

Table 10.1 - Wells and Springs within 1.2km of development

<i>Well/Spring</i>	<i>NGR</i>	<i>Nature of use (information provided by landowner)</i>
Well 1	421230, 405500	Extinct
Well 2	421340, 404350	Extinct
Well 3	421610, 403980	Extinct
Well 4	420230, 404560	Extinct
Well 5	419210, 405700	Domestic Supply
Spring 1	420350, 406380	Supplies to properties at Broadstone Lodge Farm
Spring 2	421330, 405320	Domestic Supply
Spring 3	421900, 405010	Domestic Supply
Spring 4	421260, 404060	Extinct

10.5.3 Local water supplies

All properties within 1.2km of the proposed development have been identified and their water source determined. The results are tabulated in **Table 10.2**.

Table 10.2 - Water Supplies to Properties within 1.2km of development

<i>ID</i>	<i>Property</i>	<i>NGR</i>	<i>Source</i>
1	Broadstone Lodge Farm Cluster	420450, 406180	Spring
2	Green Gate Farm	420720, 406020	Borehole
3	Brown's Edge Farm	420330, 405750	Well
4	Spicer House Farm	420460, 405580	Spring
5	Annat Royd Farm	421160, 405220	Borehole
6	Far Royd Farm Custer	421710, 404950	Borehole
7	Whitley House	421330, 404170	Mains
8	Carr House Cluster	421330, 404080	Mains
9	Eagle Nest Cluster	421010, 404060	Mains
10	Small Shaw Farm Cluster	420780, 404000	Mains
11	Flash House Farm Cluster	420880, 404120	Mains
12	Illions Cluster	420300, 403990	Mains

ID	Property	NGR	Source
13	The Lanes	420130, 440090	Mains
14	Middle Cliff	419760, 404150	Mains
15	Lower Whitley Farm	419100, 404410	Mains
16	Maythorne Cross	418740, 405230	Mains
17	Broadstone Equestrian	419480, 405870	Mains

10.5.4 Surface and Groundwater Classification

The Environment Agency (EA) classifies all significant waters in England. The nearest classified surface water feature is the River Don, located approximately 1.75km to the south of the proposed site.

The EA have classified the River Don as “Moderate”. This means the EA are “quite certain” the River Don has a “Moderate” ecological status; the chemical status has been deemed to “Not Require Assessment”.

The EA also classifies significant groundwater bodies which at the proposed site are “Douglas, Darwen and Calder Carboniferous Aquifers”. The overall status of this groundwater has been classified as ‘Poor’. The quantity of groundwater has been classified as ‘Good’ with uncertainty and has a chemical status of ‘Fail’.

10.5.5 Flooding Risk

From the Risk of Flooding from Rivers and Sea Map (available on the Environmental Agency website) it can be seen that there are two areas deemed to be at a high risk of flooding that fall within the study boundary – Ingbirchworth Reservoir and Royd Moor Reservoir. Beyond the study boundary the nearest areas deemed to be at risk from flooding are the areas along the banks of the Scout Dike Reservoir approximately 2km to the east of the proposed turbine locations. It should also be noted the River Don is also classified as being high risk. The project is unlikely to have any impact on the flooding risk of these areas.

10.5.6 Hydrogeology

The EA Groundwater Map indicates that the strata beneath the site are classified as Secondary A, which is moderately permeable.

The BGS Geology of Britain Viewer (1:625,000) indicates that the project is located in a region underlain by two different rock formations. The site comprises of Pennine

Lower Coal Measures Formation and South Wales Lower Coal Measures Formation and Greenmoor Rock. This information was verified by the site investigations for the adjacent Spicer Hill Wind Farm, which found that clayey sand and gravel was predominantly underlain by mudstone and sandstone of varying strengths. During the investigation undertaken in 2011 groundwater was recorded at a depth of 12m.

The Geology of Britain viewer indicates that there are no superficial deposits recorded in the area.

10.5.7 Confirmation of baseline conditions

Intrusive ground investigations will be completed prior to turbine construction to gain site specific information such as groundwater levels, soil permeability and geology.

