

**APPENDIX A**

# Results of Desktop Study

## DESKTOP STUDY

The following sets out the results of the desktop study. The information gathered through the course of the desktop study has been used to inform the impact assessment which is set out in this report.

### Topographic setting

The topographic setting of the site is presented on Figure 1. The following comments relate to the topography of the site:

- The WTG locations are predominantly located on a remnant plateau formed by the Thorpdale Volcanics geological unit. The plateau has been incised, with predominant drainage direction to the north east. Surface levels range between about 100 m AHD in creek valleys on the eastern side of the site to 260 m AHD on the crest of hills.
- Due to inferred relict landslide features, the site has an irregular, or 'stepped' surface over some areas, with several hundred metres separating prominent breaks in slope.
- The drainage courses are valleys with relatively steep sided (20° to 30°) slopes. There is evidence for recent landslide activity on the sides of some of the gullies. Silver Creek and Stony Creek are two prominent drainage courses that flow towards the north east from the site.
- Catchment dams have been constructed in some natural drainage paths for agricultural purposes.
- The Kennedy Haulage quarry is located near the centre of the site and comprises two pits from which materials of the Thorpdale Volcanics are extracted.
- There are numerous forestry roads throughout the area in various states of repair and accessibility.

## Geology and subsurface materials

### Regional geology

The 1:63,360 scale geological mapsheet for Mirboo North (GSV, 1967, see Figure 2) shows the surface geology in the project area to consist primarily of Tertiary (Oligocene) age Thorpdale Volcanics (formally Thorpdale Volcanic Group), described on the mapsheet as comprising basic lava flows, plugs, dykes and pyroclastics, along with interbedded bands of clay and coal. Limited areas of outcropping Tertiary (Oligocene) age Childers Formation have been recorded beneath the Thorpdale Volcanics near the centre of the project area. The Childers Formation consists of sand, clay, conglomerate, gravel, quartzite and thin brown coal seams. The Tertiary (Pliocene to Miocene) age Latrobe Valley Group is mapped in the north and south of the project area, interbedded with the Thorpdale Volcanics and Childers Formation. Minor areas of Quaternary aged alluvium are mapped within creek channels. Basement rock beneath the site is expected to be of the Cretaceous age Wonthaggi Formation, although this is not mapped as outcropping within the project area. This is composed of sandstone and siltstone with minor conglomerate and black coal.

### Near surface materials

With reference to Figure 2, there are two predominant geological units that are expected to underlie the site. Most of the site, including around Delburn are expected to be underlain by the Eocene to Oligocene Older Volcanics (Thorpdale Volcanics). The eastern and part of the southern part of the site are expected to be

underlain by the more recent Pliocene to Miocene age Latrobe Valley Group, although based on the current WTG layout, a maximum of six WTG locations are expected to be underlain by this material.

Localised Quaternary alluvium is expected to be present around water courses, although this material is not expected to significantly influence the development of the DWF. A brief description of the main geological units expected at the surface of the site is provided in Table A1. We anticipate there could be local areas of uncontrolled (i.e. non-engineered) fill associated with past activities on the site including works associated with logging activities.

**Table A1: Anticipated near surface geological units**

Age	Unit reference	Map symbol	Description
Quaternary (Holocene)	Unit 1	Qra	Alluvium – gravel, sand, silt and clay (fluvial deposits).
Latrobe Valley Group (Pliocene to Miocene)	Unit 2	Tph	Sand, silt, gravel and ferruginous sand. Interbedded with sand and clay in varying proportion.
Thorpdale Volcanics (Eocene to Oligocene)	Unit 3	Tvd	Basic Lava and associated pyroclastics, basic plugs, dykes, interbedded clay and coal.

