Murra Warra Wind Farm Geology and Hydrology Assessment Report

Author: RES Australia

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Revision History

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EXECUTIVE SUMMARY

RES Australia Pty Ltd is seeking to develop a Wind Farm of up to 116 Turbines approximately 32 km northeast of Horsham and immediately north and south of the section of Minyip-Dimboola Road that runs between the Blue Ribbon Road and the Henty Highway. The site has a total area of approximately 4,200 hectares and is predominantly utilised for broad acre cropping.

This Geology and Hydrology Assessment Report has been prepared to ensure the Wind Farm Project proceeds with minimum disruption to the regional and local environment and its preparation has drawn upon feedback from key stakeholders, various desktop studies and site test pits and inspections completed in September 2015.

The Wind Farm is situated in the Murray Basin geological area and consists of many layers of "recent" marine and freshwater / estuarine sediments of approximate total depth 140m overlying the cratonic base rock formations of the East Australian great dividing range which dating from the Cambrian to Ordovician period. The topography of the site is basically featureless being extremely flat with a general fall of 1m in 1000m towards the Murray River into which the general basin area drains to the north. No significant earthworks will be necessary for the construction of the project. It is anticipated that a Quarry with adequate materials for the project can be developed within the boundaries of the Wind Farm in order to minimise the amount of truck movements associated with track construction.

There are no designated waterways or even minor streams within the site area. The obsolete open channel rural water supply system is being filled on an ad hoc basis and these channels are not required for local storm water control. The site is about 7km west of the Yarriambiack Creek but is not in an area prone to flooding and was not inundated during the Wimmera River flood event of 2010 – 2011 when the Yarriambiack Creek flowed for the first time in 15 years. Given the flat nature of the site it is not anticipated that any construction works will cause scour or adverse sedimentation impacts in the area.

The open channel rural water supply system was replaced with a piped system in the Wimmera region between 2006 and 2010, and this water is expected to be drawn upon for construction purposes. Alternatively, groundwater bores may be able to be used for road building purposes and dust suppression only - as the salinity of the groundwater is high there is no noteworthy beneficial use of it for agricultural or residential / commercial purposes in the area. The groundwater table is approximately 30m deep at the centre of the project site and no excavations or quarrying activities during construction will intercept it. Standard construction environmental controls will be able to mitigate against minor adverse impacts the works may cause to both surface and groundwater resource.

A separate Work Plan for the Quarry will be developed in parallel with the Permit Application process for the Wind Farm and further detailed geotechnical investigations will be carried out prior to construction should a permit for the project be issued.

Based on an assessment of the subject site's geology and hydrology features, it is considered that the granting of consent for the development of a proposed Wind Farm Project would not result in any significant adverse impact upon the soil and water features of the subject site and surrounding area and the proposal would be capable of complying with relevantly applicable legislation and guidelines.

1 INTRODUCTION

RES Australia Pty Ltd is a 100% owned subsidiary of the Renewable Energy Systems group of companies (RES Group). RES Group is a specialist renewable energy developer with 30 years' experience. To date RES Group has built wind farm projects of over 10 GW around the world (with 128 wind farms developed and another 1.7 GW currently under construction). RES Australia has staff located in both Victoria and New South Wales and is currently developing a number of other sites in Victoria, New South Wales and South Australia.

This report describes the existing soil and water conditions at the site of the proposed Murra Warra Wind Farm project. The report considers the potential for any impact of the project upon the existing soil and water conditions; and recommends design principles and construction methodologies to mitigate against any impact.

The report draws on;

- Feedback and discussion with key stakeholders (GMW Water, Yarriambiack Shire Council and Horsham Rural City Council and the Wimmera Catchment Management Authority),
- Published reports and maps;
- Various desktop studies,
- On-site inspections undertaken by RES Australia's construction manager and Civil Engineer,
- Test Pits excavated on site during September of 2015.

RES Australia is committed to delivering the Murra Warra Wind Farm Project with minimum disruption to the regional and local environment of which the Hydrology and Geology subset form a part.

2 PROJECT DESCRIPTION

The project will consist of a wind energy facility comprising of up to 116 wind turbine generators.

Turbines will be three bladed and have an expected capacity of approximately 3.6MW (rated capacity will depend on final turbine selection) reaching a maximum height to the tip of the rotor at its highest extent which will not exceed 220m. The turbines will comprise of up to 5 tubular steel tower sections, mounted by a nacelle containing the generator, gear box and electrical equipment. Crane pads of approximately 40x60m will be located at the base of each turbine tower. Each turbine will require a transformer and switchgear which will be housed inside the tower base, or externally, immediately adjacent to the base. Should an external transformer be required, typical dimensions are 5.5m length, 3m width and 3m height.

The turbines will be accessed via a network of access tracks which will be approximately 6m wide to allow access for construction and for ongoing maintenance throughout the life time of the wind farm. Where possible site access tracks will be established to utilise existing access points and roads. It is estimated that there will be approximately 75km of new tracks and upgraded roads required and approximately 50 access points from minor rural roads. There may be a need for some alterations to road junctions close to the site.

Internally, electricity will be distributed from each wind turbine to the Terminal Station via a network of medium voltage 33kV underground and overhead cables. It is estimated that there will be approximately 18km of overhead line, with pole heights of approximately 35m and 70-75km of underground cabling.

There will be a Utility area, Collector/ Switch Yard, Terminal Station and Quarry which will be co-located at approximately 618363m Easting 5967266m North.

The Utility area will be in a secure enclosed compound and will comprise of an operations and maintenance building, car parking, a site office, warehousing/workshop facility and an external yard area for storage which may include a bunded area for fuel storage, and other ancillary equipment.

The Collector/Switchyard will be in a secure enclosed compound and will be where overhead and underground cables from the wind farm collection system will be terminated. Typically this will comprise of bus bars, switchgear, metering, a control building, reactive and harmonic filtering plant and other ancillary equipment. There will be pylon structures to support cables from the internal overhead lines and out to the adjacent Terminal Station.

The Terminal Station will be in a secure enclosed compound and will typically consist of transformation equipment, bus bars, switch gear, disconnectors, a control building, communications tower and other ancillary equipment to enable connection to the adjacent 220kV transmission line including surge arrestors and pylon structures to support cables from the collector yard and up to the adjacent 220kV transmission line.

The Quarry will be approximately 12Ha inclusive of temporary stock piles for overburden material. The quarry will be used to provide base materials for road building. The location of the quarry will be adjacent to and immediately north of the Utility area and Terminal Station.

Six potential locations have been identified for the placement of hub height anemometry masts. These will be used for monitoring the performance of the wind farm. Final selection of no more than four of these locations will be made after final turbine selection has been made.

There will be other temporary infrastructure associated with the construction of the wind farm. A main site construction compound will be located adjacent to the utility area and will typically comprise of offices, laydown area, concrete batch plant, storage, workshops, bunded fuel storage a water storage dam and other ancillary construction equipment. Because of the extent of the site there may be need for

an additional two general construction compounds. Preliminary sites for these have been identified in the south west adjacent to the Kings Roads and in the north east adjacent to the Kewell North School Road. These compounds will contain a sub set of the elements described above for the main site compound. There will be two further construction compounds, one to service the construction of the Terminal Station and another one to service the construction of the connection to the 220kV transmission line. These facilites will be located adjacent to the Terminal Station and will also contain a sub set of the elements described above. All temporary infrastructure will be removed at the end of the construction programme and the sites rehabilitated if required by regulators and landowners.

The general location of the proposed Wind Farm, showing Council and Water Catchment Management Boundaries, is attached in Appendix A - *Drawing 1: Murra Warra Wind Farm Location Plan*.

Figure 1 – Site Location Showing Grampians (dark green region) to the South

3 GEOLOGY

3.1 Topography

LIDAR data has been obtained for the Wind Farm site and this is shown in Appendix A, *Drawing 2: Murra Warra Wind Farm Site Topography and Drainage*. The site generally falls from north to south and contains a single "shallow ridge" line running in the same direction that may be part of an old sand dune / marine formation of the underlying Loxton Sands.

Levels typically range from RL130-134m at the southern extents of the site, falling to RL124m at the northern extent adjacent to Barrett Road. The bed of the Yarriambiack Creek is generally at RL118-120m in the vicinity of the site.

The maximum track slope is expected to be in the order of 2-3%. From an Engineering Perspective the site can be considered flat and there will be no significant geotechnical terrain related risks to overcome during construction of the Wind Farm. Large scale cuts and fills for either the site access tracks or the wind turbine foundations will not be required.

Figure 2 - Typical topography – Dimboola Minyip Road at intersection with Dogwood Road

3.1 Soils

Wimmera soils are highly variable at both regional and local scales; with multiple soil types often present within a single paddock. Different soil types have different susceptibilities to degradation.

There are three major soil groups in regions of the Mallee, Wimmera and the south western Victorian. Vertosols (cracking clay soils), Sodosols (soils with a strong texture contrast between surface and subsurface horizons and with subsoil horizons that are sodic) and Calcarosols (gradational textured soils with an abundance of lime in the profile).

