Appendix 8.7

Wind Turbine Interactions

APPENDIX 8.7 Wind Turbine Interactions

The interaction of the plume with the DePuy wind turbine located approximately 400 metres south-east (at an angle of approximately 325°) of the proposed stack location, has been assessed below.

Studies have found that the cross-wind radius of the wake of the wind turbine extents approximately 1.2 x diameter (i.e. radius of 120m in this case) at a distance 6.9 x diameter (690m) downwind[1]. Thus, at a distance of 400m downwind, the wake will laterally extend to a radius of 70m (diameter of 140m). Due to the limited lateral spread in the wake, the effect of the wind turbine is likely to occur during specific, rather narrow, wind directions i.e. when the wind is blowing from a north-west direction (between 310° - 340°) the plume may interact with the wind turbine leading to possible changes in dispersion and turbulence of the plume (Scenario1, Fig. 1 in Figure A8.3).

Another possible effect is when the wind is blowing from 130° - 160° the wind turbine will cause a velocity deficient in the wake of the turbine and thus the wind speed at the stack will be reduced leading to possible changes to dispersion and turbulence of the plume (Scenario 2, Fig. 2 in Figure A8.3).

Figure A8.3 Upwind And Downwind Plume Interaction With A Nearby Wind Turbine

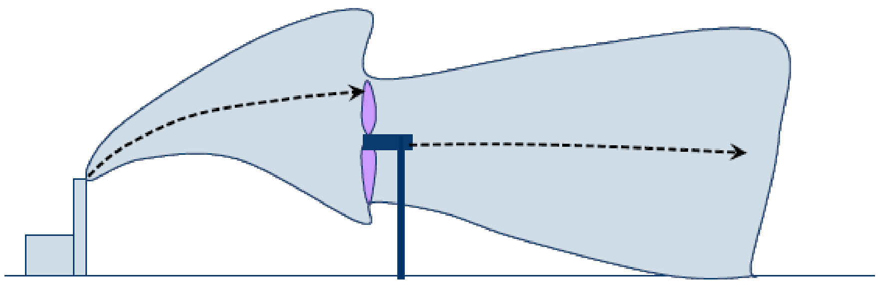


Fig. 1 Upwind plume trapped into the wake of a wind mill

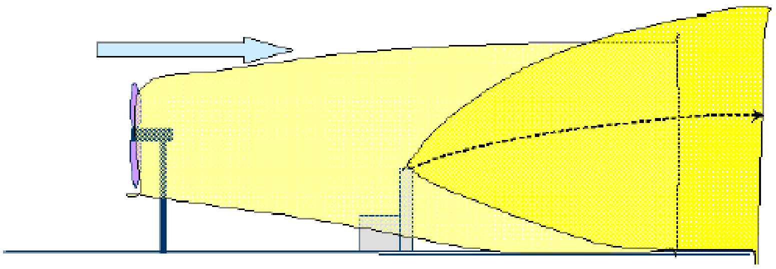


Fig. 2 Downwind plume is emitted into the wake of a wind will

Taken from "Erbrink & Verhees "Enhanced Dispersion From Tall Stacks Near Modern Wind Mills", Poster Presentation International Technical Meeting on Air Pollution Modelling and its Applications, Utrecht (2012)

As shown in Table A8.18 and Figure A8.4, the frequency of Scenario 1 is relatively small with a five-year average of 11.9% and a maximum year (Year 2010) average over this period of 15.7%. Again, as shown in Figure A8.5, the frequency of Scenario 2 is minor with a five-year average of 5.6% and a maximum year (Year 2013) average over this period of 6.9%. Periods when the turbine will not be in operation (i.e. when wind speeds are below 2 m/s or above 25 m/s) have been excluded from the

[1] Porte-Agel et al, A Numerical Study of the Effects of Wind Direction on Turbine Wakes and Power Losses in a Large Wind Farm (2013) Energies 6 5297-5313

totals. Thus, for 82.5% of the time, based on a five-year average, no interaction between the plume and the turbine is likely to occur.