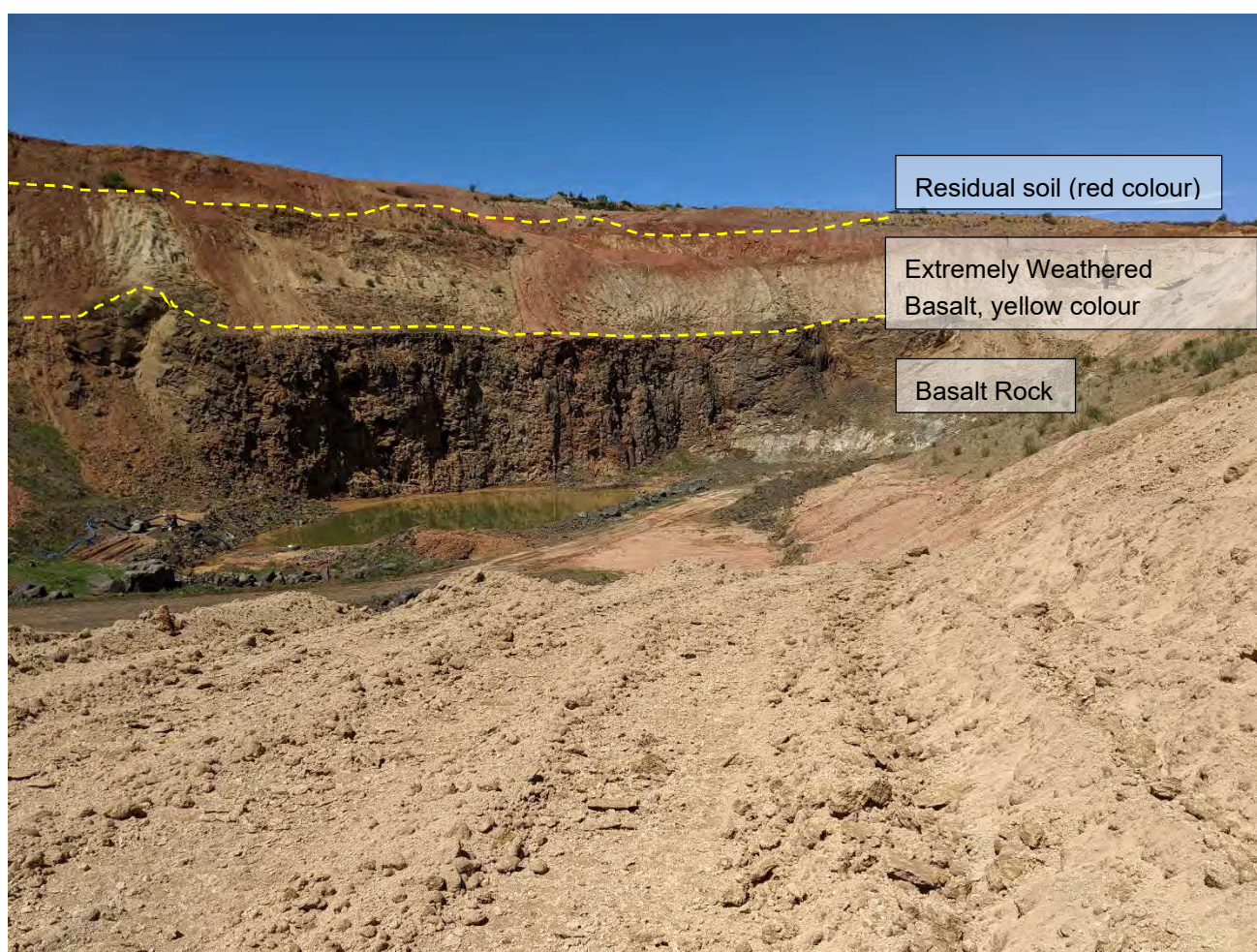
Note that given the Unit 2 (Latrobe Valley Group) materials are expected to be interbedded with the Unit 3 materials (Thorpdale Volcanics), it is possible that excavation near the geological boundaries, will pass through the Latrobe Valley Group and into the Thorpdale Volcanics. Note that the geological map appears to indicate that WTG T32 is to be located on alluvial materials. However, site inspections indicate this is unlikely to be the case.

## Weathering

The upper portions of the Unit 3 Thorpdale Volcanics which are expected to underlie most of the proposed WTG are typically deeply weathered to a red-brown high plasticity clay, which is characteristic of the Thorpdale area. This clay is susceptible to volume changes in response to moisture changes. The clay is expected to be underlain by basalt rock, however the depth to basalt can be highly variable.

The Unit 2 Latrobe Valley Group shows some evidence of weathering, including ferruginisation whereby there is some cementation of sand by iron oxides and occasional very high strength ferricretes.