10.6 Assessment of Predicted Impacts and Effect

This section presents an assessment of impacts on the water environment which may occur during the construction, operational and decommissioning phases of the development. The sensitive receptors are identified and the predicted impacts are assessed and their significance rated.

Details of the site and the works to be conducted can be found in Chapter 2: The Proposed Development. **Figure 10.1** provides a plan of the development.

10.6.1 Sensitive Receptors

The identification of sensitive receptors, taking into account baseline conditions, is summarised in **Table 10.3** below. It should be noted that a distinction has been made between properties that draw water from the water table, and the overall condition of the water table itself.

Table 10.3 - Sensitive Receptors

Receptor	Comment
Watercourse	The River Don has an overall status of moderate, an overall ecological status of moderate with a good potential by 2027. There are several reservoirs (Ingbirchworth, Scout Dike and Royd Moor) in the surrounding area with local importance. It is also important to note that the Annat Royd Beck feeds the Royd Moor Reservoir.
Groundwater	The region is located in an area underlain by moderately permeable strata.
Properties with a Private Water Supply	The only source of potable water for several neighbouring properties is abstracted from the water table.

10.6.2 Predicted Construction Impacts

The most disruption, and therefore the greatest risk of impact to the water environment, will occur during the construction phase of the project.

Disruptions to flow paths

The development does not require the crossing of any streams or other surface watercourses, and so there is no risk of a watercourse being hydraulically impeded. As such, a drop in hydraulic gradient of a watercourse is predicted to be of negligible significance.

However, there could be active subsurface field drains around the site which may be affected during track excavation and construction. Furthermore, the track and associated drainage could impede existing surface runoff routes, particularly during periods of heavy rainfall. The impact caused by these disruptions to flow is predicted to be of low significance.

Sedimentation and Erosion

It is predicted there may be an impact caused by erosion of track and hard-standing surfaces and of excavated spoil material. This could lead to sediment being carried with the runoff and reaching a watercourse. Cable laying also has the potential to damage soils and introduce new drainage pathways which could generate silt laden run-off. The amount of the resultant suspended solids pollution will be greater during heavy rainfall events, although the dilution potential of the watercourses is also at its greatest during these periods. At times of low flow, it is very unlikely that silt could reach a watercourse. The significance of this impact is considered to be low.

Increase in runoff

Construction of the access tracks, sub-station and crane hard-standings will result in localised changes to the surface water hydrology. The cambered tracks may interrupt natural flow paths. The new track will also shed water more quickly than the existing ground. An increase in runoff in the area can compound various other predicted impacts, such as chemical pollution, erosion and sedimentation. Furthermore, increased runoff could add to a flood risk in the area.

The cumulative area of tracks and hard-standing on the proposed site is expected to only lead to a very slight increase to runoff. It is unlikely any runoff would affect the areas at risk of flooding on the banks of the surrounding reservoirs and the River Don, further downstream. The magnitude of the impact is taken to be low.

Chemical Pollution

There are several potential sources of chemical pollution to both surface water and groundwater during the construction phase of the development. The spillage or leakage of construction associated oil, grease, fuel, concrete, cement, foul water or other chemicals can have a serious negative impact on the quality of surface water and/or or groundwater. Runoff or groundwater could also carry spills or leakages resulting in pollution of a sensitive receptor. Local topography limits the potential for polluted runoff to travel, so polluted runoff contaminating a watercourse is predicted to be of medium significance.

Due to the moderate permeability of the strata beneath the site, groundwater travel is likely to occur locally, so polluted runoff contaminating groundwater is predicted to be of medium significance. **Table 10.4** includes a summary of the predicted impact from chemical pollution at each private water supply within the 1.2km study boundary. The overall impact on private water supplies is predicted to be low.

Lowering of the water table

Given what is known about the ground conditions in the area and the extents of the excavation works, groundwater is not expected to enter the foundation excavations. As such, dewatering should not be required and therefore the groundwater table would not be affected by the works. Any private water supply out with a 250m 'dewatering boundary' is not predicted to suffer an impact. There is a presumption that cable trenches and access roads may disrupt the groundwater flow directions by creating shallow drainage and preferential pathways and, as such, a further boundary of 100m around cable trenches and access tracks has been applied. **Table 10.4** includes a summary of the predicted impact from dewatering at each private water supply within the 1.2km study boundary.