- Vertosols are often called cracking clay soils. They have a clay texture (>35% clay) throughout the profile; display strong cracking when dry, and shrink and swell considerably during wetting and drying phases. Based on colour of the upper 50 cm ofthe soil profile, they can be grouped into suborders. Grey Vertosols are the most common in the Wimmera, with minor

occurrences of Red and Brown Vertosols. Self-mulching Vertosol soils are common in the Horsham and Kaniva regions.

- Sodosols occur on a wide range of landforms (from gently undulating plains and rises to undulating low hills). Surface soil textures and depths vary considerably and have significant implications for management. Sodosols tend to be found mainly in the southern, eastern and western Wimmera with smaller areas in the northern Mallee and east of Birchip. Sodosols are also common on basalt plains and rises throughout much of south-western Victoria. They are also common on sedimentary plains and rises in lower rainfall areas. The subsoils of Sodosols in the region often display a strong shrinking and swelling characteristic i.e. vertic, and the subsurface horizons can be ferric i.e. contain significant amounts of ferruginous nodules 'buckshot'.
- Calcarosols do not have a strong texture contrast between surface and subsurface horizons and are calcareous throughout. They often contain calcium carbonate (lime) as soft or hard fragments. They are most common in the north-east of the region. Calcarosols (often called 'mallee loams', 'mallee sands' or 'calcareous earths') are soils formed on calcareous aeolian sediments of variable texture. Calcarosols vary quite considerably in terms of soil texture, ranging from those dominated by sands to those that are clayey throughout, and this has a big influence on the agronomic properties of the land. Three kinds of Calcarosols occur: light textured (sandy to loamy), heavy textured (clay loamy to clay) and stony.

3.2 Regional Geology

To the East of the proposed Wind Farm, a multifaceted history of massive tectonic events has formed what is now the eastern seaboard area of Australia. The formation of this eastern zone is characterised by uplift, folding, faulting, volcanic intrusion and the resultant metamorphosing of ancient marine mudstones and sandstones, circa 450+ Million Years ago. The Grampians Ranges and Mt Arapiles, to the south and west of Horsham respectively, are considered to be the southern visible extremity of this Great Dividing Range / Eastern Seaboard Highlands geological system which runs to the far north of Queensland.

This complex Cratonic activity to the east (and which also underlies the site in the base rock formations) is also responsible for the formation of the Murray - Darling basin / river system in which the subject Wind Farm lies. The exit point of the Murray River and the position of the coast line to the southwest of the site has changed frequently in the past during various periods of high sea level and associated receding of the shoreline within what is now the basin. Thus, the site area has been subjected to patterns of marine inundation, and coastal lake and river system formation which have laid down sediments on top of the base rock features over time. The uppermost layer of these marine sediments, described as "Loxton Sands" (Nwl), have also recently been subject to the deposition of alluvial / floodplains material, as with the "Shepparton Formation" (Nws) that exist to the south and east of the site. These units are described on the Australian Stratigraphic Units Database as follows

> **"Shepparton Formation (Nws) -** Unconsolidated to poorly consolidated mottled variegated clay, silty clay with lenses of polymictic, coarse to fine sand and gravel; partly modified by pedogenesis, includes intercalated red-brown paleosols. Forms extensive flat alluvial floodplains. circa 20 to 30 thousand years ago". Shepparton Formation Overlies:
>
> "**Loxton Sand (Nwl)**, Marine to marginal marine deposits. Fluviolacustrine and coastal, siliceous and clayey sand. Heavy mineral sands containing rutile, zircon and ilmenite. Often referred to as Loxton-Parilla Sand to describe the unit as it occurs across borders from Victoria to South Australia. Circa 7.2 to 10 Million Years old".

To the far South, beyond the Grampians, recent and extensive volcanic activity has formed the Basalt Volcanic Plains of South West Victoria which flow generally towards the coast. And to the west of the site, the recent air blown (Aeolian) "Molineaux Sands" of the Little Desert have intruded from the coastal regions of South Australia nearly as far as the Wind Farm site. Figure 3 on the page following shows the context of the site relative to the main surface geology features of South West Victoria.

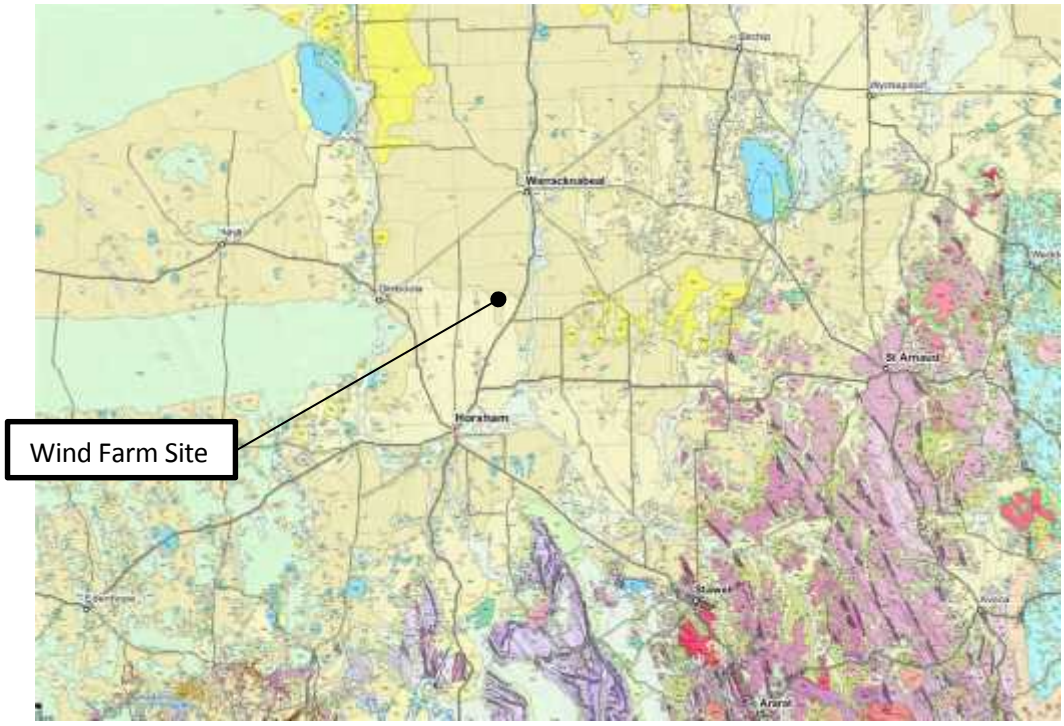

Figure 3 - Regional Geology (250k Seamless – source http://er-info.dpi.vic.gov.au/)

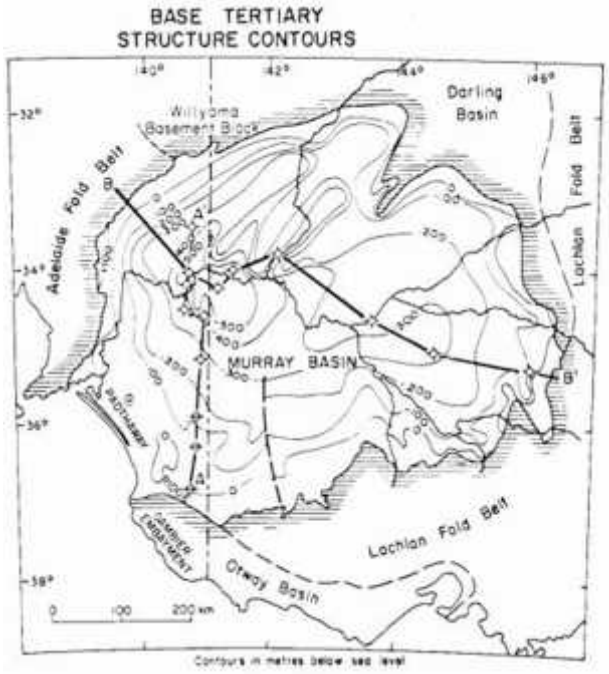

Figure 4 - Murray Basin Base Rock Structure Contours in Metres

The depths of Loxton Sands

(formally designated as Parilla Sand, **Tpp**), plus other various underlying sedimentary deposits within the Murray Basin can vary from tens of metres to hundreds of metres depending on the distance from the edge of the basin as shown left in Figure 4[ref5].

The underlying Cratonic base rock at the Wind Farm site has been specifically mapped[ref6] as "St Arnard Group" (**cmt**) basalts and volcanclastics dating from the Cambrian to Ordovician period, circa 440 Million Years Ago. This baserock falls within the Stawell Folding / Faulting Zone of rock formation as shown on the Rock Relationship Diagram below in Figure 5. More recent granitic intrusions such as those designated (**Dgm** and **Dglm** etc.) date from 400 to 370 Million years ago.

The "approximate" location of the Wind Farm site with regards to base rock geology structures is indicated by the vertical red line, it should be noted that the basin sediments shown on top of the base rock in the figure is simplification.

