MEMO

TO:	State of Queensland – Minister for Economic Development Queensland
FROM:	WSP Australia Pty Ltd
SUBJECT:	**Preliminary Assessment of Salisbury Plains for Large-Scale Wind Project Development**
OUR REF:	PS201111-WIN-MEM-001 RevB Salisbury Wind Update.docx
DATE:	**9 June 2023**

1. INTRODUCTION

The Minister for Economic Development of Queensland (EDQ), on behalf of the State Government of Queensland has requested WSP Australia Pty Limited (WSP) to undertake an update to the previous assessments of the long-term wind regime of the Salisbury Plains site.

An initial analysis was undertaken by WSP in 2019 that aimed to assess the suitability of the prospective site for potential large-scale wind farm development [1]. The preliminary assessment relied upon data measurements from the 10 m Abbot Point mast, supported by mesoscale wind data. In 2022, an updated analysis was conducted using one (1) year of onsite wind data, captured by means of a Sodar unit installed on site [2].

The updated analysis detailed in this report relies on a further year of onsite wind data from the Sodar, with a total measurement period of 2.4 years.

The Salisbury Plains Wind Project (SPWP) is located approximately 30 km west of Bowen and 7 km south of Abbot Point Port, Queensland. The prospective site is owned, in freehold, by EDQ and is located within the Abbot Point State Development Area [3].

The site is located less than 1 km from the coast. Bruce Highway travels across the site and separates the prospective development area into a northern and southern section. The northern section consists of simple terrain with minimal forestry while the southern section contains Mount Roundback, with areas of dense forestry and some areas of simple terrain to the southwest side of the section.

Figure 1.1 illustrates SPWP and surrounding landmarks.

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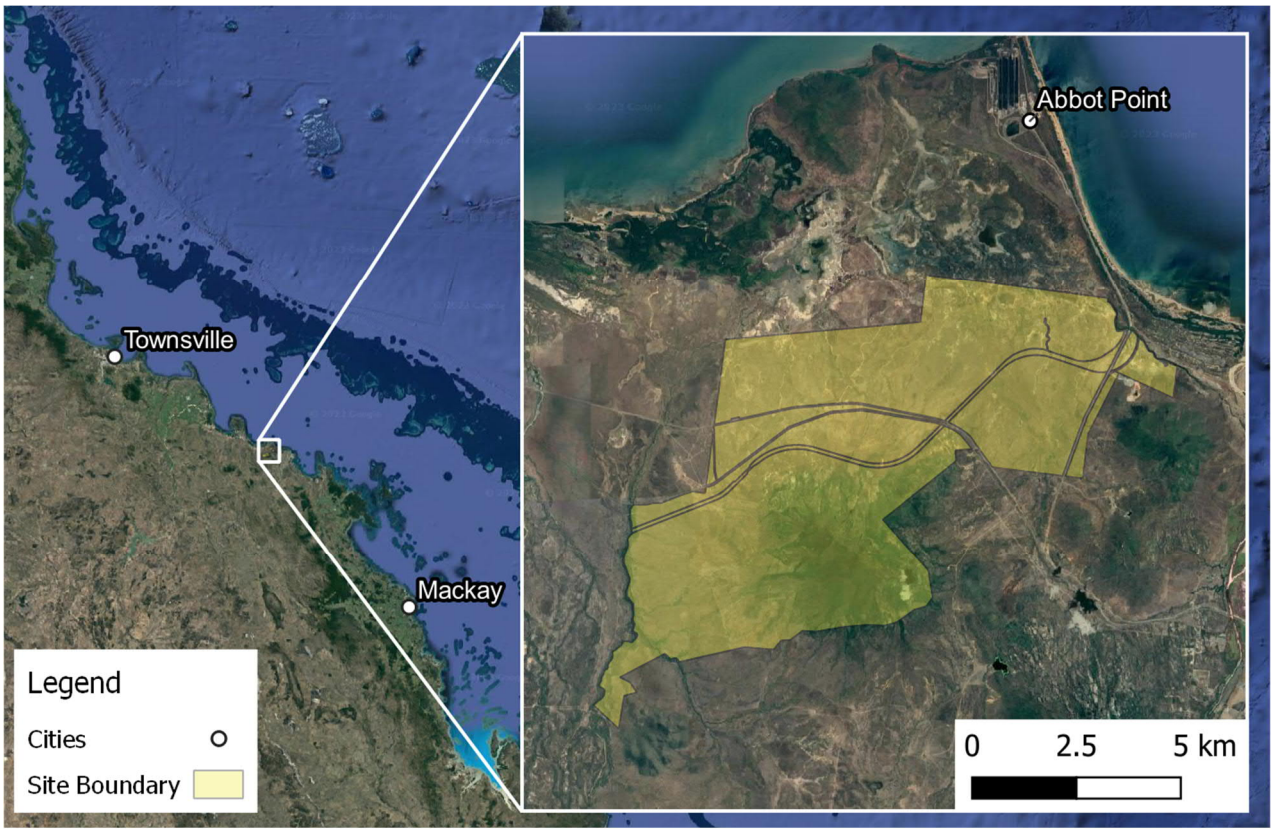

Figure 1.1: Salisbury Plains development area (SPWP)

2. SCOPE

The following section outlines WSP's approach and methodology for undertaking the desktop analysis of the long-term wind regime at the SPWP. The preliminary assessment of the SPWP intends to provide a review of the site wind resource for suitability for a potential large-scale wind farm development. As per WSP's variation request *Salisbury Plains WF Variation Request_001* [4], works within this assessment involved the following steps:

- Analysis of onsite wind data: WSP has processed the additional data from the same Sodar considered in the previous assessment [2]. WSP has processed the dataset to remove suspicious data as well as any seasonal bias. This is further discussed in Section 4.2.
- Long term adjustment: WSP has assessed the measured wind dataset on site for representation of the site's long-term wind regime. This is discussed further in Section 5 of this document.
- Shear extrapolation to potential hub height: using the Wind Atlas Analysis and Application Program (WAsP) WSP has extrapolated the site wind regime to a hub height of 160 m. This is discussed further in Section 5.3.
- Wind flow model: WSP has used WindPro v3.6 and WAsP v12.8 to create the wind flow model across the site, as discussed in Section 5.4.
- Preliminary layout assessment: WSP has used the wind flow model to conduct a high-level layout assessment that considers an indicative number and location of turbines that can be placed within the site boundary.
- Conclusions and recommendations for next steps required for the successful development of SPWP.

3. INPUT DATA

EDQ has supplied WSP with wind data measured at SPWP. The site wind monitoring campaign began in October 2012 with the installation of the 10 m Abbot Point Meteorological Mast (APMM), followed by the deployment of a Fulcrum3D Sodar unit (FS1M_1159) in November 2020.

This assessment has relied on Sodar data downloaded up until 11th April 2023 (approximately 15 additional months of data since the previous assessment). The Sodar was deployed adjacent to APMM at the end of November 2020, approximately 60 m southeast of the mast. The area surrounding both monitoring locations is considered flat, simple terrain with low lying grass in all directions.

APMM consists of a Vaisala ultrasonic anemometer mounted at a height of 10 m above ground level (AGL). APMM is generally configured with lower grade instrumentation and is not deemed of sufficient quality for inclusion in a financial-grade wind energy yield assessment.