Table A8.18 Frequency of Wind Direction For Scenarios 1 and 2

Met Station / Year	Frequency of Wind Blowing From 310° – 340° (Scenario 1)	Frequency of Wind Blowing From 130° – 160° (Scenario 2)
Cork Airport / 2010	15.7%	5.2%
Cork Airport / 2011	8.8%	4.6%
Cork Airport / 2012	11.1%	5.8%
Cork Airport / 2013	12.7%	6.9%
Cork Airport / 2014	10.8%	4.5%
Roches Point / 2014	12.3%	6.6%
Average	11.9%	5.6%

Figure A8.4 Windrose Showing Frequencies of Wind From 320 - 330° In Year 2010

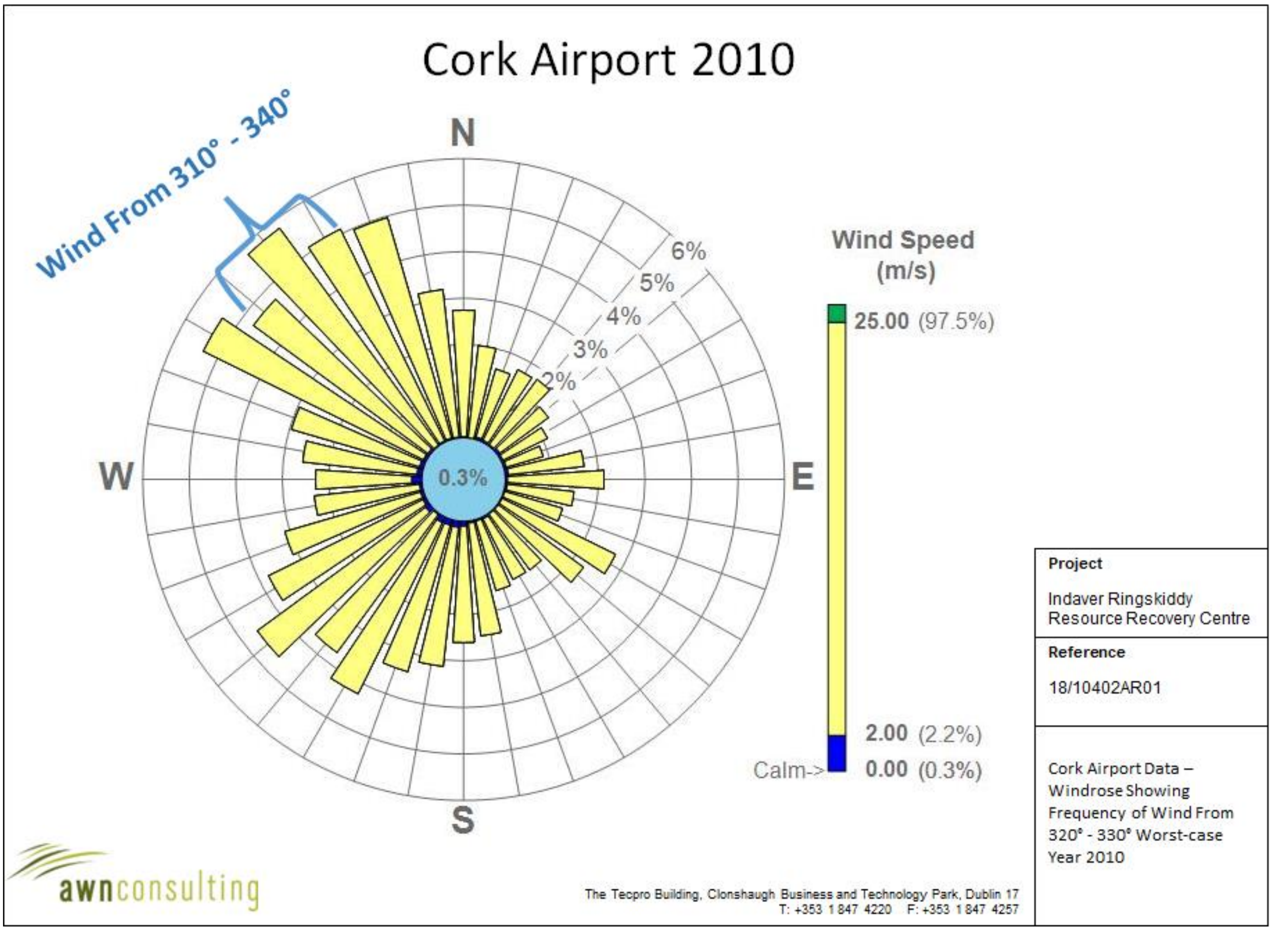
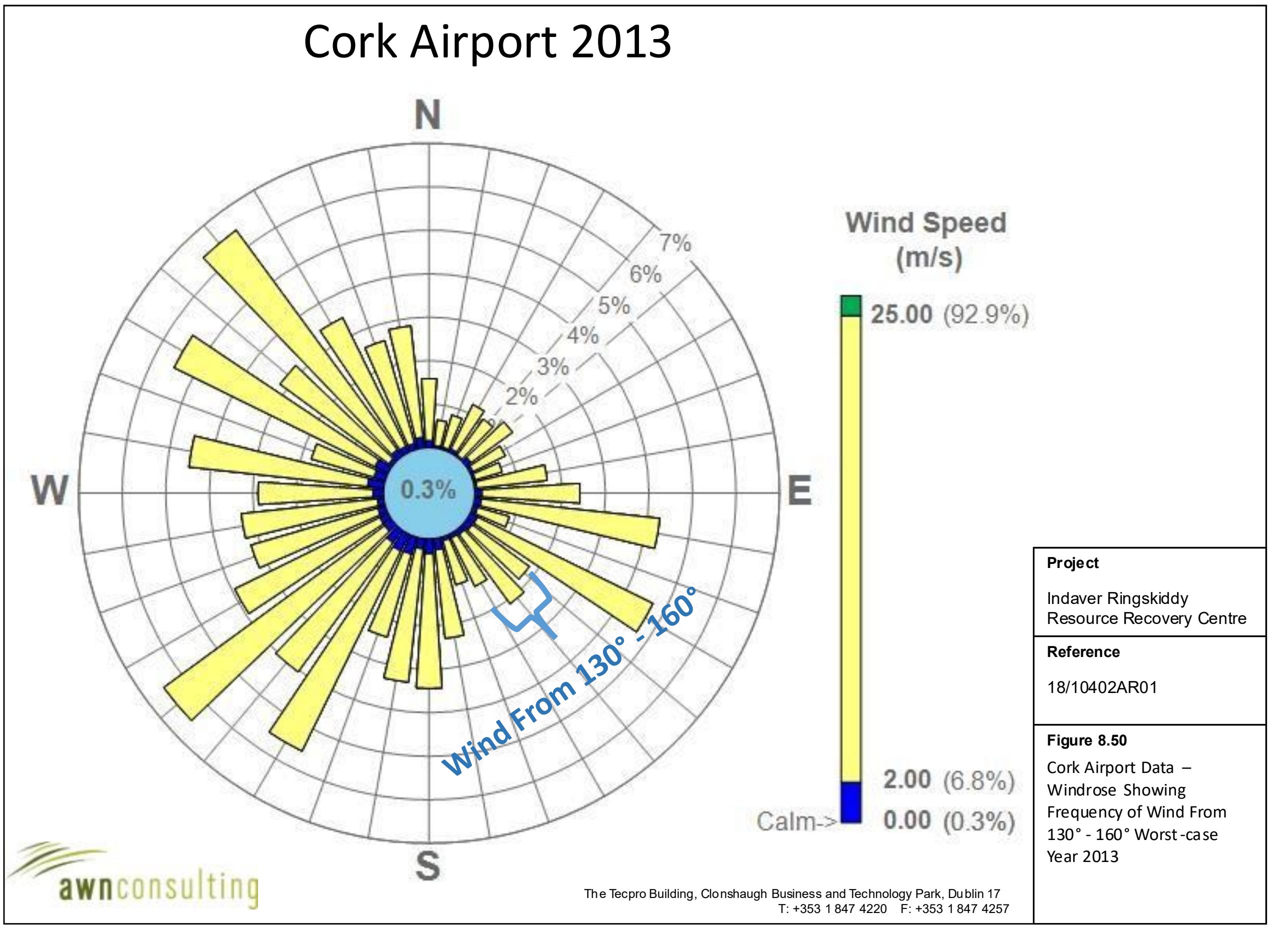