Exposures through the Thorpdale Volcanics observed in the Kennedy Haulage Quarry along with borehole logs provided by quarry management indicate a varied subsurface profile through this material. In general, the profile comprises a 6 m to 7 m thick layer of high plasticity clay inferred to have derived from the in situ weathering of the Thorpdale Volcanics. This is underlain by inferred extremely weathered basalt, which occurs as a hard clay to low strength rock and has a characteristic yellow colour. There appears to be multiple layers and varied distribution of the extremely weathered basalt before competent basalt rock is typically encountered at a depth of 15 m or more, noting that at some locations in the vicinity of the quarry, the basalt rock is encountered near surface. A profile within the Thorpdale Volcanics observed at the Kennedy Quarry is shown in Plate A1.



**Plate A1: General profile exposed in Kennedy Haulage Quarry**

Silcrete rock was observed at one location within the vicinity of the quarry and appears to be present near the top of the extremely weathered basalt.

No exposures were observed through the Latrobe Valley Group. However, past experience with this material indicates that it is typically a dense to very dense sand or hard clay containing a variable proportion of clay to sand.

## Groundwater

### Aquifer units

The main hydrostratigraphic units in the project area and their properties are summarised in Table A2.

**Table A2: Summary of regional hydrogeological units**

Unit	Thickness (m)	Aquifer type	Typical salinity (TDS, mg/L)	Typical bore yield (L/s)
Thorpdale Volcanics	Up to 60	Unconfined and confined fractured basalt aquifer	Less than 1,000	Variable, less than 4

Unit	Thickness (m)	Aquifer type	Typical salinity (TDS, mg/L)	Typical bore yield (L/s)
Childers Formation	40 to 50	Confined sand aquifer	Less than 1,000	Less than 5
Latrobe Valley Group	> 100	Sand and gravel aquifers locally confined by interbedded coal and clay	Less than 900	Up to 150
Wonthaggi Formation	> 100	Fractured rock aquifer	1,000 to 3,500	Less than 5

## Sources:

Nott, 2004. Groundwater Occurrence in the Gippsland Basin. Department of Sustainability and Environment, Note No. 5.

Lahey & Tickell, 1980. Explanatory Notes on the Western Port Groundwater Basin 1:100 000 Hydrogeological Map.

Geological Survey of Victoria, Report #69.

Australian Stratigraphic Units Database. <https://asud.ga.gov.au/search-stratigraphic-units/>