In the previous assessment, wind data from APMM was analysed qualitatively and used to correct for the wind direction measurements at the Sodar. It was not used as an input to the wind flow model [2]. In this updated assessment, further wind data has been downloaded from APMM to update the qualitative analysis of the wind characteristics on site. Again, it has not been used quantitively as input to the wind flow model.

In addition to the supplied onsite data, WSP has procured several long-term reference datasets to supplement onsite measurements at SPWP and obtain an indicative estimate of the long-term wind regime at SPWP.

Table 3.1 details the supplied and procured data used in this assessment.

Table 3.1 Input Data for SPWP Wind Analysis

ITEM	DESCRIPTION	SOURCE
Met Measurement Data – Abbot Point	Wind and environmental data measured from the Vaisala met station unit provided in local time.	EDQ Supplied [5], [6]
Ultrasonic Sensor Datasheet	Vaisala Weather Transmitter WXT530 datasheet – EDQ have indicated that the supplied datasheet is for a newer version of the ultrasonic sensor.	EDQ Supplied [7]
Salisbury Plains Sodar (SN: FS1M_1159)	Wind and environmental data measured from the Fulcrum3D Sodar unit provided in local time	EDQ Supplied [6]
Long-Term Data	Long-term Reanalysis wind data from several long-term reference sources	WSP Procured [8] [9]

4. DATA COLLECTION AND QUALITY CONTROL

4.1 WIND MEASUREMENT SUMMARY

As mentioned previously, the wind measurement campaign at SPWP began in October 2012 with the installation of a 10 m mast, APMM. A Vaisala ultrasonic anemometer was installed at the top of the mast and has been recording data consistently up to present. WSP notes that the anemometer has not been calibrated nor has viewed the exact associated instrument datasheet. The QLD Department of Environment and Science (DES) currently owns and operates the APMM mast. EDQ has provided the datasheet for a newer model, Vaisala Ultrasonic WTXT530 and WSP has been informed that the specifications have remained mostly unchanged with the newer model [10].

Based on the documentation provided, WSP notes that the anemometer has a measurement uncertainty of 3% for wind speeds at 10 m/s and is compliant to IEC Standards [7]. It should be noted that this is considered on the higher end of instrument uncertainties considered appropriate for financial-grade wind and energy assessments.

Following the preliminary analysis undertaken by WSP in 2019, the Sodar unit was deployed on site in November 2020. The unit is located approximately 60 m southeast of the APMM mast and has been recording wind measurements from 50 m up to 200 m AGL.

Table 4.1 outlines the monitoring campaign and the data period considered at SPWP. Figure 4.1 illustrates the locations of the mast and Sodar at SPWP

Table 4.1 SPWP Site Monitoring Campaign (Zone 55L, WGS84 datum)

Monitoring location	Easting	Northing	Elevation	Monitoring period	Measurement height
	[m]	[m]	[m AMSL]		[m]
APMM	609,687	7,793,754	15.0	12/10/2012 – 30/04/2023	10
SODAR	609,743	7,793,726	15.0	24/11/2020 – 11/04/2023	50-200

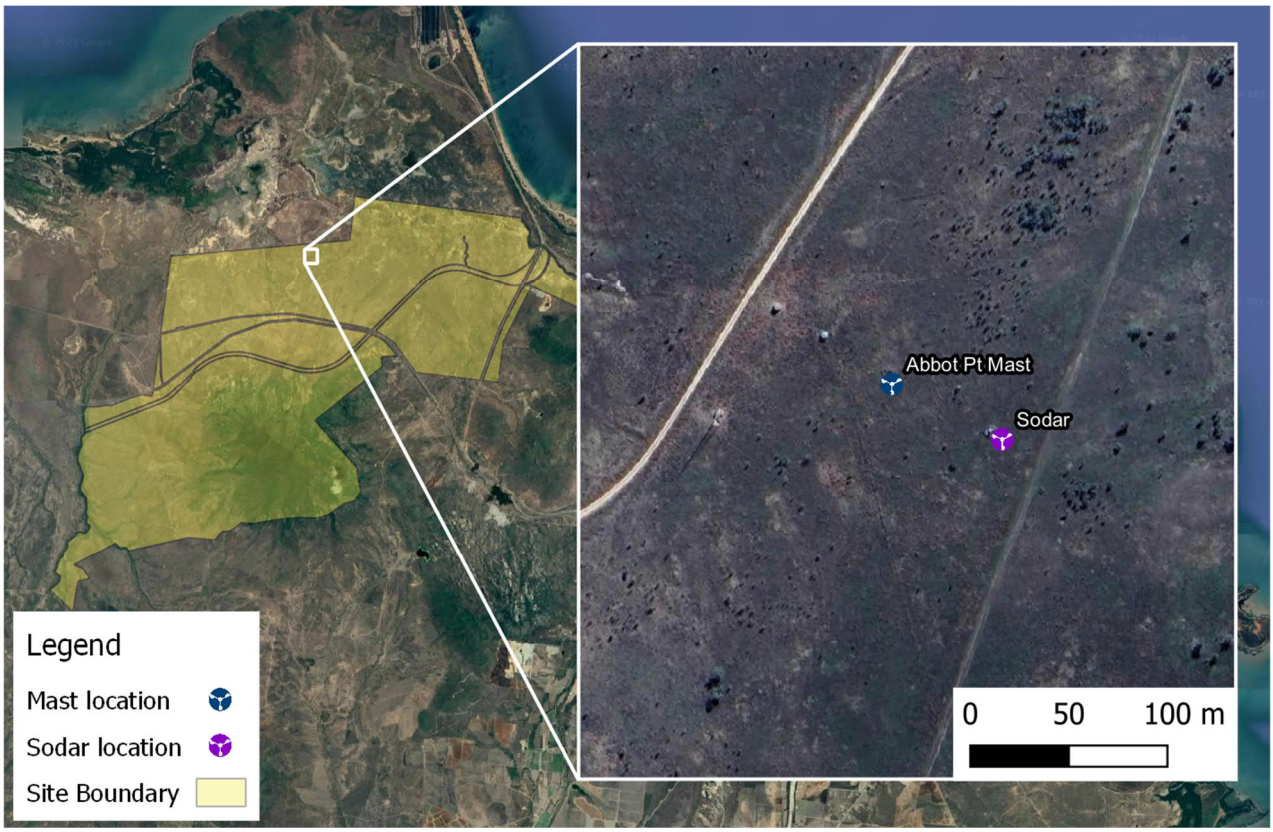

Figure 4.1 Wind monitoring locations at SPWP

4.2 INPUT DATA QUALITY ASSURANCE

Data recorded at the APMM was accessed via the Queensland Government website [5] [6]. In the previous assessment, yearly datasets for the period spanning from 2012 up to and including 2020 were downloaded and compared against monthly versions of the APMM datasets and it was observed that all monthly datasets were in UTC while the yearly datasets were in UTC+9 hours. The 2021 dataset was provided directly to WSP, with the timestamp in local time (UTC+10hours) [11]. WSP then retrospectively corrected all datasets to local time (UTC+10 hours) and reviewed the complete dataset to ensure all remaining data is valid and free of erroneous values.

In this updated assessment, WSP downloaded additional mast data up to and including April 2023. This was downloaded in UTC. Data recorded at the Sodar was also accessed via the Queensland Government website [6]. The data was provided in both UTC and local time (UTC+10 hours) for measurement heights ranging from 50 m up to 200 m (inclusive).