Figure A8.5 Windrose Showing Frequencies of Wind From 130 - 160° In Year 2013



8.7.1 Effect of Wind Turbines on Dispersion Due To the Velocity Deficit

The effect of DePuy wind turbine located within 400 m of the proposed main stack of the Ringaskiddy RRC has been assessed using the ADMS model. All other turbines in the region are at a significantly greater distance from the facility and will have an insignificant interaction with the plume.

ADMS has the ability to model the wake from the wind turbine in the region where the flow field is affected by the turbine. The flow wind will be influenced by the wind turbine leading to changes in the wind speed (velocity deficient) and turbulence (eddy currents) i.e. the wind speed downstream of a wind turbine will be reduced whilst there will be an additional shear-induced turbulence in the wake and a lack of large-scale wind direction meandering. These changes to the flow field affect the calculations of the location of the stack plume centreline and the plume spread parameters[2]. ADMS has been validated using real wind turbines as part of the EU funded TOPFARM project with the report concluding that the model predicts wake-affected wind fields which agree well with observations[3].

The model first calculates the existing flow field and any associated changes to the wind / turbulence flow field due to the presence of the wind turbine for every hour of the year. ADMS then models the dispersion of the plume from the stack and determines whether the stack plume will interact with the turbine wake either via scenario 1 (the plume encounters the wake of the wind turbine) or scenario 2 (the turbine affects the wind speed and turbulence which encounters the plume leading to changes to plume dispersion) as described above.

2 CERC (2016) ADMS User Manual Section 9.23

3 CERC (2011) CERC Activities Under The TOPFARM Project: Wind Turbine Wake Modelling using ADMS

The effect of the wind turbine on ambient air concentrations due to emissions from the Ringaskiddy RRC stack was assessed by modelling the NO_2 emissions from the facility both with and without the wind turbines in place and comparing the results. Data for the wind turbines was taken from manufacturers datasheets.

The modelling results are detailed in Table A8.19 for the 1-hour concentration (measured as a 99.8th%ile) and Table A8.20 for the annual mean result for Years 2010 – 2014 for Cork Airport and 2014 for Roches Point. The results indicate that the difference in the maximum concentrations at the worst-case receptor at ground level for the years modelled are not significantly affected by the wind turbine. The maximum difference in the "With" and "Without" scenarios for the 1-hour results (measured as a 99.8th%ile) was a difference of 4.3% of the 1-hour limit value.

The results for the annual mean scenario also demonstrate that the difference in the maximum concentrations at the worst-case receptor for the years modelled are not significantly affected by the wind turbine. The maximum difference in the "With" and "Without" scenario for the annual average results was a difference of 1.1% of the limit value.

Based on the small magnitude of changes in concentrations between the "With" and "Without" wind turbine scenarios modelled, the wind turbine is not deemed to have a significant effect on dispersion of pollutants from the proposed Ringaskiddy RRC as all pollutants will remain well within the ambient air quality standards when adjusted by 1% - 4.3% of the ambient air quality standards.

Thus, adjusting the results by 1% - 4% of the ambient limit values to account for wind turbine effects will have only a minor influence on results and all ambient levels of regulated pollutants will remain well below the ambient air quality standards.

Table A8.19 Difference in Modelled 1-Hour NO_2 Concentrations (expressed as a 99.8th%ile) for "With" and "Without" Wind Turbines Scenario using ADMS ($\mu g/m^3$)

Pollutant / Year	Averaging Period	Process Contribution "Without" Wind Turbine ($\mu g/m^3$)	Process Contribution "With" Wind Turbine ($\mu g/m^3$)	Difference of "With" and "Without" ($\mu g/m^3$)	Difference as a % of the Limit Value
NO_2 / 2010	99.8th%ile of 1-hr means	37.0	45.6	8.6	4.3
NO_2 / 2011	99.8th%ile of 1-hr means	37.7	46.0	8.4	4.2
NO_2 / 2012	99.8th%ile of 1-hr means	40.1	42.2	2.1	1.0
NO_2 / 2013	99.8th%ile of 1-hr means	33.9	39.0	5.1	2.6
NO_2 / 2014	99.8th%ile of 1-hr means	40.6	43.2	2.6	1.3
NO_2 / 2014 (Roches Point)	99.8th%ile of 1-hr means	37.6	35.3	-2.3	-1.2

Table A8.20 Difference in Modelled Annual Mean NO_2 Concentrations for "With" and "Without" Wind Turbine Scenarios using ADMS (µg/m³)

Pollutant / Year	Averaging Period	Process Contribution "Without" Wind Turbine (µg/m³)	Process Contribution "With" Wind Turbine (µg/m³)	Difference of "With" and "Without" (µg/m³)	Difference as a % of the Limit Value
NO_2 / 2010	Annual Mean	1.0	1.0	0.01	0.02
NO_2 / 2011	Annual Mean	0.67	0.92	0.24	0.61
NO_2 / 2012	Annual Mean	0.65	0.72	0.07	0.16
NO_2 / 2013	Annual Mean	0.73	0.75	0.02	0.06
NO_2 / 2014	Annual Mean	0.49	0.91	0.42	1.1
NO_2 / 2014 (Roches Point)	Annual Mean	0.49	0.52	0.03	0.08

8.7.2 Effect of Wind Turbines on Wind Field Parameters

The wind field in the vicinity of the wind turbine has been investigated using ADMS. The mean wind speed (m/s) at a height of 100m has been modelled in ADMS both with and without the wind turbine in order to determine the extent of the region where the wind speed is affected on an annual mean basis.