Table 10.4 - Analysis of Potential for Impact on Sensitive Water Features within 1.2km of development

Well/ Spring	Surface Water Runoff Pollution Impact		Dewatering Impact	
	Impact Analysis	Significance	Impact Analysis	Significance
Well 1	A small amount of runoff from turbine 3 may reach this receptor, however any runoff will pass over 800m of rough grazing farmland prior to reaching this receptor.	Low	Unlikely as receptor is outwith both the applied 250m and 100m boundaries around dewatering activities.	Negligible
Well 2	Unlikely pathway as receptor is located south-east of the site and local topography suggests run-off will be to the east.	Negligible	Unlikely as receptor is outwith both the applied 250m and 100m boundaries around dewatering activities.	Negligible
Well 3	Unlikely pathway as receptor is located south-east of the site and local topography suggests run-off will be to the east.	Negligible	Unlikely as receptor is outwith both the applied 250m and 100m boundaries around dewatering activities.	Negligible
Well 4	Unlikely pathway as receptor is located south of the site and local topography suggests run-off will be to the east.	Negligible	Unlikely as receptor is outwith both the applied 250m and 100m boundaries around dewatering activities.	Negligible
Well 5	Unlikely pathway as receptor is located north-west of the site and local topography suggests run-off will be to the east.	Negligible	Unlikely as receptor is outwith both the applied 250m and 100m boundaries around dewatering activities.	Negligible
Spring 1	Unlikely pathway as receptor is located north-east of the site and local topography suggests run-off will be to the east.	Negligible	Unlikely as receptor is outwith both the applied 250m and 100m boundaries around dewatering activities.	Negligible
Spring 2	A small amount of runoff from turbine 3 may reach this receptor, however any runoff will pass over 700m of rough grazing farmland prior to reaching this receptor.	Low	Unlikely as receptor is outwith both the applied 250m and 100m boundaries around dewatering activities.	Negligible
Spring 3	Unlikely pathway as receptor is located beyond the Annat Royd Beck.	Negligible	Unlikely as receptor is outwith both the applied 250m and 100m boundaries around dewatering activities.	Negligible
Spring 4	Unlikely pathway as receptor is located south-east of the site and local topography suggests run-off will be to the east.	Negligible	Unlikely as receptor is outwith both the applied 250m and 100m boundaries around dewatering activities.	Negligible

10.6.3 Predicted Operational Impacts

There will be a few on-site activities during operation of the wind turbines relating to regular maintenance or repair of the machines. During these activities there will be a need to bring small quantities of oil, greases and other materials on to the site. The sub-station, access tracks and crane hard-standings will result in localised changes to the surface water hydrology for the duration of the project, with the potential effects of erosion, sedimentation and increased runoff as discussed in Construction Impacts.

10.6.4 Predicted Decommissioning Impacts

The activities during decommissioning are broadly similar to those during construction, however, the level of activity will be less as some of the roads and sub-surface elements will be left in place.

10.7 Mitigation

The potential impact of the project on water quantity is minimal, so the mitigation measures focus on preventing water pollution. There are a number of recognised best practices and measures to mitigate and eliminate the predicted impacts previously discussed. A full intrusive ground investigation will be carried out to provide data for designing appropriate mitigating measures before construction begins.

10.7.1 Use of existing infrastructure

The design makes use of existing access tracks as far as possible, reducing new construction activities and new infrastructure as far as possible.

10.7.2 Construction

The following measures will be implemented to manage the predicted impacts at the site during the construction phase. Construction will be carried out according to EA and CIRIA guidance for site works.

Disruption to existing flow

Following good practice guidance in the design and construction of the culverts or bridges will ensure that the crossing is correctly designed in a way that will minimise or completely remove possible impacts. If a culvert is feasible, the design will ensure that the culvert is of a sufficient size such that the soffit is higher than the bank, and the width is at least that of the natural channel. Culverts will be correctly aligned and sloped to the drain. Existing flow depths will be maintained, and the culvert base will be of natural substrate.