WSP has reviewed all data recorded by the Sodar and excluded any data corresponding to a Signal-to-Noise Ratio (SNR) less than 7, as per manufacturer's recommendations [12]. Further cleaning of the dataset was conducted to remove any remaining suspect data.

4.3 MEASURED DATA STATISTICS

The data measured on site has been analysed to provide insight into the wind characteristics at SPWP. The analyses have been completed using the measured wind data, cleaned of erroneous values and with no further data processing applied.

WSP has the following comments and recommendations based on the review of the measured data at SPWP:

- The prevailing wind direction at SPWP is south-easterly.
- The turbulence intensity (TI) generally appears relatively consistent from all sectors, with slightly above average turbulence intensity from the south-west and slightly below average turbulence intensity from south-east.

However it should be noted TI measurements from a Sodar are generally not deemed acceptable for use in a bankable wind and energy yield assessment.

- Wind speeds are observed to increase at APMM and the Sodar throughout the daytime for measurement levels up to approximately 140 m. For Sodar measurement heights of 150 and 160 m there is less diurnal variability, and for heights above 160 m, the wind speeds are observed to be higher at night. WSP however also notes there is lower data coverage at the upper heights, and the drop in coverage may not be capturing the diurnal variation sufficiently. WSP recommends that a conventional meteorological mast is installed as close to hub height as possible to confirm the wind speed fluctuations on a diurnal basis.

While WSP has observed a good level of correlation between the Sodar and the APMM mast, there is still some uncertainty associated with the absolute wind speeds recorded by the Sodar. It is recommended that the performance of a Sodar unit is verified against a conventional mast.

The duration of the site wind monitoring campaign can be found in Table 4.1. Please note that the periods shown represent the overall duration of the dataset, as provided by EDQ, prior to any data review undertaken by WSP.

Table 4.2 illustrate the monthly data coverage [%] of the measurements taken by the Sodar on site at 160 m AGL following the quality assurance checking undertaken by WSP.

Table 4.2 Data availability of the Sodar at 160 m AGL (filtered measured data)

YEAR	MONTH											
	1	2	3	4	5	6	7	8	9	10	11	12
2020	-	-	-	-	-	-	-	-	-	-	19.3[1]	88.2
2021	91.9	80.3	88.1	93.9	93.8	89.8	90.4	90.4	91.3	81.8	86.6	87.4
2022	79.6	81.7	79.8	94.5	88.0	92.0	89.5	87.8	86.7	87.3	86.0	87.7
2023	77.8	83.0	80.1	25.4[1]	-	-	-	-	-	-	-	-

Notes:
1) Low coverage due to incomplete months

Table 4.3 illustrates the monthly data coverage [%] of the measurements taken by APMM at 10 m AGL, following the quality assurance checking undertaken by WSP.

Table 4.3 Data availability of the APMM mast at 10 m agl

YEAR	MONTH											
	1	2	3	4	5	6	7	8	9	10	11	12
2012	-	-	-	-	-	-	-	-	-	62.1	100.0	100.0
2013	96.1	99.0	99.1	99.9	100.0	100.0	100.0	99.9	98.8	100.0	99.6	100.0
2014	100.0	99.7	95.7	100.0	100.0	99.9	100.0	90.5	-	-	34.9	100.0
2015	100.0	100.0	100.0	100.0	100.0	100.0	99.9	100.0	100.0	100.0	100.0	100.0
2016	100.0	98.4	88.2	100.0	99.9	100.0	100.0	100.0	99.7	0.1	87.9	100.0
2017	100.0	100.0	73.7	-	17.5	98.9	99.3	99.6	100.0	100.0	100.0	100.0
2018	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.9	100.0	100.0
2019	100.0	100.0	100.0	99.7	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2020	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	96.9

YEAR	MONTH											
	1	2	3	4	5	6	7	8	9	10	11	12
2021	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	97.2	100.0
2022	100.0	100.0	99.7	100.0	99.9	100.0	99.1	99.5	100.0	100.0	100.0	100.0
2023	100.0	99.9	100.0	100.0	-	-	-	-	-	-	-	-

Figure 4.2 to Figure 4.5 illustrate the measured wind climate at SPWP.

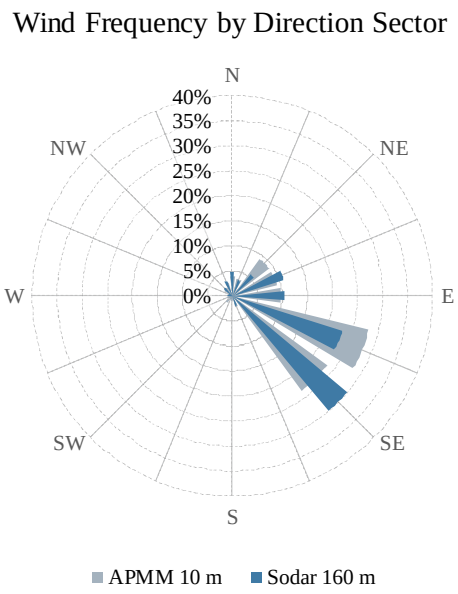

Figure 4.2 Wind frequency by sector

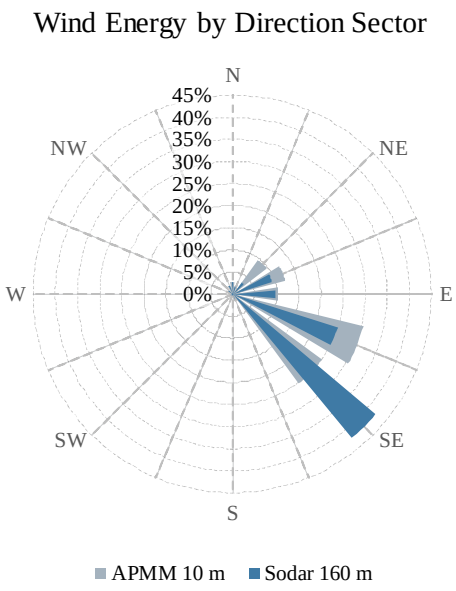

Figure 4.3: Wind Energy by Direction Sector (%)

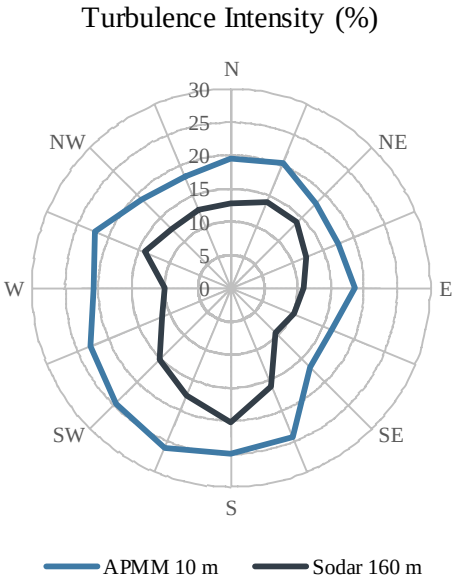

Figure 4.4: Turbulence Intensity (%)

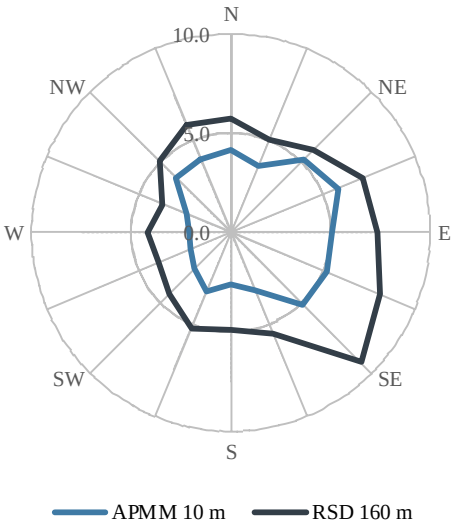

Figure 4.5: Mean Wind Speed (m/s)