As shown in Figure A8.6, the wind field at a height of 100m above ground in the absence of the wind turbine is essentially uniform with an average wind speed of between 6 – 6.5 m/s. Figure A8.7 shows the wind field at 100m with the DePuy wind turbine in place. It is evident that there is a reduction in mean wind speed in the region of the wind turbine with mean wind speeds falling to 3.5 m/s within 100m downwind of the prevailing wind near the turbine. However, within 400m the annual mean wind velocity deficit is not apparent, and wind speeds return to levels which exist in the absence of the wind turbine.

The wind field in the vicinity of the wind turbine can be used by ADMS to determine the vertical turbulence (m/s) in the region of the wind turbine. The vertical turbulence (m/s) at a height of 100m has been modelled in ADMS both with and without the wind turbine in order to determine the extent of the region where the vertical turbulence is affected on an annual mean basis.

As shown in Figure A8.8, the vertical turbulence at 100m in the absence of the wind turbine is essentially uniform with an average vertical turbulence of between 0.5 – 0.55 m/s. Figure A8.9 shows the vertical turbulence at 100m with the DePuy wind turbine in place. It is evident that there is an increase in vertical turbulence in the region of the wind turbine with mean vertical turbulence increasing to 0.75 m/s within 100m downwind of the prevailing wind near the turbine and levels of 0.65 m/s extending to 350m downwind of the prevailing wind. In the region of the proposed Ringaskiddy RRC stack, the annual mean vertical turbulence is predicted to increase, at a height of 100m from 0.5 - 0.55 m/s to 0.55 - 0.6 m/s.

Given the range of meteorological conditions examined above the assessment is considered robust. Guidance from the EPA[9] (in AG4 (2020)) states that in relation to air dispersion modelling that "*the most recent year of the meteorological data set used should have been compiled within the last ten years*" (which is Year 2014), the fact that the most recent year assessed is Year 2018 complies with the EPA requirements for air modelling assessment.

Figure A8.6 Cork Airport 2014 Data – Mean Speed (m/s) At 100m Above Ground Level In The Absence Of The De Puy Wind Turbine