Sedimentation and Erosion

During construction of the track, drainage will be controlled by placing drainage ditches on the uphill slopes. All earth bunds, soil and waste material storage areas will

be located as far as possible from site watercourses and will be well managed to minimise runoff and erosion. The project drainage will be designed such that access tracks will be cambered to shed surface water into a suitable drainage system.

Adoption of sustainable drainage principles, such as making use of vegetation to slow water flows and filter sediments, should minimise the risk of sediments reaching watercourses. The new drainage network will be kept separate from the existing field drain network to avoid any potentially contaminated runoff from the new infrastructure discharging into local watercourses. If this is not practical, drains will be installed along the length of the tracks which would feed into a soak-away. The soak-away would incorporate an overflow for periods of heavy rainfall. A possible drainage layout solution is shown on **Figure 10.1**. Methods incorporated are designed to be sustainable and to cope with storm events.

To minimise disturbance impacts, cables will be laid in small trenches along the side of the access tracks as far as possible. Trenches will be dug during drier periods, as far as practicable, and spoil material will be temporarily placed on the uphill slope to reduce the likelihood of runoff entering the excavations. The electric cables will be laid quickly and backfilled to minimise water ingress to the trenches. Their actual impact in terms of creation of new drainage pathways, or damage to soil profile, is likely to be negligible provided the best practice methods are followed.

Chemical Pollution

Construction traffic will use specified roads and parking areas at all times, where practicable, to reduce compaction and associated run-off in the wider area. Appropriate control measures, such as shallow vegetated channels, will be installed to convey haul road and hard-standing runoff and treat pollutants.

Concrete will be delivered in ready-mix wagons which will only be allowed to 'wash-out' in designated areas where suitable control measures are in place. Full details of the foundation construction will be provided in the construction method statement. We anticipate this being required as a planning condition. Once construction is complete and the soil has been replaced over the foundation and reseeded, the change to surface water runoff and risk of pollution is predicted to be negligible.

A pollution incident response plan will be developed in accordance with EA PPG 21. Spill response measures will be put in place to ensure that any accidental spillages at the surface can be contained and quickly removed from site.

All fuel and other chemicals will be stored and managed in accordance with best practice procedures. Best practice is included in EA Pollution Prevention Guidance Notes (PPGs). All fuel will be stored in a bunded container. Oil spill kits will be stored

in the site office. All oils, greases and chemicals will be stored in a locked bunded container near the site office. Where oils and diesel are brought on to site for refuelling or maintenance, these operations will be carried out in designated areas of hard-standing located at least 20m from the nearest watercourse or drain. Standard methods will be adopted within these designated areas that minimise the risk of spillage. Contingency plans will also be in place for dealing with any spillage that may occur.

Any contaminated material encountered during construction will be dealt with according to environmental best practice, following suitable chemical analysis. Such material will be contained, treated, or disposed of, to a suitably licensed disposal facility.

Implementation of the procedures described above will mitigate the significance of a chemical pollution impact to low.

Increase in runoff

Adoption of sustainable drainage, as discussed in the Sedimentation and Erosion section above, will allow for the capture of runoff from the site, and render impacts caused by runoff negligible.

Lowering of the water table

Should planning permission be granted, an intrusive investigation will be carried out and groundwater monitoring standpipes installed at the locations of each of the turbines. The investigation will include an assessment of the ground permeability and water potential. Mitigating measures for any potential dewatering and disposal of groundwater will be provided in a construction method statement.

10.7.3 Operation

The proposed mitigation for the construction of the access roads will continue to function through the life of the project. Routine maintenance for the roads will be carried out in summer months when the tracks are dry. Operational best practice procedures will continue to be adopted, with the risk of water pollution from such activities considered to be negligible.

The proposed mitigation for fuels and chemicals used during the construction phase would be applied at all relevant times during the lifetime of the project. The concrete used will be of a high grade that is not prone to leaching alkalis. As such the ongoing risk of pollution on the site after construction is considered to be very low.

10.7.4 Decommissioning

It is envisaged that detailed method statements, in compliance with relevant current legislation, will be drawn up prior to decommissioning. Similar mitigation methods to those employed during construction (updated to take account of legislation current at the time of decommissioning) are likely to be appropriate.