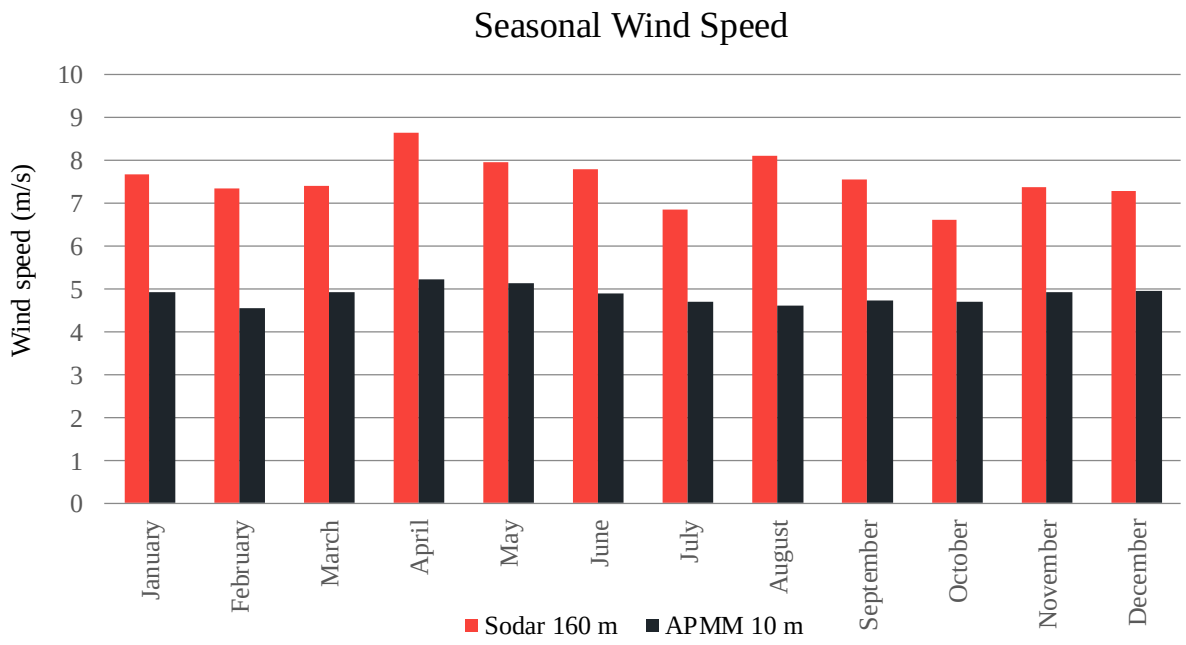

Figure 4.6 Seasonal Wind Speeds at SPWP

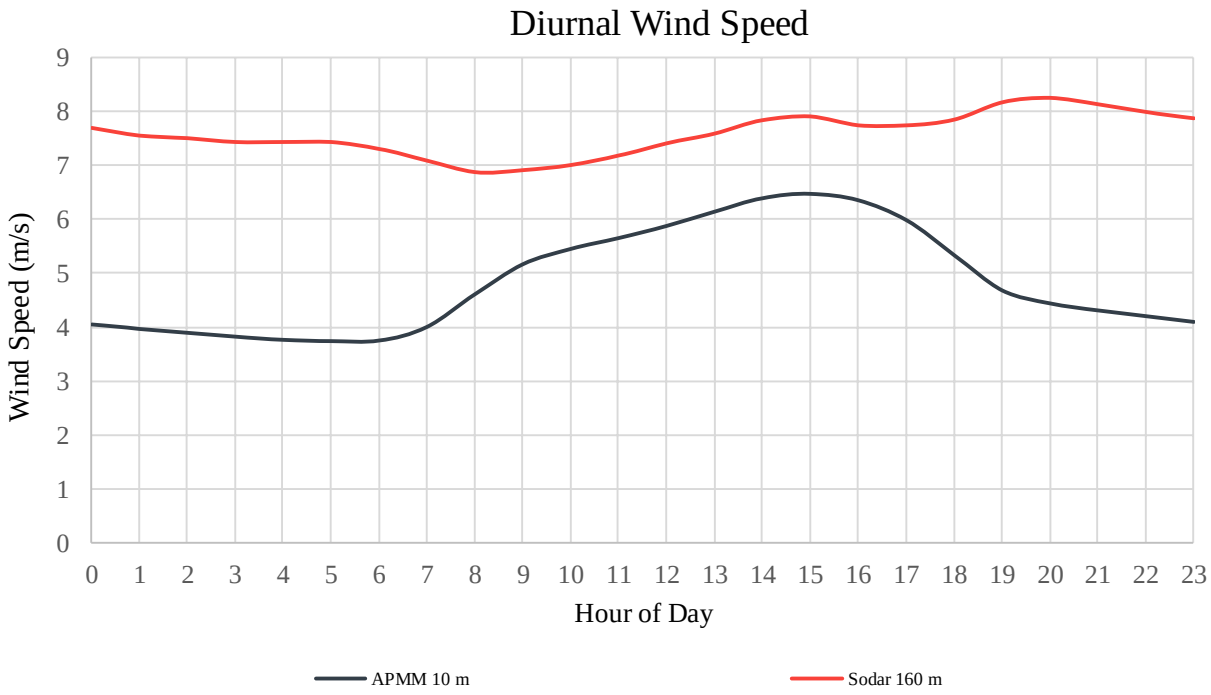

Figure 4.7 Measured Diurnal Wind Speed Trend at SPWP

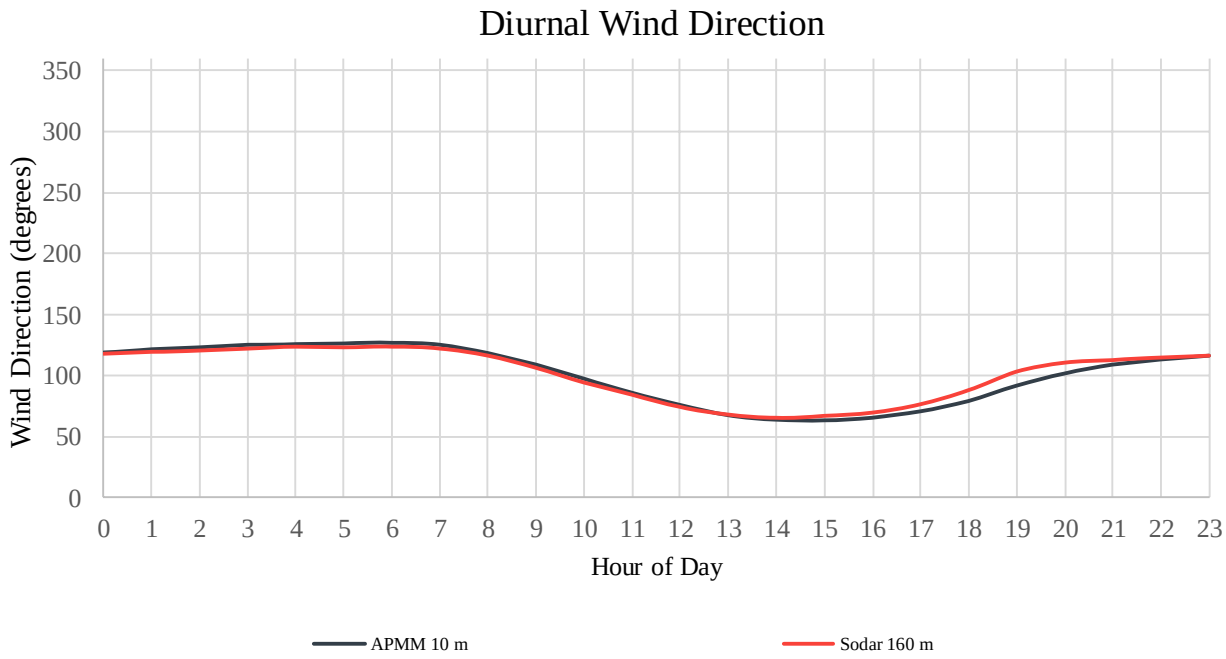

Figure 4.8 Measured Diurnal Wind Direction Trend at SPWP

5. LONG TERM WIND REGIME

As stated in the previous section, the wind measurement campaign at SPWP began in October 2012, with the installation of a 10 m tubular mast, APMM. In November 2020, a Sodar unit was installed approximately 60 m southeast of the mast. To date, the wind measurement campaign consists of one (1) meteorological mast and one (1) Sodar unit, providing measurements up to 200 m AGL.

Calibrated data from each monitoring location was provided by EDQ for the period spanning from October 2012 up to April 2023. It should be noted that calibration certificates for the anemometer installed at APMM were not provided and WSP has been unable to verify that the correct transfer functions were applied at the logger on site. This is considered further below.

Due to the natural annual variability of the wind speed across the site, it is expected that the on-site measured datasets are not representative of the long-term wind regime. As such, WSP has adopted the following methodology in order to derive a long-term wind regime at SPWP:

- Each dataset was subject to rigorous quality assurance checking processes where suspect data were identified and subsequently removed from the analysis
- In order to extend the data availability at the Sodar at 160 m, self-correlations were undertaken using the lower levels of measurement.
- Despite the close proximity of the mast to the Sodar, the lower level of measurement (10 m) at the mast did not allow for a mast-Sodar equivalency analysis. As such, it is not possible to verify the performance of the Sodar on site. However, the correlations observed between the Sodar and the mast generally showed good agreement between the two locations.
- WSP has also identified the nearby sources of long-term reference and evaluated their suitability as a potential source of long-term reference data for SPWP. In total, six (6) long-term data sources were evaluated for use as a suitable long-term wind speed reference for SPWP. The locations of these six (6) long-term reference sources are detailed in Table 5.1 and shown graphically in Figure 5.1.

Each of the above-mentioned datasets underwent appropriate cleaning and filtering to remove invalid and erroneous data before assessment for suitability as a long-term reference.

Table 5.1 Details of the long-term references at SPWP