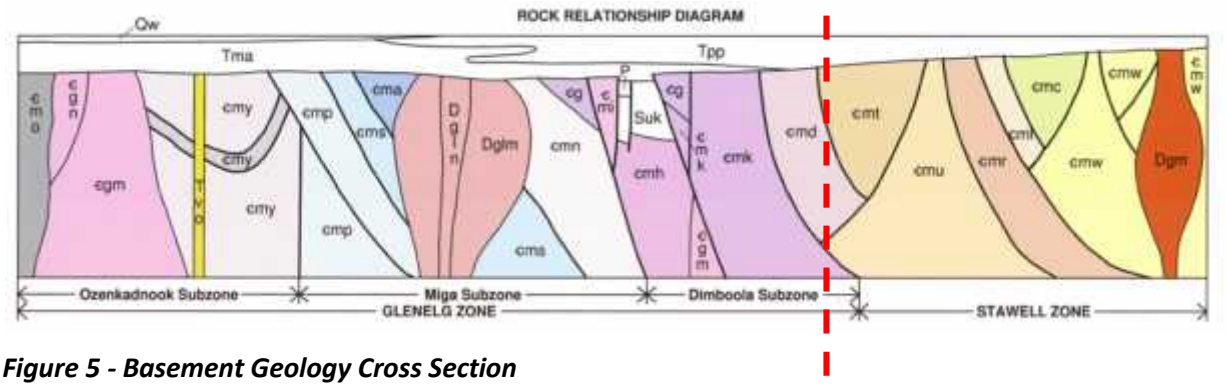

Figure 5 - Basement Geology Cross Section

[5] C.M BROWN. Murray Basin, Southeastern Australia: stratigrpahy and resource potential a synopsis, 1985, Report 246

[6] *Horsham 1:250,000 Geophysical Interpretation of Basement Geology, 1996.*

3.3 Seismicity

Based on AS1170.4-2007 "Structural Design Actions Part: 4, Earthquake actions in Australia", section 3, the hazard factor (Z) for the site is 0.08 (0.08 in 500 years probability of exceedance).

Based on the subsurface conditions at the site a Sub-Soil classification of either Class C (Shallow Soil) or D (Deep) is likely to be assigned to the site at the detailed design stage of the project as per section 4 of AS1170.4.

3.4 Local Geology

The subject Wind Farm site is located in an area of deep sedimentary deposits of both marine (Loxton Sands and underlying deposits) and alluvial (Shepparton Formation) origin as discussed in the section above. Appendix B shows the location of the proposed Wind Farm infrastructure relative to the most recent geological mapping of these deposits.

The local geology for the Wind Farm site is largely based on four boreholes located at the centre point of the proposed Wind Farm site. These boreholes are all located in the vicinity of the Minyip-Dimboola Road and Ailsa Wheat Road and intersections and all confirm Loxton / Shepparton deposits to a depth of about 40m overlying Limestone Marl layers.

Figure 6 - Existing Groundwater Bore – Minyip-Dimboola Road at the intersection of Ailsa Wheat Road

Figure 7 – Photo of Existing Groundwater Bore

A summary of the central groundwater bores is tabulated below:

Table 1 - Summary of Groundwater Boreholes within Proposed Site

Borehole No.	Date of Drilling	Depth of Hole	Drilling Type	Ground water Depth	Drillers Logs	Comments
70220	October 1974	40m	Percussion (cable)	~30.8m below ground level	Various unconsolidated clays sands silts, to 38m. Limestone blue grey marl noted at 38 to 40m.	
70219[7]	May 1976	81m	Percussion (cable)	~30.5m below ground level	Various unconsolidated sands, clays to 40m. Limestone marl noted from 40m to 49m, no logs provided beyond this.	

[7] Location of this Bore is incorrectly marked Dalyseford on the original drilling log – However the drill hole head is visible on site and logs and water depth and drilling description are consistent with the other holes in the area. State officials have correctly located the borehole on the database.

70221	10 Oct 1988	144.2	Rotary and Core Samples	~31.2m below ground level	Driller's logs similar to above, limestones noted at 45.5m.	**Stratigraphy provided and 4 Cores taken - see table 2 below**.
70222	26 Oct 1988	48	Rotary	~30.3m below ground level	Various clays and gravels to 38m depth. 38 to 48m, marl and limestone.	

Borehole 70221 is the most detailed of the drill holes and 4 cores samples were taken from this hole during drilling in 1988. The drillers log and inferred stratigraphy for this hole are summarised on the table below:

Table 2 - Summary of State Groundwater Borehole 70221

Depth	Depth	Material	Comments	Core Taken	Stratigraphy Log
0m	1.5m	Brown Clay	Brown Clay	No	
1.5m	6.5m	White Clay	White Clay	no	
6.5m	8.2m	Clay	Reddy Clay	no	6-32m Loxton Sands
8.2m	15.5m	Sand	Brown sand medium	no	
15.5m	19.6m	Gravel	Coarse gravels	no	
19.6m	38.8m	Silt	Yellow silts and ironstone bands	23-26m	
38.8m	43m	Clay	Grey clay	41-43.5m	32-52m Geera Clay
43m	45.5m	Limestone	Fossilised limestones	no	
45.5m	115.5m	Limestone	Grey marl	no	52-101 Olney Formation
115.5m	135m	Clay	White silts and clays	119-120m	
135m	144.2m	Silt	Orange silts and clays layered	141.4-144.2	
END			Base Rock not indicated		

In addition to the above groundwater boreholes, a deep borehole was drilled in 1997 about 1km to the northeast of the Wind Farm centre point named VIMP 14. This hole was part of suite of deep diamond core[8] drilling undertaken by the Victorian Initiative for Minerals and Petroleum "Test Drilling of the Southern Margin of the Murray Basin". The output report [ref 9] from this investigation program contains detailed discussion around base rock geology underlying the Basin Sediments in the Horsham area.

[8] Diamond Core logs were only taken in base rock layers – upper layers were percussion drilled.

[9] MAHER, S., MOORE, D.H., CRAWFORD, A.J., TWFORD, R. & FANNING, C.M., 1997. Test drilling of the southern margin of the Murray Basin. Victorian Initiative for Minerals and Petroleum Report 52. Department of Natural Resources & Environment, Victoria

Table 3 below contains a summary log of the VIMP14 borehole, a more detailed log from the report is included in Appendix C.

Table 3 - Summary of VIMP 14

Depth	Depth	Unit
0m	40m	Loxton – Parilla Sands
40m	58m	Winnambool Formation
58m	146m	Olney Formation
146m	194.9m	Saint Arnaud Group basement rock, described as: "multiply deformed pelitic metamorphic rock

In summary, the surface materials expected over the extent of the site are not anticipated to provide any significant challenge with respect to foundation construction. Although shallow footings (for sub-station footings) will need to be designed to ensure they are not subject to "shrink swell" load effects that can be characteristic of such silty sandy soils.

It is considered highly unlikely that any of the Project works will encounter acid sulphate soils (ASS) given the site location and local geology, the shallow nature of the proposed works (<10m) and depth to groundwater (>20m). An assessment of the soil acidity will however be undertaken prior to construction works commence with turbine foundation concrete mix specifications adjusted accordingly.

A review of the published map[10] of 'Sites of Geological and Geomorphological Significance' shows that there are none located within 50km of the wind farm site.

[10] http://vro.agriculture.vic.gov.au/dpi/vro/portregn.nsf/pages/port_lf_ppsites_sig

3.5 Quarry Development

As part of the Project RES Australia intends to develop a quarry on site for the sole purpose of serving the Wind Farm and reducing the number of deliveries required for construction of tracks and hardstands.

Two existing "sandstone" quarries in the area have been visited by RES, Finlayson Quarry operated by Millers Construction and the abandoned quarry on the wind farm site at Barrett Quarry Road. There is also an abandoned quarry directly to south of wind farm site, Exells Quarry on Exell Quarry Road.

(left) – Existing Sandstone Quarry on Finlaysons Road (about 20km south of the site and within a similar geological history this picture shows typical quality of materials stockpiled with an excavator only that may be recoverable within proposed Wind Farm quarry areas)

Figure 8 - Existing Sandstone Quarry on Finlaysons Road

Figure 9 - Existing Sandstone Quarry on Finlaysons Road (showing variable banding of materials in one part of the site)

It is understood that the materials from the Finlaysons Road quarry (shown above) has primarily been used for the construction of the Dooen grain handling facility. The quality of the material in the quarry is variable, being generally consisting of an upper layer of "orange silt" (not suitable for road capping layer, but usable as a general earth / subgrade fill) overlying a 2m to 2.5m thick layer of "weakly cemented sandstone" (suitable for road capping and the target material from within the quarry).

A disused quarry exists within the extents of the proposed Wind Farm exists on Barrett Quarry Road. This quarry has been rehabilitated with a significant amount of native vegetation being planted around the old pit area. Similarly Exels quarry to the south of the site has been abandoned for some time and has been rehabilitated.

Figure 10 - Photograph of existing Barrett Road Quarry within Wind Farm Extent

3.6 Proposed Quarry Sites and Investigations

Two potential quarry sites have been identified within the Windfarm site. Figure 11 below shows the general locations of the possible quarry sites.