## Groundwater levels

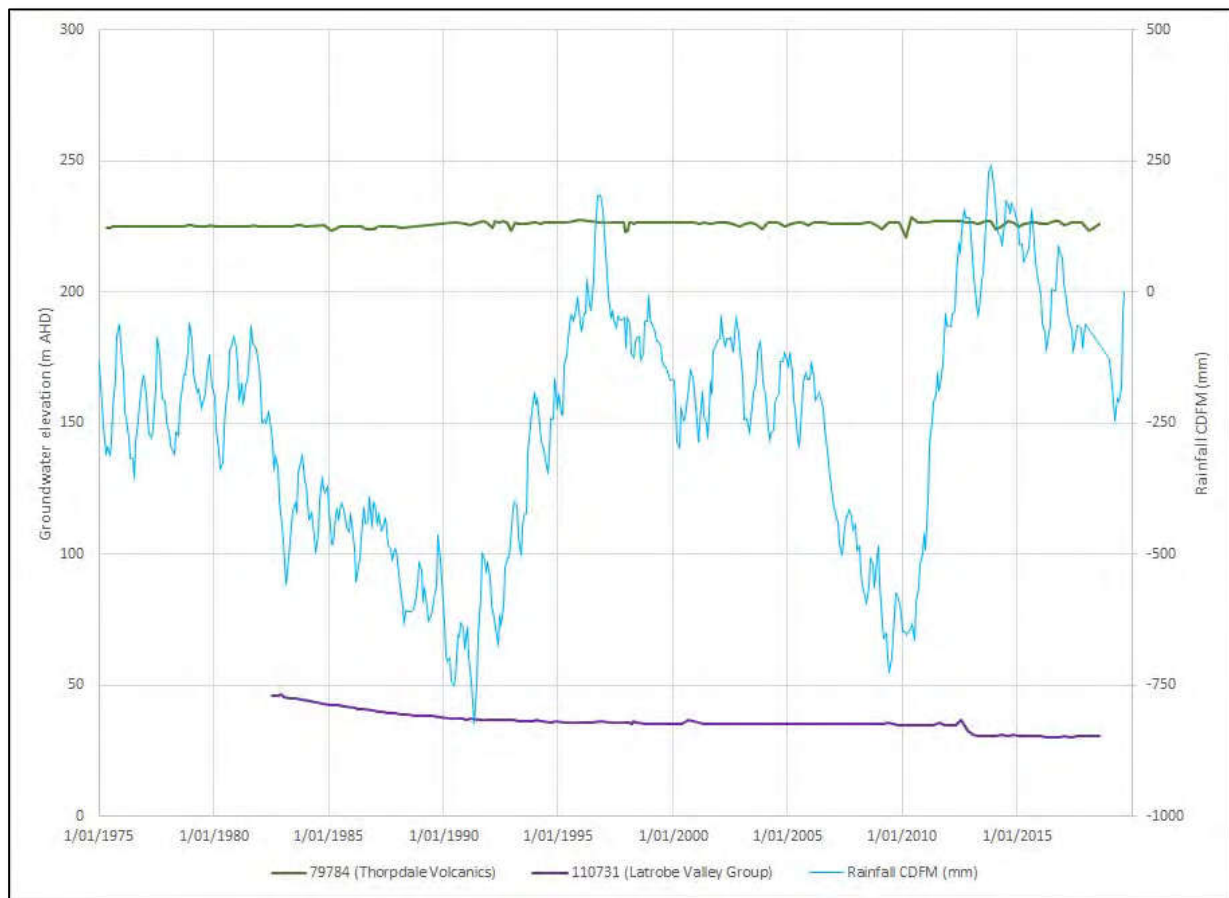
Groundwater levels in the project area estimated as part of state-wide mapping of groundwater levels as part of the Victorian Aquifer Framework are shown in Figure 4. This indicates that depth to groundwater across the project area is likely to range from less than 5 metres below ground level (m bgl), in topographically lower areas close to streams, to over 100 m bgl in areas of higher elevation. Based on this map, depth to groundwater at the eight proposed wind turbine locations (WTG16, WTG 21, WTG 34, WTG 35, WTG 36, WTG 38, WTG 43, WTG 49) may be less than 20 m bgl. Further investigation may be warranted near these locations to confirm actual groundwater levels.

A search of registered boreholes on the Water Management Information System (WMIS) maintained by the Department of Environment, Land, Water and Planning (DELWP) was undertaken to identify the monitoring wells for which long term groundwater level monitoring data may be available. Two monitoring wells with groundwater level information (IDs 110731 and 79784) were identified within 5 km of the site. The groundwater levels observed in these bores are shown in Plate A2, along with the rainfall residual mass curve. Rainfall data was obtained from the Mirboo North Water Board weather station (BOM station #85282), approximately 7 km south-west of the project area.

Bore 110731, located approximately 2.5 km to the east of the project area, is recorded as 200 m deep, but the screened interval and lithology is not reported. Based on the surface geology and depth, this bore is likely to intersect the Latrobe Valley Group. A declining in groundwater level of approximately 9 m was recorded between 1982, when the well was installed, and 2000. Groundwater level then remained relatively stable from 2000 to 2012, declined by approximately 4 m from 2012 to 2013, then remained relatively stable to 2018. The most recent groundwater level recorded (August 2018) indicates a depth to water of approximately 62 m, corresponding to an elevation of approximately 30 m AHD.

Bore 79784, located approximately 4.9 km to the west, is screened from 21 m bgl to 37 m bgl, within the Thorpdale Volcanics. The groundwater level has remained relatively stable over the period of monitoring (from 1975 to 2018). The most recent groundwater level (August 2018) records indicate groundwater to be approximately at the ground surface level, corresponding to an elevation of 226 m AHD.