Reference Source	Approximate distance to Sodar	Valid data date range	Easting	Northing
	[km]		UTM ZONE 55L (WGS84) [m]	
ERA5$_t$ Node 1	7.5	Jan 2004 – Mar 2023	604,609	7,788,206
ERA5$_t$ Node 2	21.8	Jan 2004 – Mar 2023	630,765	7,788,031
ERA5 Node 1	19.7	Jan 2004 – Mar 2023	598,013	7,777,878
ERA5 Node 2	23.4	Jan 2004 – Mar 2023	627,645	7,808,792
MERRA2 Node 1	9.7	Jan 2004 – Mar 2023	617,687	7,788,123
MERRA2 Node 2	57.7	Jan 2004 – Mar 2023	552,303	7,788,441

Figure 5.1: Locations of long-term references relative to SPWP

5.1 CORRELATION WITH SITE DATA

WSP is aware of various inconsistencies that can often be present in wind data due to changes in surrounding vegetation and objects, changes to logging equipment and intermittent measurements. These inconsistencies can also be present in Reanalysis datasets due to variation in model inputs from ground-based observations and changes to satellite meteorology and measurement streams [13].

WSP has endeavoured to identify inconsistencies in the datasets through statistical comparison of all long-term datasets against one another. This method identifies trends of variation that may be considered artificial in nature. The most common trends include:

- Signal drifts – causes may include anemometer degradation or growth of surrounding vegetation
- Step changes – causes may include tree felling, erection of new obstacles or new satellite data.

To select the most suitable reference site, WSP conducted a monthly average consistency test between the concurrent monthly periods common to each reference source using normalised wind speeds and the longest on-site measured dataset (APMM). The consistency of each dataset has been analysed on normalised wind speeds as a time series.

Figure 5.2 shows a 12-month moving average of normalised wind speeds for each source of long-term reference considered here. For the sake of comparison, the data recorded at APMM 10 m is also depicted in the figure below.

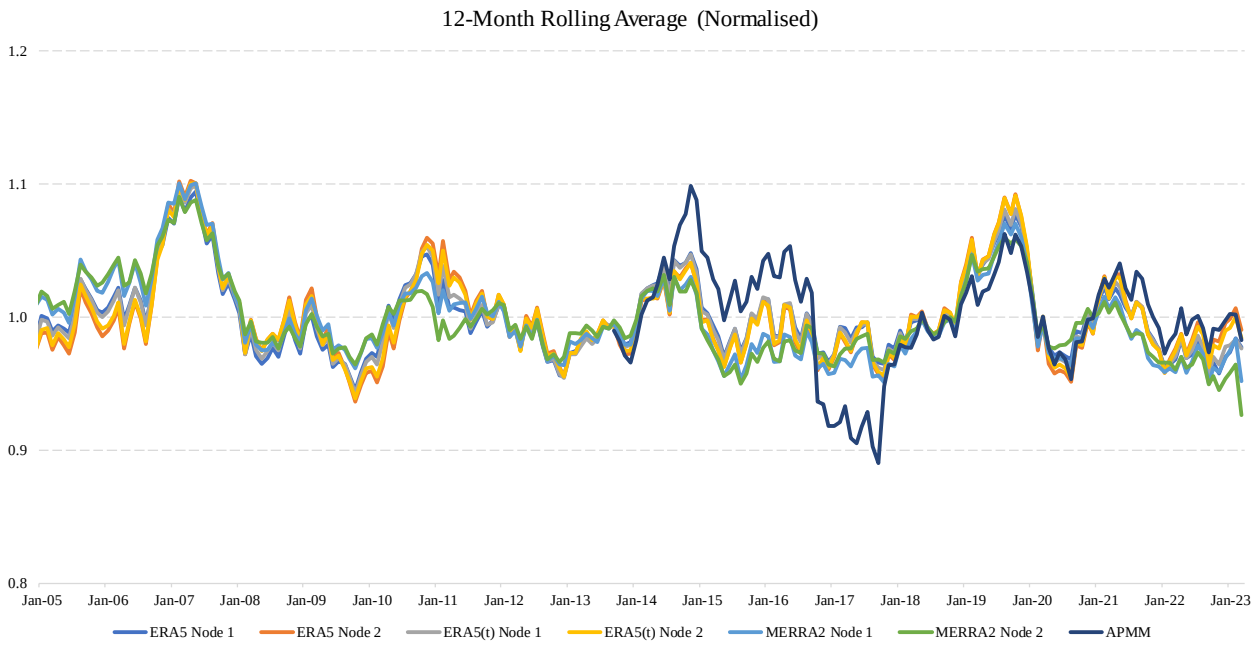

Figure 5.2: 12-month rolling average of normalised wind speeds at reference stations

All nodes from ERA-5 (Gaussian and Rectangular (t)) and MERRA-2 reanalysis datasets align well with each other, and annual trends in wind speed fluctuations. The measured data from APMM also follows the general trend. However, there appears to be larger variations at APMM prior to January 2018, consistent with the gaps observed in the measured dataset from 2012 up to the end of 2017. Overall, all sources of long-term reference were found to be consistent with the measured regime at SPWP, indicating their suitability as a potential source of long-term reference.