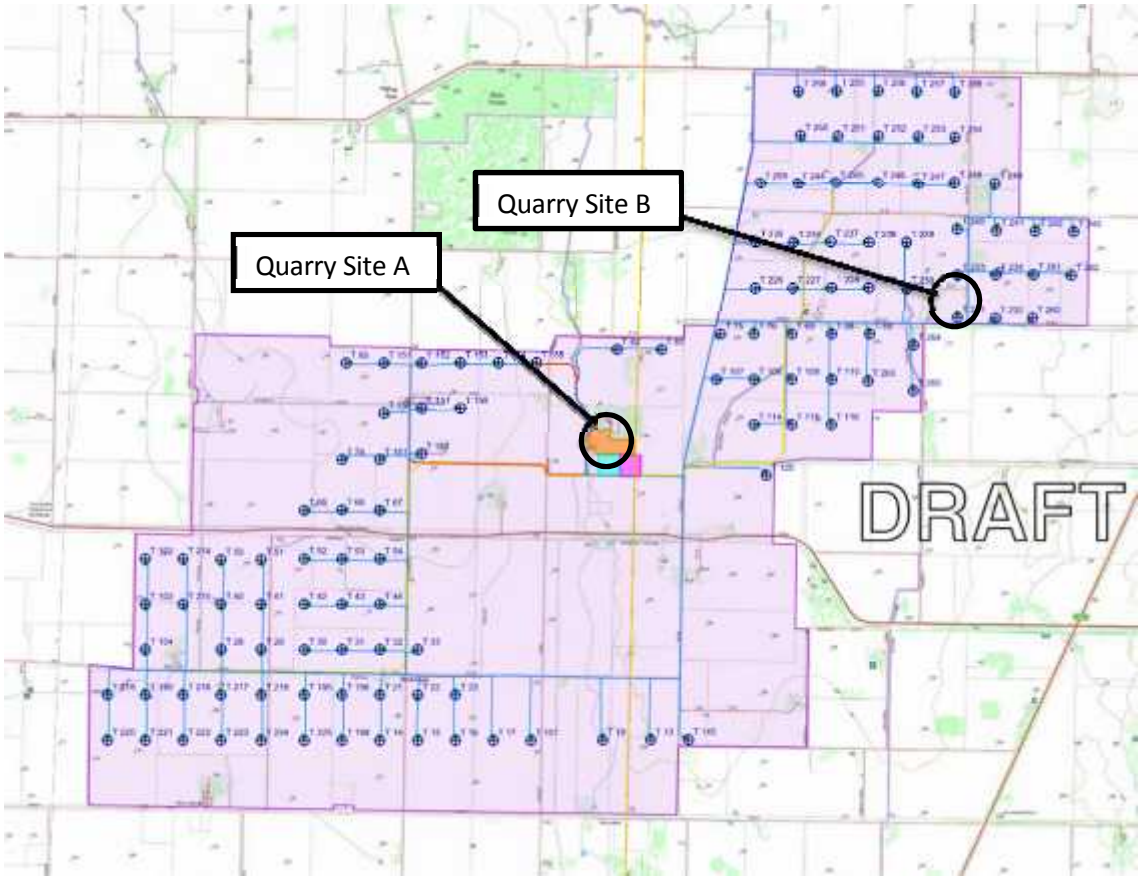

Figure 11 - Preliminary Quarry Site Locations

The first potential quarry site is located just south of the existing ***Barrett Road Quarry***, adjacent to the proposed preliminary construction compound and substation sites.

Refer to Drawing 02418D2205-05 within Appendix F for the general extent of the proposed quarry area. The proposed quarry site covers an area of approximately 12.5Ha, which is currently utilised for cropping.

Two test pits were undertaken by RES on 29th September 2015. Locations of the test pits are shown on Drawing 02418D2205-05. Test pit logs are also provided in Appendix F. The soils generally comprised an upper layer of weakly cemented orange silts and sands (1.0-1.2m depth) overlying weakly to moderately cemented sandstone to a depth of up to 7.0m.

The second potential quarry site is located to the north of Kewell North School Road, and to the west of Shalders Road. A small (approx. 60m x 60m) disused quarry pit is located on the existing farm adjacent to the potential quarry site (Refer Figure 12 below). It is understood that the material has been utilised historically to construct farm tracks. The potential quarry area is currently utilised for wheat crops.

Figure 12 - Existing Farm Quarry, Shalders Road

Two test pits (TP3 & TP4) were undertaken by RES on 29th September 2015 at the locations shown on Drawing 02418D2205-06. Test pit logs are also provided in Appendix F. The soils generally comprised upper layers of orange/brown silts and sands (1.0-2.0m deep) overlying weakly to moderately cemented sandstones to a depth of up to 5.5m.

3.7 Investigation Test Pit Results

Laboratory testing of samples taken from the test pits have been tested by Roadlab Testing Services, Ballarat. Full results of testing are provided within Appendix F and summarised in Table 4 below.

Table 4 - Proposed Quarry Samples - Lab Test Results

Pit No.	Sample Depths (m)	CBR (Soaked CBR Test)	Optimum Moisture Content OMC (%)	Maximum Dry Density (t/m^3)	Comments
Quarry Site A					
TP1	2.0m, 4.0m, 6.0m	15.0%	11.5	1.930	
TP2	2.0m, 2.5m, 3.9m	3.0%	14.9	1.807	Higher silt component
Quarry Site B					
TP3	2.5m, 4.2m, 6.2m	18.0%	10.8	1.918	
TP4	3.6m, 4.4m	15.0%	11.1	1.931	

The materials available from both the proposed quarry locations are considered be suitable as both a general subgrade fill and as a low grade base course materials adequate for Wind Farm access track construction. As expected, the materials are not suitable for concrete aggregate.

3.8 Resource Estimates

The total estimate of required materials has been computed (based on 116 Turbines and 75km of track) as follows:

In Place Required Volumes		
Subgrade Fill Materials	299,258	m^3 solid volume in place as constructed
Pavement and Capping Materials	130,688	m^3 solid volume in place as constructed
TOTAL VOLUME	**429,946**	m^3 solid volume in place as constructed

Assume Compaction Factor	1.3	
Usable Quarry Volume (Hole Size Volume)	**558,929**	m^3 solid in Quarry Volume Requirement
Assume Unsuitable Factor	0.1	
Total Quarry Volume (Excavated Hole)	615,000	m^3 Quarry Hole Size

Based on the test pit investigations carried out at both possible quarry sites it is likely that both areas could be worked to a depth of at least 6m. This would result in an area requirement of approximately 11Ha of total quarried zone within the Wind Farm. Both possible sites individually have the potential for this size of development - however Option A is the preferred location being closer to the central point within the development and therefore a Work Plan will be developed for this one location only.

3.9 Separate Work Plan Process for On Site Quarries

A Quarry Work Plan will be prepared for Quarry Location A in accordance with the requirements of Earth Resources Regulation Victoria (ERRV).

A separate process will be followed in parallel with the EES reporting and consultation for the Wind Farm, the following steps will be followed[11]:

- Seek and obtain approval in principle from the land owner or land manager for access to the land.
- Contact the local ERRV District Office and discuss the proposal with the District Manager, or representative.
- Hold an on-site meeting with representatives of the relevant government departments and authorities. This may include Environment Protection Authority (EPA); the relevant water authority; local government; Aboriginal Affairs Victoria (AAV) and the Department of Environment, Water, Land and Planning (DELWP).
- Determine whether or not a work plan is necessary (based on the criteria listed above) and if so prepare a draft work plan for the proposal.
- Obtain ERRV's endorsement of the draft work plan.
- Submit the endorsed work plan to Council with a planning permit application.

The work plan will comprise the following information:

- Details of the proposed Quarry area including background and existing conditions of the site and anticipated impacts;
- An outline of how the quarry will be developed and the proposed quarry operating procedures;
- An Environmental Management plan; and
- A Rehabilitation Plan detailing how the site will be rehabilitated.

[11] http://www.energyandresources.vic.gov.au/earth-resources/licensing-and-approvals/sand-stone-and-clay/guidelines-and-codes-of-practice/extractive-industry-work-plan-guideline

4 HYDROLOGY

4.1 Regional Hydrology

The Wind Farm site is located within the Wimmera Catchment Management Authority (WCMA) region and lies between the Yarriambiack Creek and the Wimmera River, approximately halfway between the towns of Horsham and Warracknabeal.

The Wimmera River and its more ephemeral distributary, the Yarriambiack Creek both flow northwards from the Pyrenees Ranges and are ostensibly within the Southern Murray Darling basin - However the rivers are both "landlocked" and currently discharge into terminal lake / wetland systems that have never overflowed onwards to reach the Murray River in living memory[12]. Moreover, the most upstream terminal lake of the Wimmera, Lake Hindmarsh, was dry for fifteen years until the flooding / high rainfall events of late 2010 to early 2011.

The site is closer to the Yarriambiack Creek than the Wimmera River (approximately 7km west of the Yarriambiack Creek, 27km east of the Wimmera). The Yarriambiack Creek only flows during very high rainfall events being fed from via a bifurcation of the Wimmera River about 18km east of Horsham and 11km south of Jung. The Yarriambiack Creek has a series of weirs constructed along its length to hold water. Detailed 1:100 year flood mapping of the Yarriambiack Creek has been completed by the WCMA – this is partially shown in Appendix A – *Drawing 3: Murra Warra Wind Farm Regional Hydrology.*

While the upper reaches of the Yarriambiack Creek, east of Horsham (in the Darlot Swamp) area, is prone to flooding during high flows, northwards of Jung, any floodwaters are retained tightly within the Yarriambiack Creek channel. The centre of the Wind Farm is about 15km north of Jung at an elevation of approximately 130m above sea level, at this position the Yarriambiack Creek 100 year floodwater level has been modelled to be at approx. RL122m. The lowest lying Turbines to the north of the proposed development are located at an elevation of 123m. This is approximately 6km north-east of the centre of the Wind Farm in line with where the Henty Highway crosses the Yarriambiack Creek. At this location along the Yarriambiack, the 100 year modelling in the Creek Bed is at about RL118m.