10.8 Assessment of Residual Impact and Effect

The residual impacts after mitigating factors have been taken into account are analysed with respect to their significance. **Table 10.5** below includes a summary of the residual impacts, and it can be seen that there are no residual impacts of major significance expected to occur as a result of the development.

Table 10.5 - Summary of Impact Assessment

Project Element	Effect	Sensitive Receptor	Initial Significance	Description of Mitigation	Residual Significance
Crossing of a watercourse	Drop in hydraulic gradient	Watercourses	Negligible	No crossings of a watercourse are required - no mitigation required.	Negligible
Access Track & cabling; Hard-standings	Disruption to field drainage flow paths	Watercourses	Low	Incorporating lateral drainage across tracks in design	Negligible
	Erosion and the generation of silty runoff	Watercourses	Low	Implementation of a Sustainable Drainage system to capture runoff. Adherence to best practice procedures.	Negligible
	Increase in runoff adding to flooding	Watercourses	Low	Implementation of a Sustainable Drainage system to capture runoff.	Negligible
Keeping and using concrete, chemicals/fuel onsite; refuelling.	Polluted runoff contaminating a watercourse	Watercourses	Medium	Implementation of a Sustainable Drainage system to capture runoff. Adherence to best practice procedures in the handling, use and storage of fuel, oils and chemicals. Concrete will be delivered in ready mix wagons. Wagons only to 'wash-out' in areas where suitable control measures are in place.	Low

Project Element	Effect	Sensitive Receptor	Initial Significance	Description of Mitigation	Residual Significance
	Polluted runoff contaminating groundwater	Groundwater	Medium	Implementation of a Sustainable Drainage system to capture runoff. Adherence to best practice procedures in the handling, use and storage of fuel, oils and chemicals. Concrete will be delivered in ready mix wagons. Wagons only to 'wash-out' in areas where suitable control measures are in place.	Low
	Polluted runoff contaminating potable water supply	Private Water Supply	Negligible	Runoff will not flow near any private water supplies - no mitigation required. Concrete will be delivered in ready mix wagons. Wagons only to 'wash-out' in areas where suitable control measures are in place.	Negligible
Excavation of track and foundation	Dropping of the water table harming potable water supply	Private Water Supply	Negligible	Private water supplies are outwith the area of effect of dewatering - no mitigation required.	Negligible

10.9 Conclusion

A desk-based study and site walkover were conducted to establish the baseline water environment of the site, and following this the predicted impacts caused by the development were identified.

The majority of potentially significant negative impacts on water quality are only predicted to occur in the short term through potential increased sedimentation and pollution during the construction phase. Although there is a slight risk of spillages of concrete or chemicals reaching a local potable water source during maintenance work, the risk is held to be greater during the construction phase. The same would apply to the risk of contamination of groundwater. The adoption of best practice management and control procedures by all site personnel, and the implementation of the mitigation methods proposed, will bring these risks down to acceptable levels.

11 INFRASTRUCTURE

11.1 Introduction

Operational wind turbines have the potential to interfere with:

- Communication networks that use electromagnetic signals;
- Civil aviation radars;
- Safeguarding radars operated by the MOD; and
- Other types of infrastructure such as high pressure gas, water pipes or electricity lines and cables.

The potential impact of the proposed wind turbine on this infrastructure is considered in this chapter.

11.2 Guidance

Guidance for assessing the potential impact of wind turbines on electromagnetic infrastructure is given in:

- Planning for Renewable Energy: A Companion Guide to PPS22;
- Tall structures and their impact on broadcast and other wireless systems, Ofcom, 2009; and
- Wind farms assessment tool, BBC

Guidelines and publications for assessing potential impact on aviation activities are:

- Wind Energy and Aviation Interim Guidelines, BWEA, 2002;
- CAP 428 - Safety Standards at Unlicensed Aerodromes, CAA, 2004; and
- CAP 764 – Policy and Guidelines on Wind Turbines, CAA, 2012.

11.3 Consultation

A list of consultees with aviation, telecommunications, television and other infrastructure interests in the area was identified based upon advice given in planning policy. The consultees listed in **Table 11.1** were contacted as part of this study.