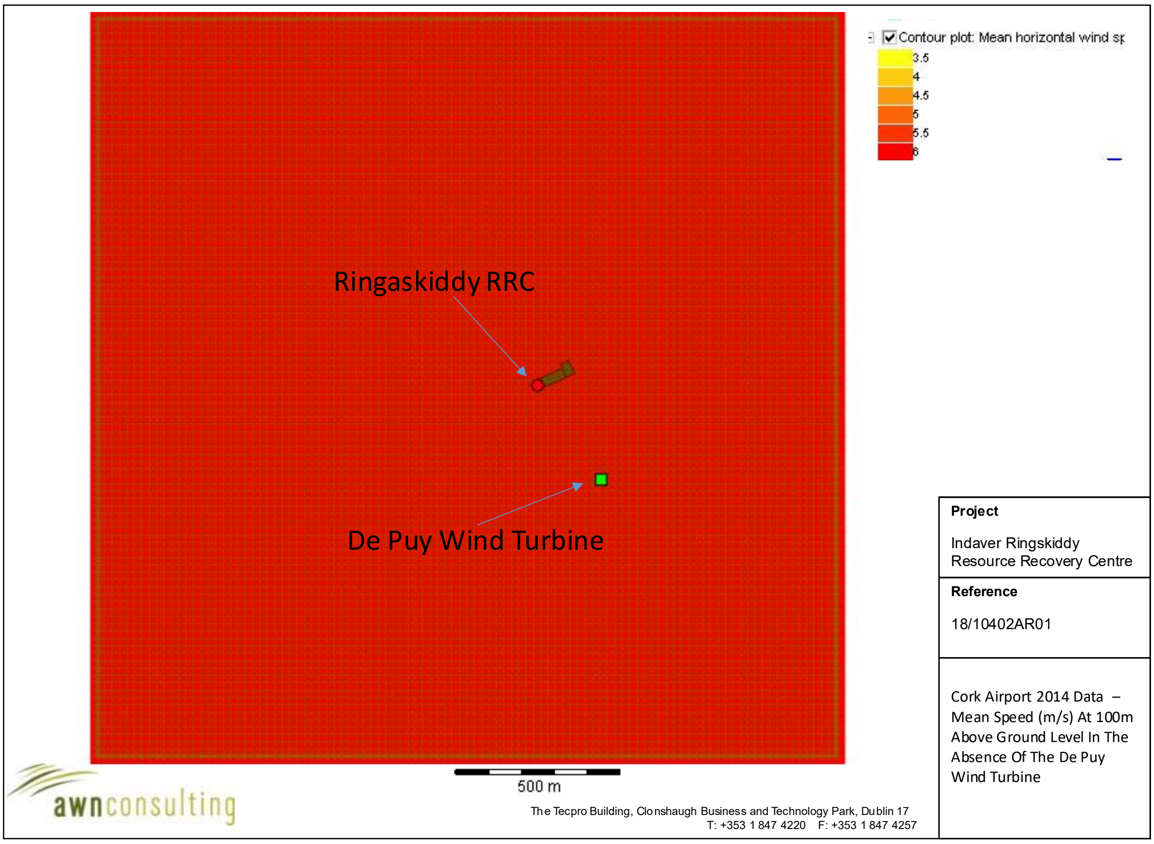


Figure A8.7 Cork Airport 2014 Data – Mean Speed (m/s) At 100m Above Ground Level In The Absence Of The De Puy Wind Turbine