Thus is all cases, the northward flowing 100 year floodwater of the Yarriambiack Creek is expected to be about 5m below the existing ground level within the Wind Farm designation and therefore it can be concluded that there is no significant risk of the site becoming flooded due to a regional flood event during the lifetime of the Wind Farm and Connection Substation Facilities.

It is also important to note that the Wind Farm project area, and more importantly the proposed sub-station location was not subject to flooding / inundation during the Wimmera region flooding of 2010 and 2011, during which the Yarriambiack Creek flowed for the first time in 15 years.

[12] Further east of the Yarriambiack is the Avon / Richardson river which is also a northwards flowing landlocked river termiating at Lake Buloke. East of the Avon / Richardson is the Avoca River that also flows northwards towards the Murray River reaching it intermitently during high flow periods.

4.2 Receiving Water Environments

The Yarriambiack Creek ultimately discharges to the north into the Lake Lascelles and Lake Coorong Reserve Area. These lakes are not listed on the 'National dataset of Australia's Ramsar Wetlands' or in the "Directory of Important Wetlands in Australia (DIWA)"

Both the Wimmera River and the most upstream terminal lake, Lake Hindmarsh, are listed as Nationally Important Wetlands. Lake Hindmarsh is the largest freshwater body in Victoria, supporting several significant water-bird species. Lake Albacutya, downstream of Lake Hindmarsh, is also listed as a wetland of international importance under the Ramsar Convention as it is a particularly good example of a near-natural wetland and it supports a large number of rare and threatened bird fauna. The Wimmera River is included in the Heritage Rivers Act 1992.

Given the considerably flat topography across the region, it is difficult to determine which parts of the windfarm site will ultimately drain to the west (into the Wimmera System) or to the east (into the Yarriambiack Creek system).

This being said, given the small volumes of additional runoff from the windfarm development, nature of the topography and local drainage network and distance to the receiving waters, the effects on the environmental values of the receiving water environments, specifically the downstream terminal lakes, are considered to be negligible.

4.3 Local Hydrology

The subject site drains generally north and falls and the land falls at an approximate rate of 1m per 1,000m. The Wind Farm straddles the now obsolete "Main Western" and "Rainbow" Channels that were formally part of the extensive 17,500km earthen open channel network that distributed water annually in the Wimmera and Mallee Regions. These open channels, managed by GWM, water have recently (2006 to 2010) been replaced with a 9,000km piped water distribution system which provides continuous pressurised water supplies to approximately 9,000 farms and 34 townships across the Wimmera and Mallee. As constructed plans of the pipeline are provided within Appendix E.

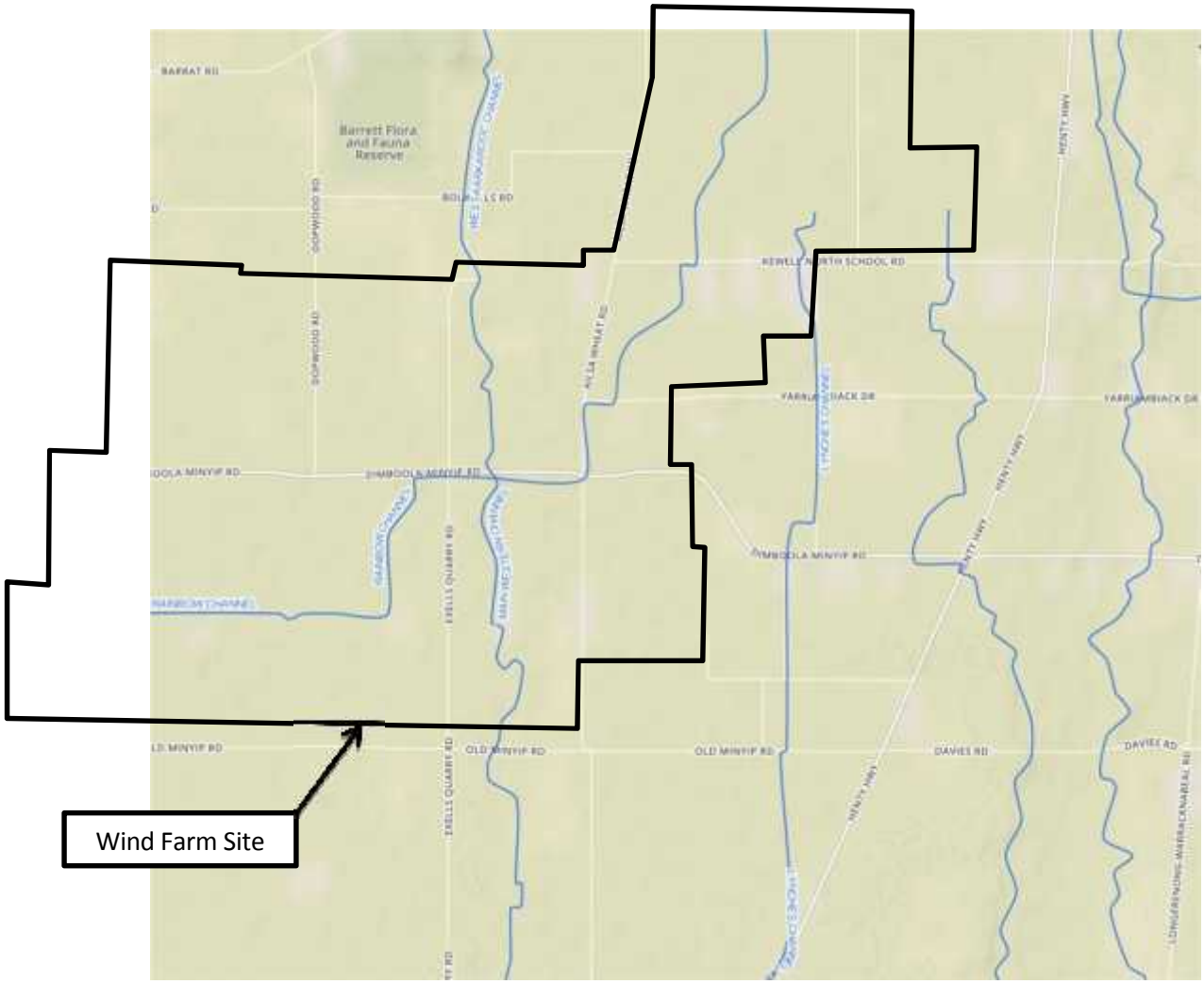

Figure 13 - Schematic Showing Obsolete Open Channel Water Distribution Network

The water distribution channels in the vicinity of the Wind Farm are not specifically required for flow management of local stormwater or as soak away storage for local surface runoff.

All channels on private property may be decommissioned (subject to consent being obtained) and the channel easements can be removed at the landowner's expense.

Channels and their decommissioned water retention dams have been shown, along with other local hydrology features, in Appendix A - *Drawing 2: Murra Warra Wind Farm Site Topography and Drainage*.

There are no designated waterways within the site that would require a Works on Waterways licence to be obtained.

4.4 Water Supply

The new piped water supply system administered by GWM Water is a potential source of water supply for the construction of the project. The Wimmera Mallee Pipeline delivers raw water to the towns and farming properties throughout the Wimmera and Sothern Mallee region. The pipeline is designed to trickle fill on-property storages throughout the day, rather than meet a peak hour demand, with most farming properties needing no more 10,000 L/day (average 0.12 L/s).

The project site is about 6 km away from the Jung to Warracknabeal 450 mm diameter trunk main. GWM Water have advised that:

- The flow rate to the project site is limited to 2 L/s (about 175 kL/day)
- The water pipes leading up to the nominated site are too small for the flow rate of 5 L/s (estimated flow requirement for the windfarm construction) and would likely result in reduced supply to properties further along the pipeline.
- Options for an increased water supply include:
    1. Construct a dedicated pipeline to the site from the 450 mm trunk main along the Henty Highway – a temporary welded HDPE pipe along fence lines may be possible (the pressure at the trunk main is approximately 40m)
    2. Construct a dedicated standpipe on the 450 mm trunk main along the Henty Highway and cart water.

4.5 Groundwater

The Wind Farm is situated east of the Wimmera River in an Unincorporated Area (UA) of the Murray Basin that is administered by Grampians Wimmera Mallee Water (GWM Water). UA's cover the areas outside Water Supply Protection Areas and Groundwater Management Areas, where groundwater is not considered to be overutilised and therefore does not need any specific management prootcole to protect the resource.

A summary of the groundwater chemistry from the existing bores located at the centre point of the proposed Wind Farm in the vicinity of the Minyip-Dimboola Road and Ailsa Wheat Road are tabulated below.