Table 11.1 – Infrastructure, telecommunications and other infrastructure consultation

Aviation Leeds-Bradford International Airport Robin Hood Airport (Doncaster Sheffield)
Telecommunications Ofcom JRC Atkins BT Airwaves
Services BskyB Installcom GTC Linesearch National Grid OpenReachFulcrum Sisplan

11.4 Assessment of Predicted Impacts and Effect

11.4.1 Civil aviation

An independent aviation study was commissioned to look in detail at the likely impacts on civilian aviation.

The report identified potential impacts upon:

- Leeds Bradford International Airport;
- Robin Hood Airport (Doncaster Sheffield); and
- National Air Traffic Services (NATS) Claxby En-Route radar.

Consultation with both Leeds Bradford and Robin Hood Airports generated no objections, and established that the current plans are unlikely to impact upon current operations.

Consultation with NATS will take place post-submission, should an objection be received. Although the new turbines fall within the bounds of disturbance caused by the existing turbines, an objection due to cumulative clutter is possible. In the event that this objection cannot be successfully challenged then a mitigation option would be agreed with NATS. This is likely to involve the introduction of a 'blank' covering the new turbines, with the area effectively being in-filled using data from the Manchester Airport radar.

11.4.2 Ministry of Defence (MOD)

An independent aviation study was commissioned to look in detail at the likely impacts on military aviation. No MoD objection is expected. The site is beyond the safeguarding areas associated with the MoD technical sites to the east and out of range of air defence radar. It is in a low priority military low fly zone and amongst existing turbines, so an objection against low flying impacts is extremely unlikely.

11.4.3 Telecommunications

Ofcom was consulted responded to say that the following companies had telecommunications links that could potentially be affected by the development:

- Atkins Ltd;
- The Joint Radio Company (JRC);
- BT; and
- Airwaves.

JRC, which analyses proposals for the potential impact upon radio systems associated with the fuel and power industry, responded to say that they did not have any objection to make with respect to radio link infrastructure.

No objection was received from Atkins Global who are responsible for providing support services for 'The Telecommunications Association of the UK Water Industry' (TAUWI).

BT responded to say that their nearest link is 425m from the closest turbine, and would therefore be unaffected.

Following completion of a study commissioned by the applicant, R4 Telecom, who provide analysis on behalf of Airwaves, advised that there would be no impact on their nearby link

11.4.4 Television

The digital switchover for the whole of the UK has been completed. A 2009 Ofcom report stated that:

“Digital television signals are much better at coping with signal reflections, and digital television pictures do not suffer from ghosting. However a digital receiver that has to deal with reflections needs a somewhat higher signal level than one that has to deal with the direct path only. This can mean that viewers in areas where digital signals are fairly weak can experience interruptions to their reception should new reflections appear.

Over time, this problem is expected to diminish as the power of transmitters is increased as digital switchover continues across the UK. However, higher transmitter powers will not be a solution in all situations which means that reflections may still affect digital television reception in some areas, although the extent of the problem should be far less than for analogue television.”

There are a number of technical solutions available should interference be prove to be an issue and if there are any impacts they are considered to be of temporary nature until a technical alternative can be put in place. Overall, any potential effects on television are considered to be negligible.

11.4.5 Services

A full service check of the site has been undertaken. The following companies have been consulted:

- BskyB;
- Installcom;
- GTC;
- Linesearch;
- National Grid;
- OpenReach;
- Fulcrum; and
- Sisplan.

No services with the potential to be affected by the turbines were identified.

11.5 Mitigation

11.5.1 Civil aviation

The aviation study identified a potential impact upon the Claxby En-Route radar operated by NATS. Should mitigation be required then the most likely option would be to 'blank' the new turbines, with the area effectively being in-filled using data from the Manchester Airport radar.

11.5.2 Ministry of Defence (MOD)

No impacts are expected and therefore no mitigation is deemed to be required.

11.5.3 Telecommunications

No impacts are expected and therefore no mitigation is deemed to be required.

11.5.4 Television

A pre and post-planning television reception survey is normal practice for wind farm developments. Should any detrimental effects be experienced at properties in the area then these are normally addressed at the developer's expense as part of a planning condition agreed with the Council.