**Plate A2: Groundwater level at registered wells**

### Groundwater flow system and receptors

Surface topography is commonly inferred to be a good indication of a water-table aquifer flow system. Local flow towards streams would be expected, with regional flow to the east or north-east towards the Morwell River. The Morwell River and its tributaries in the project area fall within the Central Foothills and Coastal Plains Segment under the State Environment Protection Policy (SEPP Waters) (2018). Waterways within this segment are considered to be slightly to moderately modified, so a 95% level of protection applies when selecting water quality objectives.

Aquatic groundwater dependent ecosystems are mapped (BOM Groundwater Dependent Ecosystems Atlas) along the various creeks which cross the project area (See Figure 5):

- Little Morwell River,
- Stony Creek,
- Silver Creek,
- Ten Mile Creek,
- Bird's Gully,
- Wilderness Creek.

This indicates that the creeks are likely to be receptors of groundwater discharge, and associated ecosystems rely on the surface expression of groundwater. Terrestrial groundwater dependent ecosystems are mapped in scattered locations across and surrounding the project area. These areas have the potential for vegetation to be reliant on sub-surface groundwater. Much of the GDE mapping is based on remote sensing data, and would require confirmation on the ground.

Regionally, groundwater levels and flow within the Latrobe Valley Group aquifers are known to be influenced by dewatering of the Latrobe Valley coal mines (SRW, 2012). This influence may not extend to the adjacent/overlying Thorpdale Volcanics and Childers Formation. The Morwell open cut is located approximately 4 km to the north-east of the project area, beyond the Morwell River.

## Groundwater quality

State-wide mapping indicates shallow groundwater in the project area is likely to have salinity of less than 1,000 mg/L.

A review of information on groundwater quality in the project area was undertaken using the information provided in the WMIS database. A total of nine wells were identified with chemical data available within 5 km of the site. All available information was collected in the 1970s. A summary of the available data is provided in Table A3. The data indicate that salinity is generally below 500 mg/L, and pH, chloride and sulphate concentrations indicate non-aggressive groundwater conditions, with reference to AS2159-2009: Exposure classification for steel or concrete piles. However, as none of these wells is located within the project area, and the age of the data, it is recommended to confirm groundwater chemistry within the project area if structures are likely to intersect groundwater.

**Table A3: Summary of chemistry results from registered wells**

Well ID	pH	EC ( $\mu$ S/cm)	Total Soluble Salts (mg/L)	Chloride (mg/L)	Sulphate (mg/L)
76630	8.0	2740	1,670	653	39
79778	8.2	454	326	58.5	15
79779	7.3	305	119	47	3
79784	8.1	660	409	77.5	-
79822	6.6	550	322	139	1
84155	8.1	554.5	392	61.5	10
84156	8.2	466	353	50	7
84157	8.0	795	-	117	-
84274	7.1	322	235	59	3

## Groundwater use

The results of a search of the WMIS database of registered groundwater wells within 5 km of the site is summarised in Table A4. A total of 77 wells are registered within the project area, but none have an extractive use listed. The realised beneficial uses in the project area identified from the search are domestic use, use for stock watering, industrial (dairy) use and dewatering. A large number of wells are registered as SEC use (State Electricity Commission). The SEC wells are thought to have been drilled for coal exploration prior to 1992, and are not likely to represent ongoing extractive use of groundwater. Dewatering bores are associated with the Yallourn open cut, approximately 4 km to the north of the project area. The location of registered wells along with their use is presented in Figure 4.

**Table A4: Registered groundwater wells within 5 km**

Groundwater Use	Number of Registered Bores within Project Area	Number of Registered Bores within 5 km of Project Area
Domestic and/or Stock	0	14
Irrigation	0	7
Dairy	0	3
Dewatering	0	53
Investigation/Observation	0	5
SEC	71	2729
Not Known	6	33

The entire project area is within both the Rosedale and Stratford Groundwater Management Areas (GMAs). The Rosedale GMA applies to “Middle Aquifers”. In the project area, this would include the Morwell Formation and Yallourn Formation of the Latrobe Valley Group (i.e. upper part). The Stratford GMA applies to “Lower Aquifers”. In the project area, this would include the Thorpdale Volcanics, Childers Formation and Traralgon Formation/Burong Formation of the Latrobe Valley Group (i.e. lower part). Permission to extract groundwater would need to be sought from Southern Rural Water, subject to availability within the Permissible Consumptive Volume (PCV) for each GMA.