Table 5 - Summary of Groundwater Chemistry within Proposed Site[13]

Borehole No.	Depth of Hole	Ground water Depth	Electrical Conductivity –EC (mS/cm)	pH (pH)	Total Dissolved Solids - TDS (mg/L)
70219[14]	81m	~30.5m below ground level	22.00	7.50	12800.66
70221	144.2	~31.2m below ground level	26.00	7.50	14869.60
70222	48	~30.3m below ground level	14.00	7.60	7857.80

Regional mapping (Groundwater Resource Appriasal, 2010) suggests an upper aquifer salinity in the range of 8,000-15,000mg/L. Based on this salinity the groundwater beneficial uses (SEPP Groundwaters of Victoria) are limited to the following:

[13] Source: Visualising Victoria's Groundwater, http://www.vvg.org.au/

[14] Location of this Bore is incorrectly marked Dalyseford on the original drilling log – However the drill hole head is visible on site and logs and water depth and drilling description are consistent with the other holes in the area. State officials have correctly located the borehole on the database.

- Maintenance of ecosystems
- Industrial water use
- Building and structures

The use of groundwater at the project site for construction purposes may be feasible for dust suppression and / or dilution by mixing with pipeline water, or pre-treatment of quarry materials. This will this be investigated closer to the time of construction if sufficient quantities of water cannot be sourced for construction from the existing GWM Water rural pipelines.

RES Australia is not aware of any existing users of groundwater in the vicinity of the windfarm site.

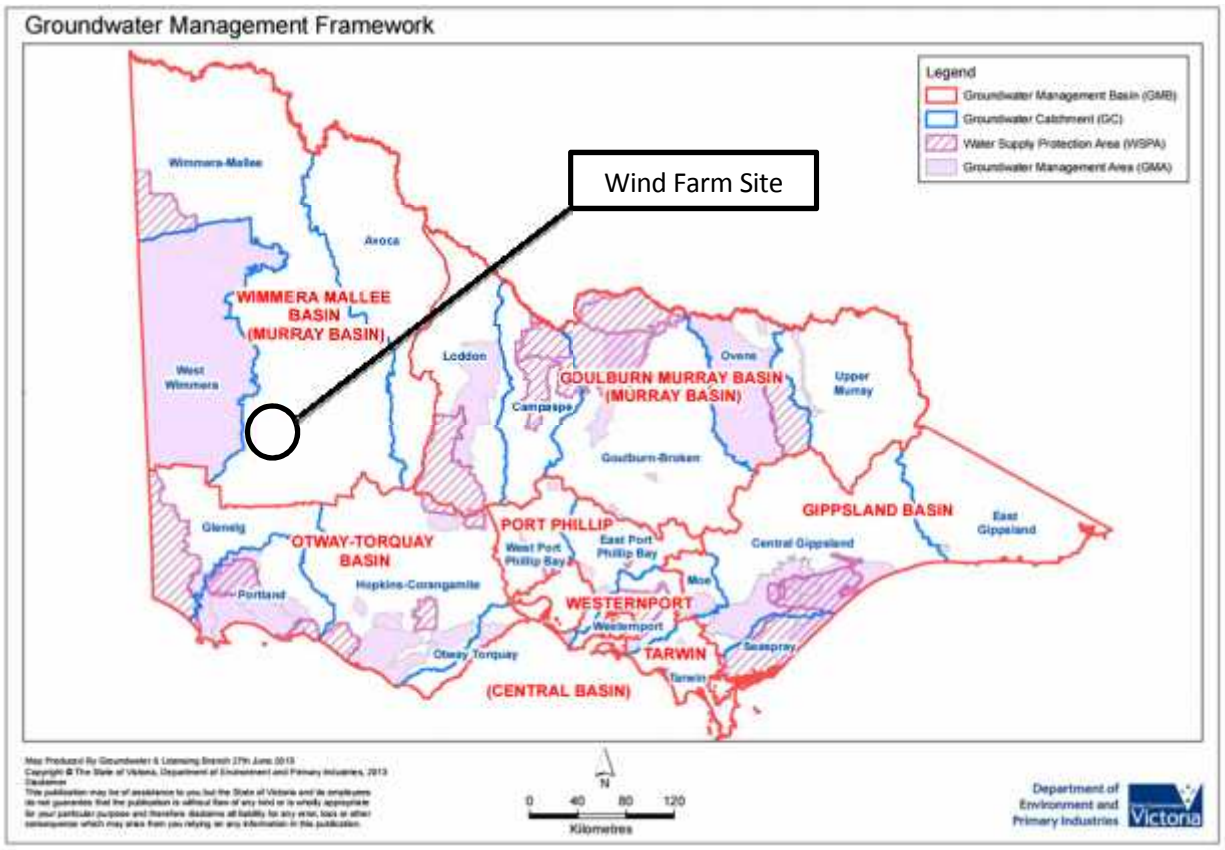

Figure 14 - Victorian Groundwater Management Framework[15]

Figure 15 below shows results from the Groundwater Monitoring Database for Borehole 70221 for the period from 1988 to 2013. Borehole 70221 is located at the centre point of the proposed Wind Farm site located at the intersection of Minyip-Dimboola Road and Ailsa Wheat Road.

[15] http://www.depi.vic.gov.au/__data/assets/pdf_file/0010/205687/Groundwater-management-framework-2130627.pdf

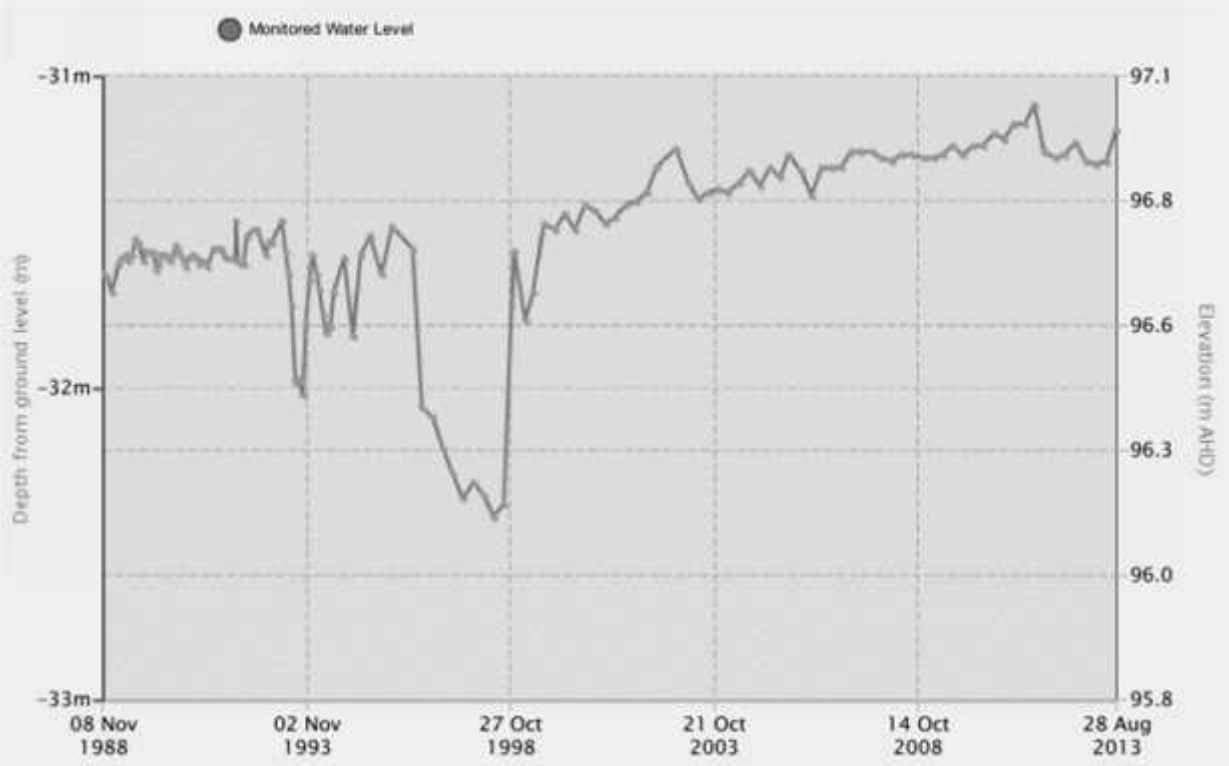

Figure 15 - Monitored Water Level - Groundwater Borehole 70221

Given the approx. 31m depth of the groundwater at the site and lack of beneficial use of the groundwater resource in the area due to high salinity levels, it is anticipated that there will be minimal risk of groundwater contamination caused by construction activities during the proposed development. It is highly unlikely that construction excavations that will intercept the groundwater table - the method of construction for turbine footings is yet to be determined, it is anticipated that a mass gravity type footing extending to a maximum depth of 3.5m (i.e. not piled, typical of peat wetland areas and not anchored typical of some hard rock sites). The quarry work plan will be drafted to a maximum/nominal depth of 10m only.

The only operational impacts on groundwater that are envisaged would be from a small septic disposal system that is installed for the wind farm site office facility which is expected to house an average 6 full time employees.