Following this, a multi-dimensional correlation study has been conducted between the reference data and the data measured at the Sodar to evaluate the linearity with the on-site measured data. All data has been correlated to the Sodar dataset, which has been deemed as the most suitable source of site data. The Sodar has been installed adjacent to the APMM mast since 2020 and has been recording data consistently at several measurement levels including at 160 m agl, the proposed indicative hub height at SPWP.

WSP has used a linear regression model to assess the long-term reference data against the Sodar dataset. All data is averaged over an hourly basis to reflect a uniform timestamp comparison across each dataset and was further averaged to daily for correlation purposes, as further discussed in section 5.2.

Table 5.2 Correlation between Sodar and long term reference datasets (daily average)

LONG-TERM REFERENCE SOURCE	CORRELATION WITH SODAR (R)
$ERA5_t$ Node 1	0.957
$ERA5_t$ Node 2	0.954
ERA5 Node 1	0.951
ERA5 Node 2	0.952
MERRA2 Node 1	0.923
MERRA2 Node 2	0.915

From the results of the consistency assessment and correlation study the following conclusions were made:

- $ERA5_t$ Node 1 at 100 m showed the highest correlation to the onsite data, due to the similar nature of the surrounding terrain of the location of the node and the Sodar. Both were of a similar distance to the coast and appear to have similar terrain exposure
- Both MERRA nodes also shows a relatively limited correlation to onsite data. Although, the MERRA-2 reanalysis dataset nodes are located close to the site, it is derived at a height of 50 m above the ground and is situated closer to the town of Bowen.
- The dataset recorded at APMM was not considered in the long-term analysis of the SPWP wind regime due to the lower level of measurement (10 m) available at the location, and the inconsistency observed in Figure 5.2.

From the results of the consistency assessment and correlation study, WSP deemed that the long-term wind regime at SPWP is accurately captured by the $ERA5_t$ Node 1.

5.2 SUMMARY OF LONG-TERM WIND REGIME

There are currently two (2) available sources of ERA5 Reanalysis data, namely the native ERA5 Gaussian Grid and the interpolated $ERA5_t$ Rectangular Grid. $ERA5_t$ is the most up to date data available and is derived from an interpolated, regular geographical grid at a horizontal resolution of ~28 km. ERA5 datasets were introduced in 2018 to replace the original ERA-Interim dataset.

ERA5 is created by the European Centre for Medium-Range Weather Forecasts (ECMWF); an independent intergovernmental organisation supported by most of the nations of Europe. ERA5 is an hourly average dataset that covers the Earth on a 30 km gaussian grid, and resolves the atmosphere using 137 levels from the surface up to a height of 80 km.

WSP procured approximately 19 years of $ERA5_t$ Reanalysis data for the period from January 2004 up to April 2023.

WSP has processed the data from the selected long-term reference source to remove any invalid data and annualise the dataset to account for seasonal bias. The remaining data has been analysed and a summary of dataset statistics is presented in Table 5.3.

Table 5.3 $ERA5_t$ Node 1 data summary (annualised)

WIND DATA CHARACTERISTICS	
Start Date	January 2004
End Date	April 2023
Duration [years]	19
Recording Interval [min]	60

WIND DATA CHARACTERISTICS	
Height [m]	100.0
Overall Average [m/s]	6.2
Data Recovery [%]	100.0

The ERA5$_t$ Node 1 was correlated to the Sodar at SPWP using daily averages, due to the difference in the diurnal patterns between the reference site and SPWP. The daily correlation method removes the fluctuations in wind speed and direction on a daily basis by means of a moving 24-hour rolling average method which averages each recorded sample with the previous 24 hours of data. WSP has used a linear regression model to predict the long-term wind speed at the Sodar at 160 m.

The results of the correlation, including the coefficients and long-term mean wind speed are shown in Table 5.4

Table 5.4 Sodar Annual long-term wind speeds

	Measurement height [m]	Annual period [yrs]	LT reference period [yrs]	Correlation coefficient [R]	Measured wind speed [m/s]	LT wind speed [m/s]
SODAR	160.0	2.0	19.0	0.957	7.4	7.5

5.3 WIND SHEAR PROFILE

While the Sodar provides wind speed measurements at the proposed hub height of 160 m, WSP has also assessed the measured shear profile at the location, using the Power Law Shear model. The magnitude of wind shear is known to vary with four main variables:

- Wind direction - the unique topography in each direction has its own influence on wind shear;
- Time of day - thermal effects during the day often result in a lower wind shear than that experienced at night;
- Season - varying surface roughness associated with changes in vegetation characteristics, together with changes in thermal effects and varying climate regimes that typically exist across seasons, and
- Wind speed, turbulence levels and the impact of topographical features depend on wind speed.

The measured shear profile at SPWP at the Sodar location is illustrated in Figure 5.3

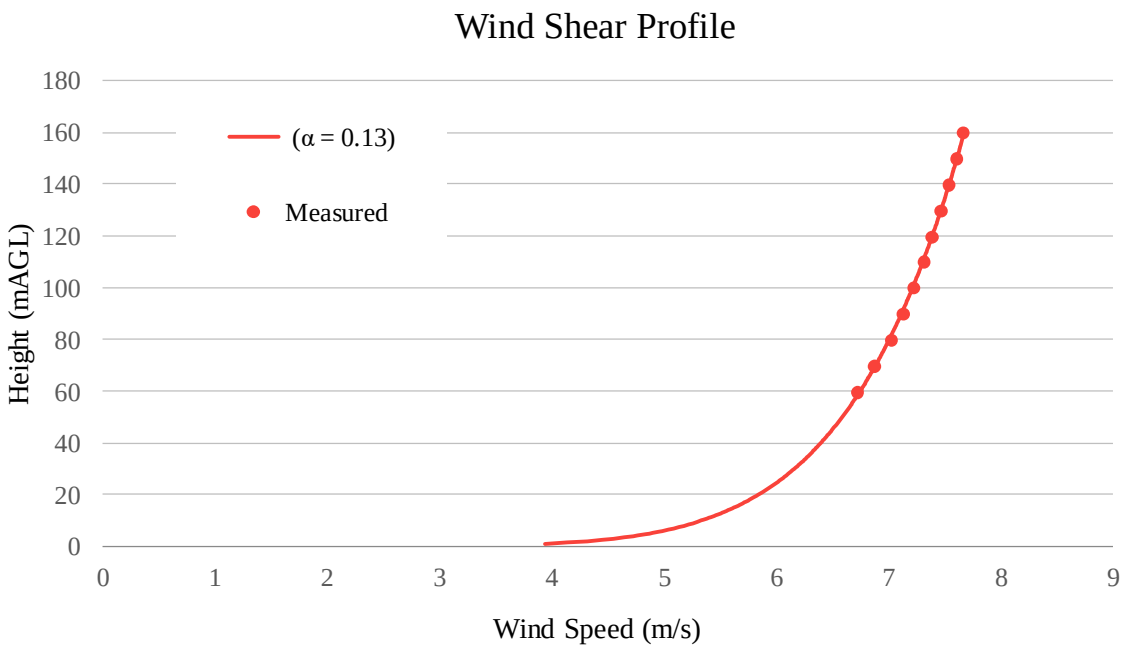

Figure 5.3 Measured Shear Profile at SPWP Sodar

5.4 WIND FLOW MODELLING

A wind resource model for SPWP has been developed using WindPRO v3.6 and WAsP Solver v12.8 with the following inputs:

