landcom 2004) and undertakes an initial assessment of their applicability to the project.

Land disturbance (including vegetation clearing and general earthworks) during construction and ongoing operation and maintenance activities have the potential to cause erosion, displacing soil which can then be deposited onto nearby land and within waterways. Of particular concern are fine, dispersible sediments that can carry other pollutants, which will not settle until they reach saline waters, and which can result in poor water quality. The steep slopes and erosion potential of soil groups within the study area are also of concern.

This section should be read in conjunction with the riparian impact assessment section of this report, which address potential impacts and proposed mitigation measures to protect riparian areas of the site.

5.1 SOIL AND WATER MANAGEMENT PRINCIPLES

The following principles generally provide effective soil and water management during land disturbance:

- Adequate investigation of where soil disturbance is likely to expose and/ or exacerbate pre-existing problems;
- Plan for erosion and sediment control concurrently with engineering design, prior to any works commencing, and integrate other landscape components (e.g.: riparian, ecological);
- Install the necessary control measures prior to works commencing;
- Minimise the area of soil disturbed and exposed to erosion;
- Conserve topsoil for later site rehabilitation/ revegetation;
- Divert clean run-on water around disturbed areas;
- Control water flow from the top of, and through the development area;
- Progressively rehabilitate disturbed lands as soon as practically possible; and,
- Maintain soil and water management measures appropriately during the construction and operation phase, with regular inspections and maintenance scheduled.

These principles should be further detailed and adopted within a SWMP, and implemented in the detailed design phase of footings, trenching and access roads prior to pre-construction activities.

Additional soils information obtained from soil testing (such as particle size distribution and dispersibility) should be considered during the preparation of a SWMP as this will impact the type and extent of control measures necessary.

5.2 MITIGATION MEASURES

A SWMP (informed by more detailed geotechnical investigations) should outline management actions for the development site(s). Design, construction and maintenance will be carried out in accordance recognised guidelines and standards, including:

- *Guidelines for planning, construction and maintenance of tracks* (NSW Department of Land and Water Conservation 1994); and,
- *Managing Urban Stormwater: Soils and Construction, 4th Edition* (Landcom 2004).

5.2.1 General Soil and Water Management

The full suite of erosion controls (e.g. catch drains upslope of earthworks, barrier fencing of 'no disturbance' areas) and sediment controls (e.g. sediment basins, sediment fences, stockpile stabilisation, stabilised site access points) will be determined during the preparation of the SWMP. The controls for the construction and maintenance of the development will be conducted in accordance with the 'Blue Book' (Landcom 2004). Particular care should be given to works located on steep slopes and the measures recommended in these areas.

5.2.2 Access Tracks and Trenching

In accordance with the *Guidelines for planning, construction and maintenance of tracks* (NSW Department of Land and Water Conservation 1994) the following will be incorporated into the SWMP:

- **Location** – site tracks to reduce the risk of sediment entering drainage lines, maintain effective vegetative buffers and kept above flood levels;
- **Grades** – tracks will have a slight grade to allow free surface drainage and to avoid ponding in wheel tracks;
- **Surfacing** – in areas of steep terrain and dispersible soils bitumen or gravel surfacing may be required;
- **Surface Drainage** – runoff will be prevented from concentrating and reaching erosive speeds;
- **Crossfall Drainage and Outlets** – outfall and/or infall drainage will be used for cross bank construction will and located such that flow is not directed back onto the track;
- **Earthworks** – disturbance of soil and vegetation will be minimised as much as possible, both on and adjacent to tracks and will follow land contours to minimise the amount of cut and fill;
- **Drainage Line Crossing** – drainage lines will be crossed with culverts and will not obstruct flows or create turbulent flows that will cause erosion;
- **Revegetation** – revegetation will be undertaken immediately following works and use locally native species as a base mix to stabilise soils to prevent erosion. In circumstances where 'Type D' soils are present and ecological values are low, a cover crop may be applied utilising sterile seed sources such as Chewing Fescue; and
- **Maintenance** – inspection of all tracks regularly and following heavy traffic use or heavy rainfall will be undertaken as part of both the Construction and Operational Environmental Management Plans.

Managing Urban Stormwater: Soils and Construction Volume 2C: Unsealed Roads (DECCW 2008) can also be used as a guide.

5.2.3 Footings

Detailed geotechnical investigations will be required to ascertain the type and extent of footings, however soil management to avoid erosion and sedimentation will adhere to the mitigation measures detailed in the SWMP.

6 Recommendations

To adequately address the erosion potential of the works due to the soil landscapes and slopes of the project site, it is recommended that the SWMP details erosion and sediment control measures. The above desktop assessment has identified additional data that would be required for the development of a SWMP, including laboratory analysis to correctly classify soil type and determine their dispersibility (such as particle size distribution, Emersion Aggregate Test, dispersion percentages, linear shrinkage). In addition, slope gradients and runoff coefficients for the site will need to be characterised to determine appropriate sediment and erosion controls.

The SWMP should address the requirements of the 'Blue Book' and be prepared by a suitably experienced consultant prior to any construction activities. Works undertaken on steep slopes will require more stringent erosion and sediment control measures to address the high erosion potential of these areas. Some soils within the project area are subject to shrink- swell and need to be

Table 3: Summary of mitigation measuresTable 3 summarizes a sequence of recommendations to ensure appropriate soil and water management of the project site and meet relevant regulatory controls.

Table 3: Summary of mitigation measures

Mitigation Action	Project Phase			
	Design	Pre-Construction	Construction	Operation
Further soils investigations (laboratory testing required)	✓			
Develop SWMP (prior to any earthworks)	✓			
Design and maintain tracks in accordance with appropriate standards (e.g. Landcom, DECCW)	✓		✓	✓
Implement erosion and sediment control plan	✓	✓	✓	✓
Minimise exposed ground and implement appropriate sediment and erosion controls			✓	✓
Manage traffic to minimise erosion and dust potential			✓	✓
Maintain tracks to prevent erosion and sediment loss			✓	✓
Regular inspection of disturbed ground to ensure efficacy of erosion and sediment controls			✓	✓

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