4.6 Rainfall

Long-term average rainfall data is indicated below for the two closest weather stations to the site:

Table 6 - Average rainfall and temperatures

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
HORSHAM POLKEMMET RD 33.6km South East (103 year record to 2012)													
max temp	29.8	29.8	26.4	21.6	17.2	14	13.4	15	17.6	21	24.8	27.7	21.5
min temp	13.1	13.3	11.2	8.3	6.2	4.4	3.7	4.3	5.5	7.1	9.5	11.5	8.2
rain (mm)	23.8	25.2	23.5	31.4	46.3	49.2	47	48.4	46	43.7	34.2	28.6	447
WARRACKNABEAL MUSEUM 21.8km North East of Site (45 year record to 2014)													
max temp	30.8	30.7	27.1	22.4	17.9	14.7	14	15.6	18.2	21.9	25.8	28.6	22.3
min temp	14.1	14.2	11.9	8.9	6.5	4.5	3.8	4.5	5.9	7.6	10.2	12.1	8.7
rain (mm)	26	21.5	20.9	26.2	39.1	37.6	40.5	43.4	40.9	37.7	31.3	28	393

Design storm event rainfall depths have been adopted from the Australian Government Bureau of Meteorology – Rainfall IFD Data System. The coordinates used for the rainfall site were taken from the centre of the wind farm site:

- Latitude: -36.432622˚ S
- Longitude: 142.316719˚ E

The adopted rainfall intensity chart is provided below (Figure 16).

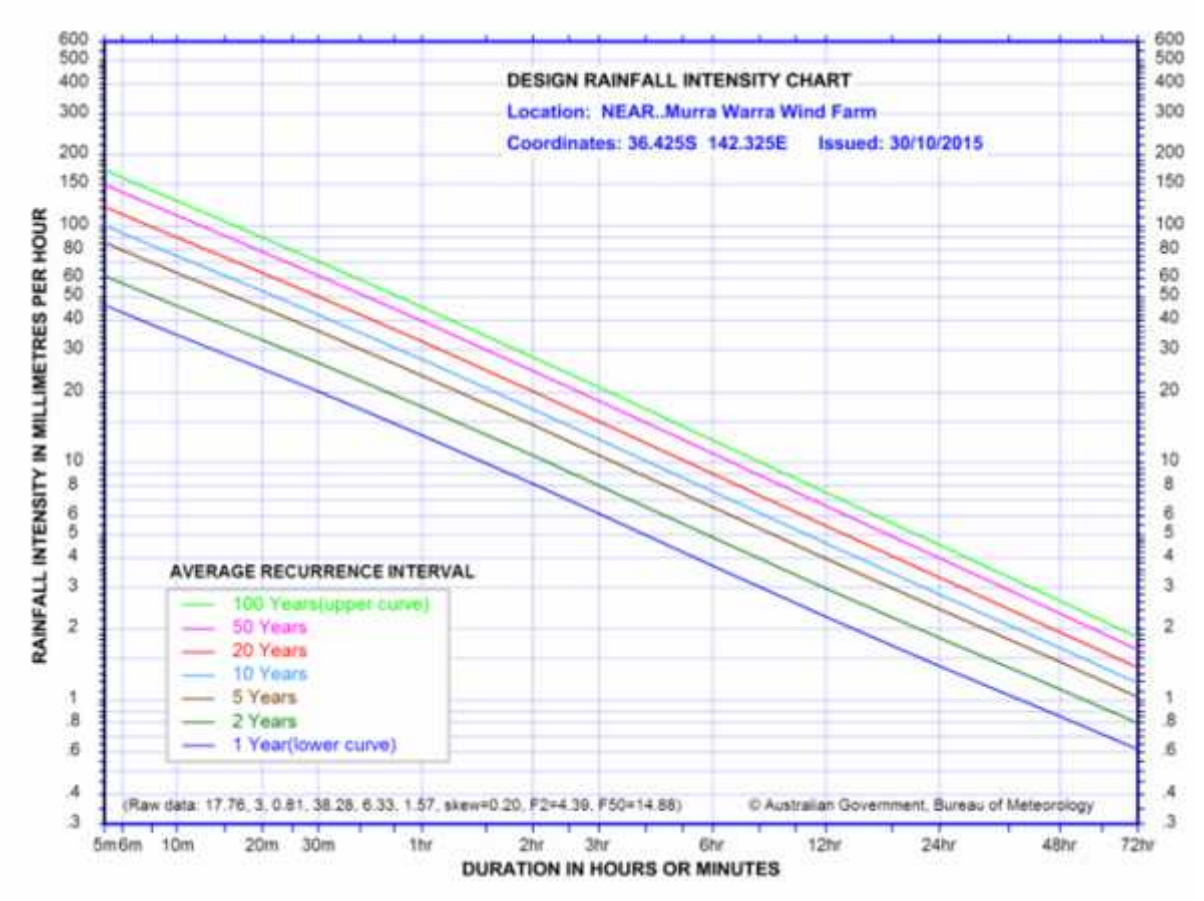

Figure 16 - Design Rainfall Intensity Chart

Table 7 below summarises the rainfall intensities for different return period storms with a range of durations. These values will be used as part of detail hydrologic and hydraulic design for all site drainage works.

Table 7 - Murra Warra Rainfall Intensities (mm/hr)

	Average Recurrence Interval						
Duration	**1 YEAR**	**2 YEARS**	**5 YEARS**	**10 YEARS**	**20 YEARS**	**50 YEARS**	**100 YEARS**
5Mins	46.4	61.7	85.3	101	121	150	173
6Mins	43.2	57.4	79.2	93.5	112	139	160
10Mins	34.8	46.2	63.6	74.9	89.8	111	128
20Mins	25.0	33.1	45.3	53.2	63.6	78.0	89.7
30Mins	20.1	26.5	36.1	42.3	50.5	61.8	71.0
1Hr	13.1	17.3	23.4	27.4	32.6	39.8	45.6
2Hrs	8.18	10.8	14.5	16.9	20.1	24.5	28.0
3Hrs	6.12	8.05	10.8	12.6	15.0	18.3	20.9
6Hrs	3.69	4.86	6.53	7.60	9.02	11.0	12.5
12Hrs	2.25	2.96	3.96	4.60	5.44	6.60	7.53
24Hrs	1.39	1.83	2.42	2.79	3.29	3.97	4.51
48Hrs	.854	1.11	1.45	1.66	1.93	2.32	2.62
72Hrs	.620	.799	1.03	1.18	1.37	1.63	1.84

(Raw data: 17.76, 3, 0.81, 38.28, 6.33, 1.57, skew=0.20, F2=4.39, F50=14.88) © Australian Government, Bureau of Meteorology

4.7 Site Drainage

As previously discussed, LIDAR survey information shows that a shallow and low lying ridge exists on the site with land generally sloping very gently north. The slope of the existing ground is so shallow that it is not considered there is any significant channelisation of local stormwater flows or any significant culvert crossings need to be considered for the development, but rather, the flows on the site can be characterised as sheet flow, with only minor localised ponding expected for even the most severe storm events. It is therefore concluded that widespread erosion of soils is not a significant risk for the development**.**

While stream and creek crossings scour risk is low for the site, during periods of high rainfall, the soils in the vicinity of the Wind Farm become saturated and the fine sandy/silty topsoil quickly builds up on vehicle wheels rendering driving on the existing ground surface (and surrounding unsealed roads and tracks) impossible. All weather roads are required for the construction and operation of the Wind Farm and to prevent pavements becoming completely saturated the existing ground track surfaces will need to be raised by a small amount as shown below in Figure below). For the Wind Farm track design, it is acceptable for inundation and overtopping of the tracks to occur from time to time during extreme rainfall events.

The final height of the track raising and track design will be determined closer to the time of construction however "crossing culverts" will be installed to prevent the damming and channelisation of sheet flows along tracks. Cross road drainage will be designed for at least the 5 year ARI event, with road longitudinal drainage, if required, designed for at least the 10 year ARI event.

Crossing culvert design, as for track design, will also be finalised prior to construction, however it will most likely consist of 375mm x 450mm box culverts (which are stronger than pipe culverts with shallow cover) installed at intervals of about 1,000m along tracks or more regularly depending on localised depressions in topography. Typical cross sections of the Wind Farm track are shown on the figure below.