- Annualised, long-term adjusted wind data at the Sodar location at 160 m;
- A digital contour map at an elevation resolution of 5 m in the general area of the wind farm, and extended to over 30 km from the site boundaries using publicly-available data produced by GeoScience Australia [14]; and

A digital roughness map was also produced by WSP based on satellite imagery, in line with the roughness classification system of the European Wind Atlas [15].

Figure 5.4 shows the wind speed model derived at SPWP using WAsP Linear Solver v12.8 and wind data recorded at the Sodar on site.

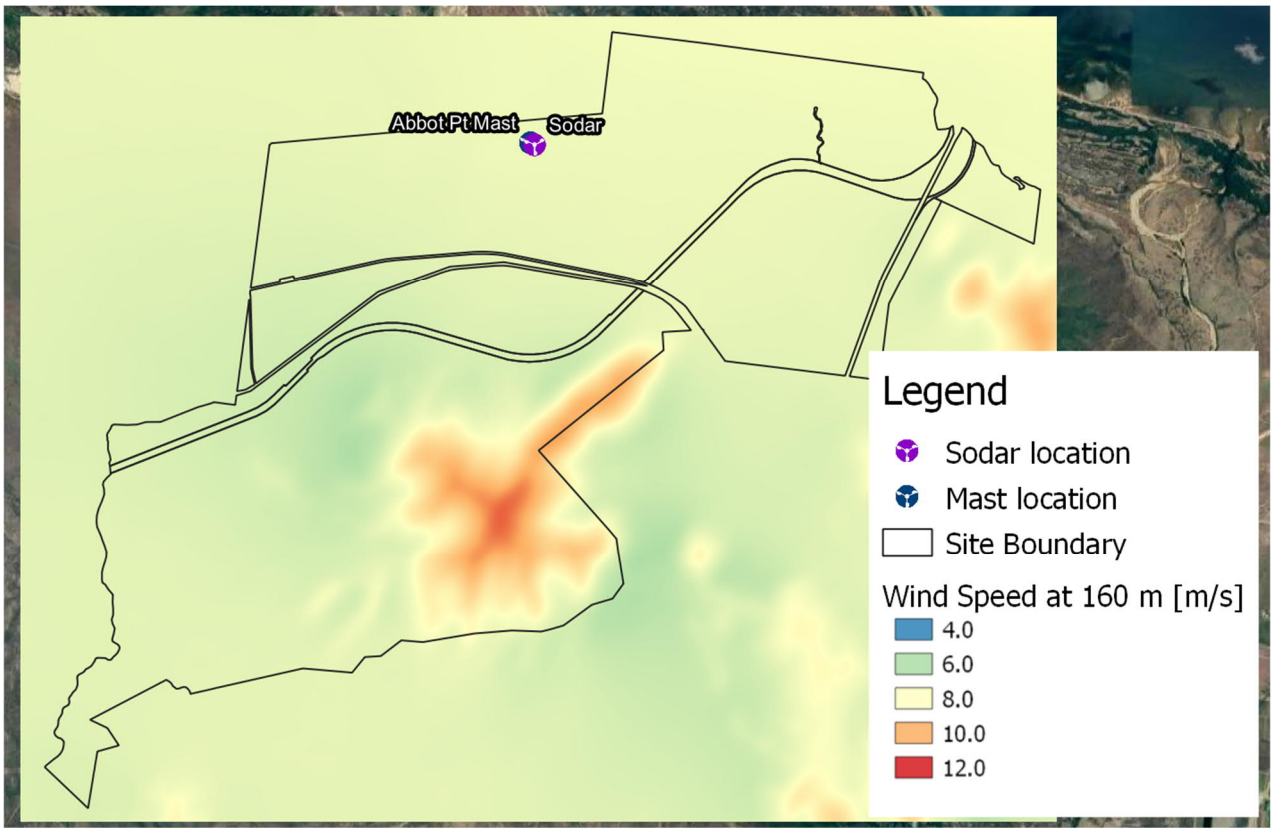

Figure 5.4: Wind speed variation at 160 m AGL using WAsP linear solver.

Wind speeds ranging from approximately 6.1 m/s to 11.0 m/s are predicted at 160 m agl across the site. The wind speed variation map shows that the highest wind speeds are observed at Mt Roundback due to its elevation.

6. RECOMMENDATIONS

WSP has reviewed the updated wind data collected at SPWP and performed subsequent analysis and adjustments to estimate the long-term wind climate at SPWP. It is important to note that as no meteorological masts have been installed near hub-height, the data monitoring campaign at SPWP is not yet considered adequate for financial grade wind energy modelling .

As a result of the high uncertainty associated with the wind flow model at SPWP, the current assessment is only suitable for examining the viability of the site for further development based on the indicative wind resources observed. WSP has provided commentary around the project's viability and current risks (with mitigation strategies) to assist EDQ with evaluating whether SPWP is suitable for additional development funding.

6.1 PROJECT VIABILITY

Using the output of the wind flow model detailed in Section 5, and WSP's general technical knowledge and experience of wind project developments, WSP has the following comments:

- The long-term average wind speed at the Sodar for a proposed hub height of 160 m is estimated to be 7.5 m/s. This is in line with WSP's previous assessment which estimated a 7.4 m/s long-term average at 140 m [2]. Typical wind projects in Australia generally have hub height wind speeds of 7.5 m/s or higher.

  Long-term averaged wind speeds across the project site range from 6.1 m/s to 11.0 m/s. It should be noted the higher wind speeds ranges are observed to be at the higher elevations from Mount Roundback, however WSP has reviewed the proposed land boundary and determined that siting WTGs in the region on/around Mount Roundback is unlikely to be feasible. Terrain slopes within this region are generally greater than 15° and may not be suitable for construction purposes or WTG load considerations. Additionally, this region may be subject to additional environmental considerations which may limit the positioning of WTGs in this region.

- Based on the site boundary provided by EDQ, WSP estimates the following potential project parameters. It is important to note that only Mt Roundback has been considered as an exclusion zone, and no other areas have been excluded. However, it is important to acknowledge these parameters are subject to potential significant changes based on the extent of exclusion zones for WTG construction, such as environmental, ecological and protected heritage exclusions.
  - Average hub height free wind speed – 7.5 m/s
  - Number of WTG locations – up to 60 WTGs
  - Indicative Total Capacity – approximately 350+ MW
  - Indicative Net Capacity Factor – ranging between 30-35 %

Please note that the above are only high-level estimates, subject to significant uncertainty. The capacity factor of SPWP will be highly dependent on the hub height wind regime observed at the site combined with the proposed WTG configuration (layout and WTG model) considered. For a more thorough assessment, it is recommended that multiple monitoring masts are erected on site, with the measurement period at each monitoring mast to be at least one (1) year.