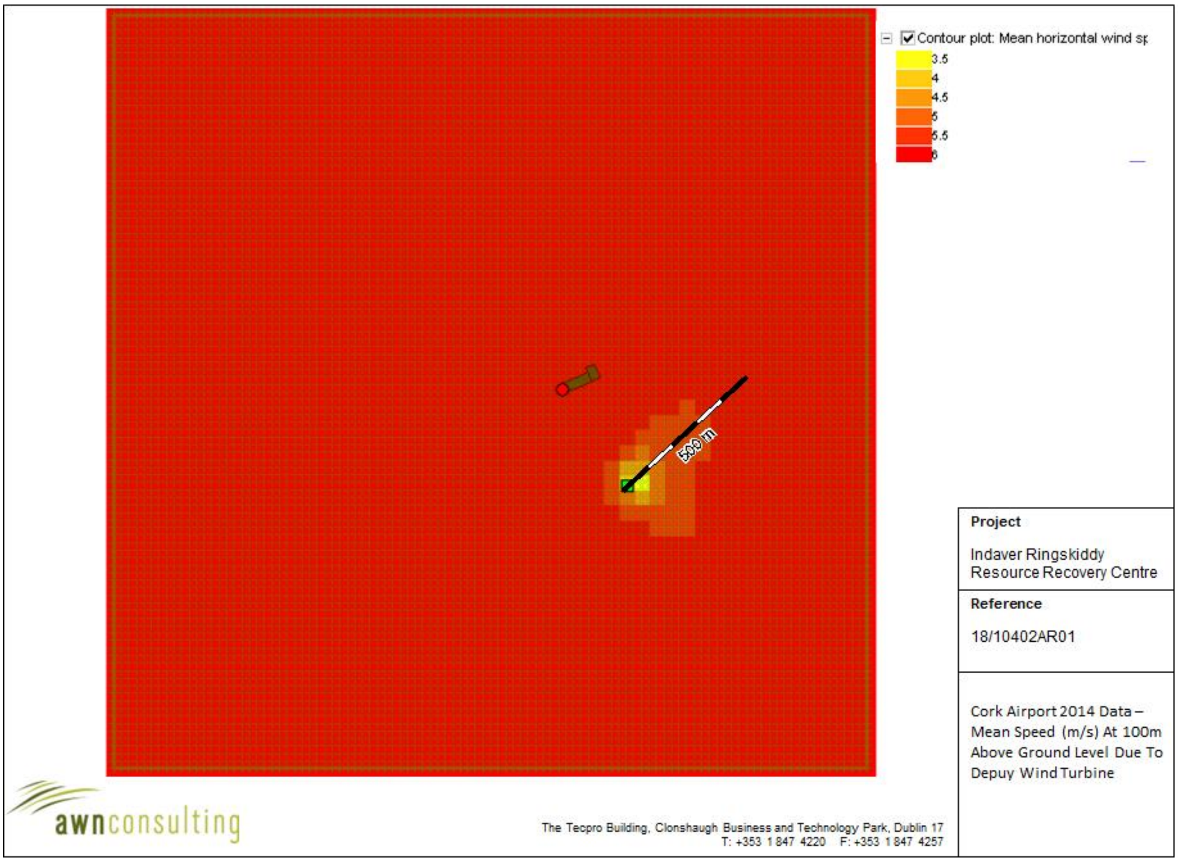


Figure A8.8 Cork Airport 2014 Data – Vertical Turbulence Variations (m/s) At 100m Above Ground Level In The Absence Of The Depuy Wind Turbine

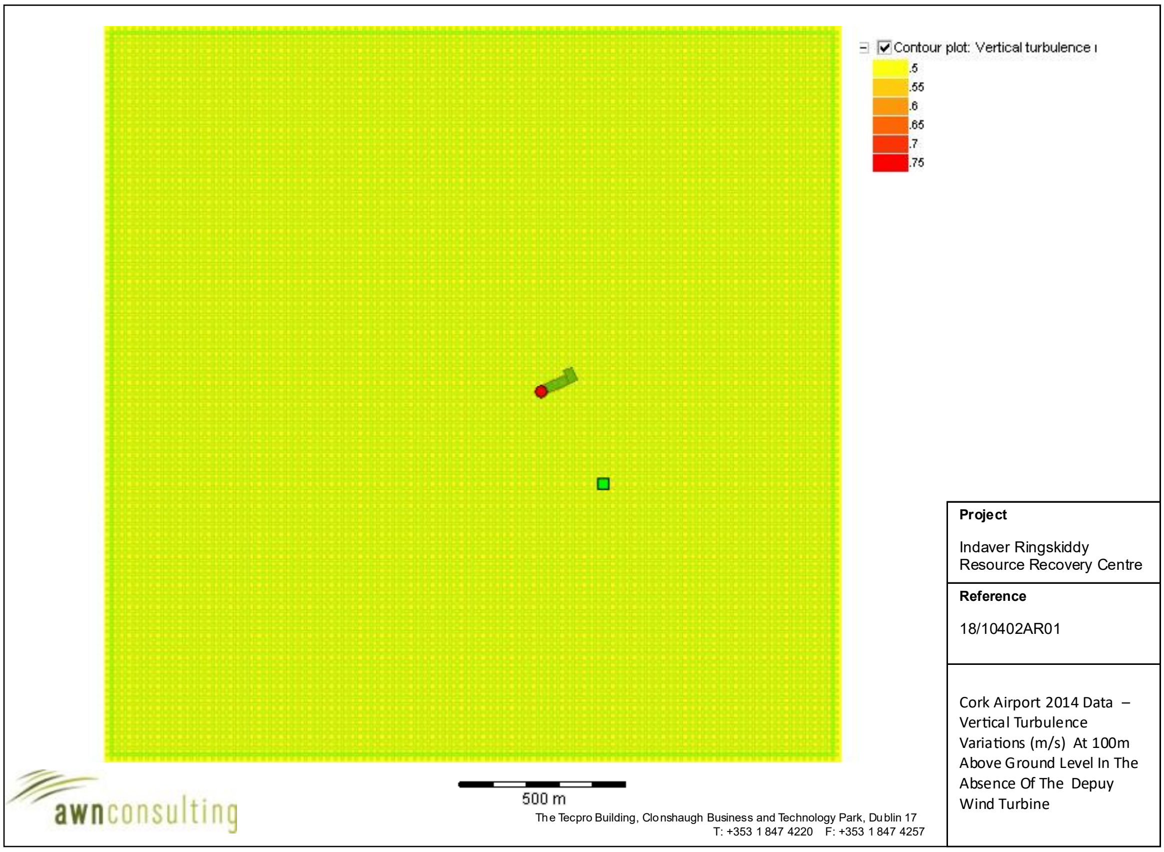


Figure A8.9 Cork Airport 2014 Data – Vertical Turbulence Variations (m/s) At 100m Above Ground Level Due To Depuy Wind Turbine