The Victorian Mineral Springs Database does not list any mineral springs in the project area. However, spring-fed creeks are common in the Thorpdale area, over the Thorpdale Volcanics (SRW, 2012<sup>1</sup>), so it is possible that groundwater springs other than mineral water are also present in the project area.

## Earthquake

A review of earthquake epicentre records on the Geovic website indicates there have been earthquakes with magnitude up to 5.4 within about 3 km of the proposed DWF. Figure 3.2(A) of Australian Standard AS1170.4 –

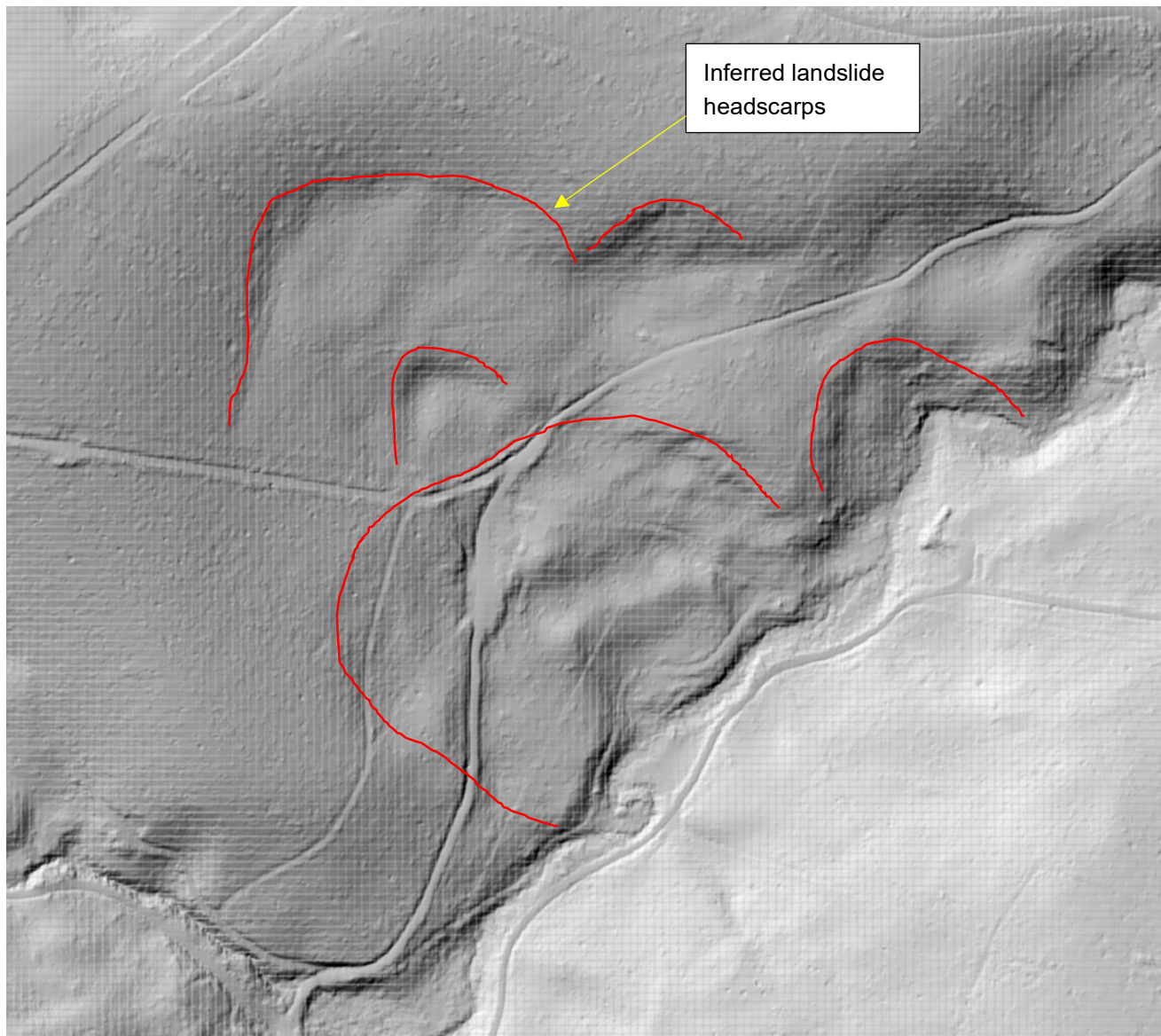
<sup>1</sup> Southern Rural Water, 2012. Gippsland Groundwater Atlas.