11.5.5 Services

No impacts are expected and therefore no mitigation is deemed to be required.

11.6 Conclusion

Potential conflicts have been identified with the NATS En-Route radar at Claxby. If this potential conflict gives rise to an objection then it is anticipated that this can be overcome through an agreement with NATS.

12 SHADOW FLICKER

12.1 Introduction

This section of the report looks at possible shadow flicker impacts as a result of the proposed development.

12.2 Background

Tall structures such as wind turbines cast shadows. The shadows vary in length according to the sun's altitude and azimuthal position. Under certain combinations of geographical position and time of day, the sun may pass behind the rotor of a wind turbine and cast a moving shadow over neighbouring properties. Where this shadow passes over a narrow opening such as a window, the light levels within the room affected will decrease and increase as the blades rotate, hence the shadow causes light levels to 'flicker' - an effect commonly known as 'shadow flicker'.

Whilst the moving shadow can occur outside, the shadow flicker effect is only experienced inside buildings where the shadow passes over a narrow window opening. The seasonal duration of this effect can be calculated from the geometry of the machine and the latitude of the site. A single window in a single building is likely to be affected for a few minutes at certain times of the day for short periods of the year. The likelihood of this occurring and the duration of such an effect depend upon:

- The direction of the residence relative to the turbine(s);
- The distance from the turbine(s);
- The turbine hub-height and rotor diameter;
- The time of year;
- The proportion of day-light hours in which the turbine operates;
- The frequency of bright sunshine and cloudless skies (particularly at low elevations above the horizon); and
- The prevailing wind direction.

The further the observer is from the turbine the less pronounced the effect will be. There are several reasons for this:

- There are fewer times when the sun is low enough to cast a long shadow;
- When the sun is low it is more likely to be obscured by either cloud on the horizon or intervening buildings and vegetation; and,
- The centre of the rotor's shadow passes more quickly over the land reducing the duration of the effect.

At a distance, the blades do not cover the sun but only partly mask it, substantially weakening the shadow. This effect occurs first with the shadow from the blade tip, the tips being thinner in section than the rest of the blade. The shadows from the tips extend the furthest and so only a weak effect is observed at a distance from the turbines.

12.3 Guidance

12.3.1 Identification of Receptors

Planning for Renewable Energy, 'A Companion Guide to Planning Policy Statement 22 ("PPS") provides technical information on a range of renewable energy technologies, including onshore wind power. This information is relevant throughout the UK.

Although it has since been superseded for planning purposes, the Companion Guide is the accepted industry standard in describing the conditions in the UK under which flicker may occur and states that the effect diminishes with distance.

The guidance further states that flicker effects are known to occur within ten rotor diameters and 130 degrees either side of north relative to wind turbines. In the case of the Spicer Hill Extension project, a distance of ten rotor diameters equates to 710m.

These sensitive receptors include residential properties including care homes; educational buildings, hospitals, cemeteries; some visitor facilities and accommodation; and proposed development areas.

12.3.2 Significance Criteria

Northern Ireland's Best Practice Guidance to Renewable Energy²⁵, which has been approved by DECC²⁶, states that an acceptable shadow flicker level at residential properties is 30 hours per year.

²⁵ Best Practice Guidance to Planning Policy Statement 18: Renewable Energy, Department of the Environment (Northern Ireland), (2009).

http://www.planningni.gov.uk/index/policy/policy_publications/planning_statements/planning_policy_statement_18_renewable_energy_best_practice_guidance.pdf

²⁶ Update of UK Shadow Flicker Evidence Base, DECC (2011)

<http://www.decc.gov.uk/assets/decc/What%20we%20do/UK%20energy%20supply/Energy%20mix/Renewable%20energy/ORED/1416-update-uk-shadow-flicker-evidence-base.pdf>

© Green Cat Renewables Ltd

12.4 Methodology

12.4.1 RESoft Windfarm Software

RESoft Windfarm software has been used to model the shadow flicker effects of the development. The program uses simple geometric considerations: the position of the sun at a given date and time; the size and orientation of the windows that may be affected; and the size of the turbine that may cast the shadows. The model adopts a conservative approach by assuming that:

- Turbines are facing the sun at all times of the day;
- It is always sunny;
- The turbines are always operating; and
- There is no local screening.