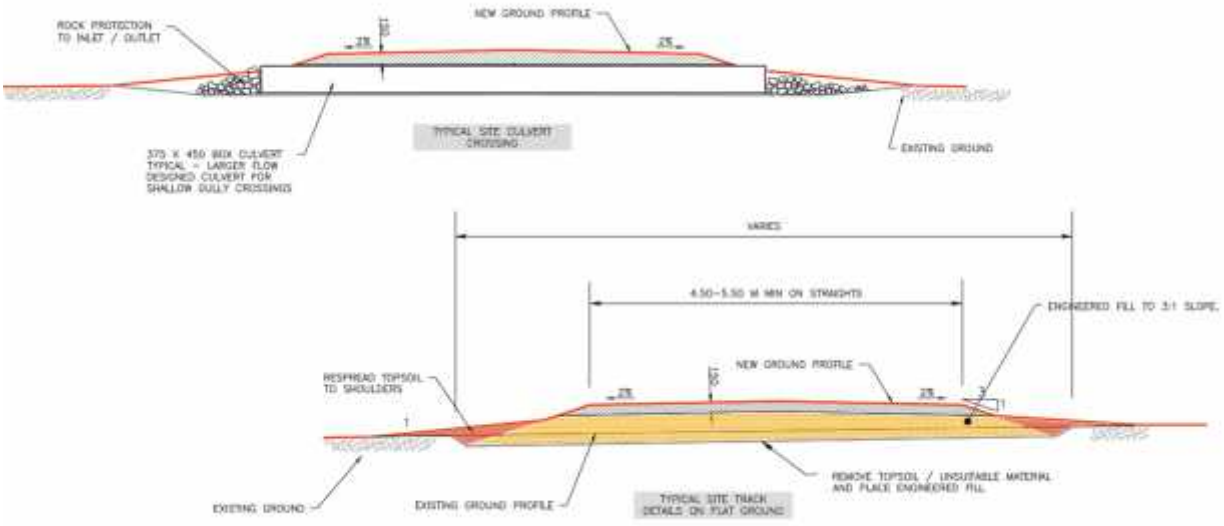

Figure 17 - Schematic Cross Sections of Wind Farm Track

5 DESIGN CONSIDERATION

5.1 Access Tracks and Hardstandings

Appropriate design, construction and maintenance of these access tracks will ensure that any effects upon soils and water flows can be minimised. A preliminary access track layout design has been undertaken with consideration of the following:

- minimise length of on-site track
- utilise the existing road network where possible
- land tenure constraints;
- vehicle manoeuvrability;
- safe sight distances;
- avoidance of ecologically sensitive areas;

The key point in minimising the impact of roads is to reduce the accumulation and channelling of water by dispersing it back into the usual catchment system.

5.2 Turbine Foundations

Although the locations of the turbines are primarily a function of wind resource modelling, micro-siting of the turbines should take account of the following considerations:

- avoid existing trees and vegetation;
- consider geological conditions to avoid areas with large depths of overburden and minimise the volume of excavation required; and
- avoid natural low-points which could disrupt natural water flow and/or drainage during wet periods.

6 CONSTRUCTION MITIGATION MEASURES

Control of erosion and potential sedimentation of waterways is a primary area of concern for works on-site. The design of the wind farm access tracks shall be undertaken with consideration of the sedimentation and erosion risks in accordance with the EPA document Construction Techniques for Sediment Pollution Control[16].

An assessment of the soil acidity will be undertaken prior to construction works commence with turbine foundation concrete mix specifications adjusted accordingly.

Mitigation strategies that would be employed during the construction phase to manage the potential for adverse environmental impacts as outlined below.

6.1 Access Tracks and Hardstandings

- Continual maintenance of drainage system and track and hard standing surfaces during construction;
- Site preparation works and major earthwork activity will be planned to occur during drier months. Where this is not possible, earthwork activity will be avoided during heavy rain events;
- Dust suppression regime for all roads and hard standings to be in place for the entire construction period including:
  - The amount of exposed earth left as a result of clearing (for site preparation) at any one time should be kept to a minimum;
  - All stockpiles to avoid loss of material during high wind events, and where practicable will be placed in areas sheltered from the wind. Where significant amounts of material are lost, a review of storage procedures should be undertaken to avoid recurrence of the event; and
  - Where vegetation is impacted by excessive dust emissions, remedial action is to be implemented, which may include revegetation of affected species;
- Stabilisation and rehabilitation of disturbed surfaces as soon as practicable after works; and
- Installation of erosion and sediment controls identified in the Soil and Water Management plan to be developed for the site (at the post-consent EMP stage).

6.2 Turbine Foundations

- During excavation for foundations, subsoil should be separated from topsoil for rehabilitation purposes. All topsoil from the excavation sites would be stockpiled and replaced to its original depth for seeding and fertilising;
- Landforms would be stabilised and rehabilitated as soon as practicable after works;

[16] EPA Victoria, May 1991. Construction Techniques for Sediment Polluton Control

- Stockpiling of material excavated from turbine bases should be placed outside drainage paths, protected with silt fences and covered at the end of the day;
- Areas disturbed during turbine installation, and not required to remain cleared, are to be reinstated to their previous condition (as far as practicable), or as agreed by landowners/Council; and
- Potential surface water contamination is perceived to increase when temporary concrete batching plant/s are proposed for use during construction. Careful consideration of the placement and management practices of any temporary concrete batching plant/s will need to occur; and suitable bunding arrangements adopted to prevent contamination of the surrounding soils.

There is a risk of contamination to soils as a result of hydrocarbon infiltration and on-site toilet facilities. The following mitigation measures should be considered during construction:

- allowance for bunded site storage areas for potential contaminants would be identified;
- storage of hydrocarbon spill kits on-site;
- operation and maintenance of machinery in a manner that minimises risk of hydrocarbon spill;
- concrete wash would be deposited in an excavated area, below the level of the topsoil; and
- minimise risk of chemical spills and ensure prompt and effective clean-up of any accidental spills.
- Ensure appropriate disposal of effluent from onsite staff facilities

7 OPERATIONAL MITIGATION MEASURES

The operational phase of the wind farm will require minimal use of on-site access tracks by maintenance personnel. The access tracks will be constructed to accommodate oversize and over mass loads. Once the wind farm is constructed, the access tracks would be available for use by the landowners to provide access throughout their properties. No soil or landform impacts are anticipated to be generated during the operational phase given the following recommended measures to restrict runoff and thus limiting off-site impacts:

- Development and instigation of a Soil and Water Management Plan;
- Monitoring of maintenance of drainage systems and sediment control devices and maintain as required;
- Construction mitigation measures listed above are instigated if sizable maintenance works are required; and
- All vehicles on-site shall follow established tracks.

8 FURTHER INVESTIGATIONS

The findings above are based on a combination of a desktop study of the information available at the time of the assessment, as listed above, a site reconnaissance by RES' Civil Engineer and Construction Manager and preliminary geological mapping and test pitting of selected sites. It is recommended that further studies and investigations are undertaken post-consent to identify issues and appropriate mitigation measures. These include:

- Development of a detailed Soil and Water Management Plan, to be included in a future Environmental Management Plan (EMP);
- Potential occurrence of Acid Sulphate Soils (ASS)
- Detailed design of the site drainage system; and
- Intrusive geotechnical investigations be carried out prior to construction works commencing on-site to confirm the information gathered, to identify soils of erosion or dispersion risk and enable safe and efficient design of turbine foundations, tracks, hard standings and site buildings.

9 CONCLUSIONS

The site investigations carried out to date for the proposed wind farm development have comprised a desktop study and a number of site inspections and assessments.

The proposed Murra Warra wind farm is located approximately 32 km northeast of Horsham, immediately north and south of the section of Minyip-Dimboola Road that runs between the Blue Ribbon Road and the Henty Highway. The site has a total area of approximately 4,200 hectares and is currently utilised for broad acre cropping.

Based on the information available at the time of writing the report the following conclusions and recommendations are made:

- Construction of turbine sites, working platforms and site tracks has, given the very flat nature of the site, minimal potential to affect or modify existing surface drainage pathways, cause erosion, sedimentation, or generate turbid run-off. Any impacts during construction and over the long term can either be eliminated or mitigated by adopting appropriate design practices and careful construction techniques.
- Provided that the principles above are implemented any effects of construction on the groundwater table are likely to be negligible in the short and long term. There is currently very little existing beneficial use of the existing saline water table by local landowners. The groundwater table is approximately 30m below the existing ground level. No construction excavations (including proposed quarry sites) will intercept the ground water table.
- There are no waterways of significance within the site area and the obsolete irrigation channels (since replaced by a piped rural water supply system) are not required for local storm water management with many of them already having been filled in. Through careful management during construction, any minor impacts to surface water can be avoided.
- Potential surface water contamination is perceived to increase when temporary concrete batching plant/s are proposed for use during construction. Careful consideration of the placement and management practices of any temporary concrete batching plant/s will need to occur.
- No water quality impacts are anticipated to be generated during the operational phase due to the minimal use of tracks during operation of the wind farm.
- RES intends to develop a quarry on site to reduce the number of road construction deliveries required for construction. Preliminary site investigations and testing indicate that the material will be suitable for the construction of tracks and hardstands. One site has been identified for which a work plan will be applied as part of the AEI permit application process for the Wind Farm.

Therefore, based on an assessment of the subject site's geology and hydrology features, it is considered that the granting of consent for the development of a proposed *Wind Farm Project* would not be considered likely to result in any significant adverse impact upon the soil and water features of the subject site and surrounding area and the proposal would be capable of complying with relevantly applicable legislation and guidelines.

APPENDIX A - DRAWINGS

Drawing 1: Murra Warra Wind Farm Location Plan

Drawing 2: Murra Warra Wind Farm Site Topography and Drainage

Drawing 3: Murra Warra Wind Farm Regional Hydrology

Drawing 4: Murra Warra Wind Farm Infrastructure Drawing

APPENDIX B – GEOLOGICAL MAPS

APPENDIX C – BOREHOLE LOGS

APPENDIX D – FLOOD MAPS

APPENDIX E – WIMMERA MALLE PIPELINE PROJECT - AS CONSTRUCTED

APPENDIX F – QUARRY INVESTIGATIONS AND RESULTS

APPENDIX G – WIMMERA CMA CONSULTATION