6.2 PROJECT RISKS

The project risks remain consistent with the previously issued assessment by WSP.

Wind projects may be subject to a number of risks associated with planning and environmental approvals, grid connection, turbine technology and Operation and Maintenance (O&M) and Engineering, Procurement and Construction (EPC) contractual arrangements. The project is not at a stage of development where it is possible to quantify/qualify all risks associated with the project.

To assist EDQ with evaluation of the potential for future development at SPWP, WSP has attempted to identify key risks associated with the **wind flow model** only, as detailed in Table 6.1 below. This list of risks should be considered non-exhaustive and will evolve as the Project progress. WSP recommends these risks are continually evaluated as the project evolves.

Table 6.1 Wind Flow Modelling Risks

RISK	DESCRIPTION
Diurnal Wind Profile	Wind speed measurements captured at SPWP currently indicate that higher wind speeds may be anticipated during daytime periods. This diurnal profile is shown by APMM as well as Sodar measurement heights up to roughly 140 m. As height increases above 140 m, the diurnal profile flattens and then suggests higher wind speeds during night. As noted in Section 4.3, the higher measurement heights may not be capturing the complete diurnal variation.
Low Accuracy instrumentation	The current measurement campaign at SPWP has used instrumentation with an accuracy of ±3 % at 10 m/s and an output resolution of 0.1 m/s. Additionally, the uncertainty associated with the performance of the Sodar unit cannot be quantified due to the lack of suitable concurrent conventional anemometry on site. Wind monitoring for financial grade energy assessments typically uses instruments with an accuracy < 1 % [16], with any remote sensing devices (RSD's) successfully validated against conventional anemometry. It is recommended that a well configured/instrumented meteorological mast is installed at a later stage to confirm the performance of the Sodar on site.

RISK	DESCRIPTION
Significant horizontal extrapolation	WSP's current wind model at SPWP relies on wind flow modelling at distances in excess of 10 km. Industry best practice recommends that all WTG locations are located within 1-2 km of a measurement device.
Areas of complex terrain	WSP notes that whilst majority of the site is flat, the terrain on and around Mt Roundback is complex in nature. This terrain feature is located to the south-east of the site, in line with the predominant wind direction. In reality, this terrain feature may adversely impact the downstream WTGs, which may not be adequately captured by linear flow models like WAsP. It is known that WAsP wind flow modelling can underperform in complex terrain and WSP recommends the use of computational fluid dynamics (CFD) in the wind flow model.
Capturing stability in the wind flow model	Although WAsP can be tuned to capture atmospheric stability to a certain extent, being a linear flow model it does not accurately capture varying degrees of stability that a non-linear model such as CFD can capture with a better accuracy.

7. CONCLUSION

WSP has conducted an updated high-level assessment of the wind data collected at SPWP, including adjustments to estimate the long-term wind regime at SPWP.

The updated analysis includes additional wind data measured at the Sodar on site up until the 11th April 2023, which was annualised to a 2-year period to remove any potential seasonal bias. The data collected at the Sodar has not been verified against a conventional mast due to the lack of concurrent measurement heights with APMM.

This updated analysis aims to aid in decision making for conducting further research into the possibility of development of a large-scale wind farm at Salisbury Plains. The desktop analysis is of a preliminary nature and the numbers presented herein are subject to a high degree of uncertainty and should be treated with care.

Overall, the additional year of Sodar data supports the findings from the initial year of data, with the measured wind speed average increasing marginally in 2022. As such, the conclusions and recommendations from this updated analysis are generally consistent with the previous assessment. It should be noted that this assessment assumed a hub-height of 160 m (up from 140 m in previous assessment) in line with the available hub height options for newer WTG models seen in the industry.

WSP has the following comments and considerations regarding the wind measurement campaign at SPWP:

- The predominant wind direction at SPWP appears to be south-easterly.
- The long-term estimate wind regime at SPWP experiences some seasonal variation, with slightly lower wind speeds from June to October observed at APMM.
- The measured wind speed profile shows a high level of diurnal variability at lower measurement levels, with significant increases in wind speeds during the day. As the met mast is situated close to the ground (at 10 m), the high level of diurnal variability is expected. A smaller level of diurnal variability is observed at the Sodar at 160 m.
- The wind shear profile has been modelled using the Power Law Shear model combined with the Sodar measurements. WSP notes that the measured shear profile and alpha value (0.13) is in line with Industry's expectations of sites of similar terrain complexity as SPWP.
- The long-term adjusted average wind speed measured at a hub height of 160 m at the Sodar location is 7.5 m/s.

- WAsP is a linear wind flow model that captures unstable/neutral flows. However the conditions on site may not always be neutral and exhibits varying degrees of atmospheric stability, which is a limitation of the WAsP wind flow model.

WSP has produced a wind flow model across the project site using WindPRO v3.6 and WAsP v12.8. A high-level review of a potential wind farm size and generation at SPWP was then conducted. Based on locations deemed suitable for WTG siting at SPWP, WSP estimates the following project parameters may be feasible for SPWP:

- Average hub height (160 m) free wind speed – 7.5 m/s
- Number of WTG locations – up to 60 WTGs
- Indicative Total Capacity – approximately 350+ MW
- Indicative Net Capacity Factor – ranging between 30-35 %

Please note that the above are only high-level estimates, subject to significant uncertainty. The capacity factor of SPWP will be highly dependent on the hub height wind regime observed at the site (including the diurnal variation) combined with the proposed WTG configuration (layout and WTG model) considered.

In addition to comments and considerations outlined above, WSP has identified the following items as key high risks/uncertainties with the study at the time of writing:

- Low accuracy instrumentation at APMM
- Unverified performance of the Sodar, including uncertainties that are unquantifiable at this stage
- Significant horizontal extrapolation

If the project is to progress further, the key recommendation from WSP is a meteorological mast at least 3/4 the height of the proposed hub height or higher, compliant with industry standard instrumentation is installed on site.

WSP also notes that QLD power prices and network constraints, currently hinder power project development for assets with significant daytime generation. As such, projects with higher energy generation during evening periods are likely to prove more favourable for development.

WSP has also flagged the following items for consideration in the development of SPWP, which may affect the feasibility or cost (construction or operational cost) of a wind farm on the site:

- Wind farm constructability such a site geotechnical conditions for WTG foundations, substation foot-print, and access roads.
- Assessing terrain steepness for internal access routes for WTG component delivery and laydown areas.
- Statutory planning.
- Grid connection.
- General and Indigenous community acceptance.
- Local road and transportation infrastructure to ensure components can be delivered from a nearby port.
- Local flora and fauna studies to assess any endangered species.
- Nearby dwellings that could be impacted by shadow flicker, noise or visual impact.
- Electromagnetic interference impact assessments.
- Cultural heritage studies.
- Assessment of unexploded ordnance risk for the site area.
- As SPWP is located in a tropical cyclone region. WSP also recommends a cyclone risk and extreme wind assessment is performed.

8. LIMITATION STATEMENT

This Report is provided by WSP Australia Pty Limited (*WSP*) for State of Queensland – Minister for Economic Development Queensland (*Client*) in response to specific instructions from the Client and in accordance with EDQ's Request for Services dated 20th March 2023 and agreement or letter of acceptance with the Client dated 4th April 2023 (*Agreement*).

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