2007 'Structural design actions Part 4: Earthquake actions in Australia' indicates that the hazard factor ( $z$ ) for the Delburn region is 0.11.

## Landslide and slope instability

Review of the digital terrain model by a principal engineering geologist has been undertaken to identify areas that appear to have been subject to previous slope instability. The residual soils of the Thorpdale Volcanics are known to be susceptible to landslides, with several landslides previously occurring around the Thorpdale area. Relict landslides have been identified based on indications in the digital terrain model, similar to that presented in Plate A3.



**Plate A3: Example of inferred landslide within project area**

Figure 3 indicates areas inferred to be subject to landslide and slope instability. These susceptible areas are typically associated with steeper slopes in the vicinity of water courses.

Field visit suggested that whilst there is evidence for past large scale landslide activity, there is no evidence for recent large scale landslide activity. Slightly hummocky and stepped ground observed in some locations appears to be indicative of historical landslides, probably thousands of years old. An example of stepped ground is presented in Plate A4 where the distance between breaks in slope is several hundred metres.



**Plate A4: Example of stepped ground, track into WTG41**

One example of a recent landslide was observed whilst traversing between WTG 8 and 9 (Plate A5), noting that the landslide was not observed to be at a WTG location. The landslide was observed to be about 30 m wide and had occurred on an approximately 30 degree slope, noting that this is one of the steepest slopes within the proposed wind farm area.





**Plate A5: Example of recent landslide, traverse between WTG 8 and WTG 9**

We note that no evidence for recent landslide activity was observed at any of the WTG locations visited during the site visit.

## Sites of geological significance

The GeoVic website does not identify any sites of geological significance within the project boundaries.

## Acid sulfate soils

The CSIRO Acid Sulfate Soils Probability map indicate generally a “low probability of occurrence” to “extremely low probability of occurrence” in the vicinity of the site. However, discrete localised areas of “high probability of occurrence” are present in the vicinity of the site located near waterbodies.

## Surface hydrology

The GeoVic website indicates that the site is not located within a designated water supply catchment area. However, the Narracan Creek Catchment area is located within 1.2 km of the western site boundary. The

project site does not appear to be within any declared water supply catchment or groundwater water supply protection areas.

## Sources of select fill and aggregate

During the site visit of the Kennedy Haulage quarry, observation was made of the products produced by the quarry. Based on discussions with quarry management, we understand that materials produced in the quarry are typically used for road construction, including most of the logging tracks within the proposed wind farm area. We were also provided with laboratory test results for some of the materials produced by the quarry. The following products are produced at the quarry:

- VicRoads 20 mm and 40 mm Class 3 and Class 4 crushed rock.
- 7 mm and 14 mm concrete aggregates.
- Various 'resheet' mixes, generally derived from extremely weathered basalt and screened to 20 or 40 mm minus.
- Various non-descript crushed rock products and spalls.

Based on our preliminary observations and on the test results viewed, we expect that the Kennedy Haulage quarry will be a feasible source of most of the select fill and aggregate products required for the project, including concrete aggregates and road base materials. However, this preliminary indication is subject to detailed assessment of specific material and volume requirements.

## Historical aerial photographs

Commercially available historical aerial photographs were obtained for review. The observations from the review are summarised in Table A5 and copies of the historical aerial photographs are provided in Appendix B.

**Table A5: Aerial photograph observations**

Date of Photograph Run	Notes
1945	The available photograph only covers the central northern portion of the site. This portion of the site mostly consists of tree covered areas with visible paddocks and roadways across the area. Rural residential dwellings and farm sheds are scattered across the area. A disturbed area is located between the proposed locations of WT08 and WT09 and to the west of WT45.
1965	The site mostly consists of tree covered areas with some visible paddocks and roadways. Inferred cropping is evident in the south of the site.
1980s	The available photographs cover limited sections of the site. The visible areas of the site appear to be generally unchanged from the 1965 photographs.

Date of Photograph Run	Notes
2010s (NearMap)	The site mostly consists of tree covered areas with some visible paddocks and roadways. Some areas have been cleared of trees since the previous photographs. A disturbed area is located in the north of the site. Kennedys Quarry is visible in the centre of the site. There does not appear to be any dwellings on the site however numerous dwellings and farm sheds are located near the boundary of the site. A number of creeks and surface water bodies are evident within the site.

## Environmental Protection Authority database

### Certificates and Statements of Environmental Audit (EPA Victoria)

Certificates and Statements of Environmental Audit are statutory documents that are issued after a statutory environmental audit of a property has been conducted. A *Certificate of Environmental Audit* is issued for property where, following an audit, an environmental auditor believes the environmental condition of the land is suitable for any beneficial use. A *Statement of Environmental Audit* is issued where, following an audit, an environmental auditor believes the land is not suitable for all possible beneficial uses, but is suitable for specific uses or developments; it may contain conditions of clean-up or management of contamination.

A search of the EPA Victoria 'List of Issued Certificates and Statements of Environmental Audit' and Visualising Victoria's Groundwater website did not identify any completed environmental audits within 1 km of the site.

The closest environmental audit to the site boundary is located approximately 7 km east north east from the closest corner of the site and was completed in 2002 (CARMS No. 47803-1).

### Groundwater Quality Restricted Use Zones (EPA Victoria website)

A groundwater quality restricted use zone (GQRUZ) is an EPA declared area where, following an environmental audit, groundwater pollution remains, usually as a result of previous industrial activity. A GQRUZ is implemented when attempts have been made to clean up the groundwater and EPA determines that restrictions should remain on how the water can be used without further treatment.

A search of Visualising Victoria's Groundwater website indicates there are no GQRUZs within 1 km of the site.

### EPA Priority Sites Register (EPA Victoria)

The Priority Sites Register lists sites for which the EPA has issued a Clean-Up Notice (CUN) or a Pollution Abatement Notice (PAN) pursuant to sections of the *Environment Protection Act 1970*. The condition of these sites is not compatible with the current or approved use of the site without active management to reduce the risk to human health and the environment. Such management can include clean-up, monitoring and/or institutional controls.

The Priority Sites Register (current to 30 September 2019) does not list the site, or any site within 1 km of the site.



## Post Closure Pollution Abatement Notices

Following closure, landfills continue to pose risks to the environment. In order to ensure that the risks are appropriately quantified and managed, owners of closed landfill sites are issued with a Post Closure Pollution Abatement Notices (PC PAN) that requires the closed landfill to be managed so there are no unacceptable risks to the environment.

EPA Victoria maintains a database for locating issued PC PAN documents (EPA Interaction Portal). The database was queried 28 October 2019 and did not list any PC PANs within the townships/localities (Boolarra, Darlimurla, Delburn, Driffield, Hernes Oak, Narracan and Yinnar) that intersect the site.

## Victorian Landfill Register

Publicly available to all Victorians, the Victorian Landfill Register (VLR) draws information from various sources. It lists all current and known closed landfills in Victoria. Information contained in the VLR is intended to be used only as a guide and is not to be relied upon as being either complete or accurate. The VLR brings together information from:

- EPA landfill licences and post closure pollution abatement notices;
- Regional Waste and Resource Recovery Implementation Plans; and
- Historic landfill records held by EPA.

Sites that are located within 500 m of landfills, or former landfills may require further assessment for potential ground gas risks, such as methane.

The VLR interactive webpage was queried on 28 October 2019 and shows that an operating landfill is located 750 m to the north of the site (at its closest point) and is operated by Energy Australia Yallourn Pty Ltd, the type of waste received was not available on the VLR. No other landfills were listed on the register within a 1 km radius of the site.

An interest search of Energy Australia Yallourn Pty Ltd found that Energy Australia Yallourn submitted a Financial Assurance proposal to the Victorian EPA for three operational landfills located at Yallourn. The three landfills include an ash landfill, a hard waste landfill and an asbestos landfill. The Financial Assurance Proposal was approved by EPA in December 2018.

Additionally, the VLR interactive webpage shows that an operational landfill is located at the Hazelwood Power Complex and receives ceramic-based fibres, asbestos and ash waste, the landfill is located approximately 1.7 km south east of the site at its closest point.