Based upon the Guidance outlined above, all of the potentially sensitive receptors within a distance of 10 rotor diameters (710m) of the Spicer Hill Extension turbines that are within 130 degrees either side of north relative to the turbine have been included in the assessment.

The proximity of the Spicer Hill Extension turbines to existing Spicer Hill turbines and the Blackstone Edge turbines means that cumulative shadow flicker impacts could potentially arise at nearby properties. Blackstone Edge has not been included as it would be decommissioned before the Spicer Hill Extension was constructed. Details of these developments are shown in **Table 12.1**.

Table 12.1 – Details of developments considered for the cumulative assessment

Development	Turbine Details	Easting (to 10m)	Northing (to 10m)
Spicer Hill	3 x Enercon E70 (57m hub height, 71m rotor diameter)	420630	404830
		420650	405190
		420390	404940
Blackstone Edge	3 x Nordex N80 (60m hub height, 80m rotor diameter)	419570	405230
		419560	405540
		419870	405200

The approach to the assessment is set out below:

1. To assess the shadow flicker impact of Spicer Hill Extension turbines at all potential receptors within 710m of the development.
2. To calculate cumulative shadow flicker effects at those receptors that are:
 - a. Within 710m of the Spicer Hill Extension turbines and predicted to experience some shadow flicker impact; and
 - b. Within 710m of the existing Spicer Hill turbines; and/or

- c. Within 800m of the existing Blackstone Edge wind turbines.

Results have been presented for Spicer Hill Extension turbines alone as well as for the cumulative effects of both the Spicer Hill Extension turbines, the existing Spicer Hill turbines and Blackstone Edge, where relevant.

12.4.2 Modelling of Windows

Window dimensions have been estimated using information gathered from site. Where window dimensions were unobtainable a standard dimension of 2m x 2m with a centre point of 2m above ground level was used.

The orientation of each window with a potential view of the turbines has been included in the model, measured in terms of degrees from north. This means, for example, that if a window faces due south it is 180 degrees from north.

12.4.3 Model Conditions

Calculations have been carried out using ReSoft's WindFarm software. This models shadow flicker effects by using simple geometric considerations: the position of the sun at a given date and time; the size and orientation of the windows that may be affected; and the size of the turbine that may cast the shadows. The model adopts a conservative approach by assuming that:

- Turbines face the sun at all times of the day;
- It is always sunny;
- The turbines are always operating; and
- There is no local screening.

12.4.4 Correction Factors

Correction factors which take into account actual annual hours of sunlight for the area, hours of turbine operation, and average yaw angle have been applied to the initial theoretical results in order to reach more realistic overall potential levels of shadow flicker effect. The correction factors are derived from the following:

- The average sunlight hours for the Penistone area which is ~1,445 hours. This has been estimated from the 1981-2010 met office data for Sheffield. Therefore, on average it is sunny for ~32% of the daylight hours.
- The rotor of a modern wind turbine can be expected to turn approximately 90% of the time.
- According to the Danish Wind Energy Association website, shadow flicker is reduced to 63% of the maximum possible if the wind turbine is assumed to be randomly yawed relative to the sun position.

The corrected results are therefore 18% of the uncorrected total (0.32 x 0.90 x 0.63= 0.18).

12.4.5 Assessment of Impact

As confirmed by DECC’s Report ‘Update of UK Shadow Flicker Evidence Base^[1], there is no standard UK Guidance on acceptable levels of shadow flicker. The only guidance that provides suggested levels is Northern Ireland’s Best Practice Guidance to Renewable Energy^[2], which recommends that shadow flicker at neighbouring offices and dwellings within 500m should not exceed 30 hours per year. This position is based on research by Predac, a European Union sponsored organisation promoting best practice in energy use and supply which draws on experience from Belgium, Denmark, France, the Netherlands and Germany.

Table 12.2 shows the impact assessment matrix that was used in this assessment, which is based upon this guidance.

Table 12.2 – Impact Assessment Matrix

Calculated annual hours of shadow flicker effects		
>30h	<30h	Zero
High	Medium / Low	None

12.5 Baseline

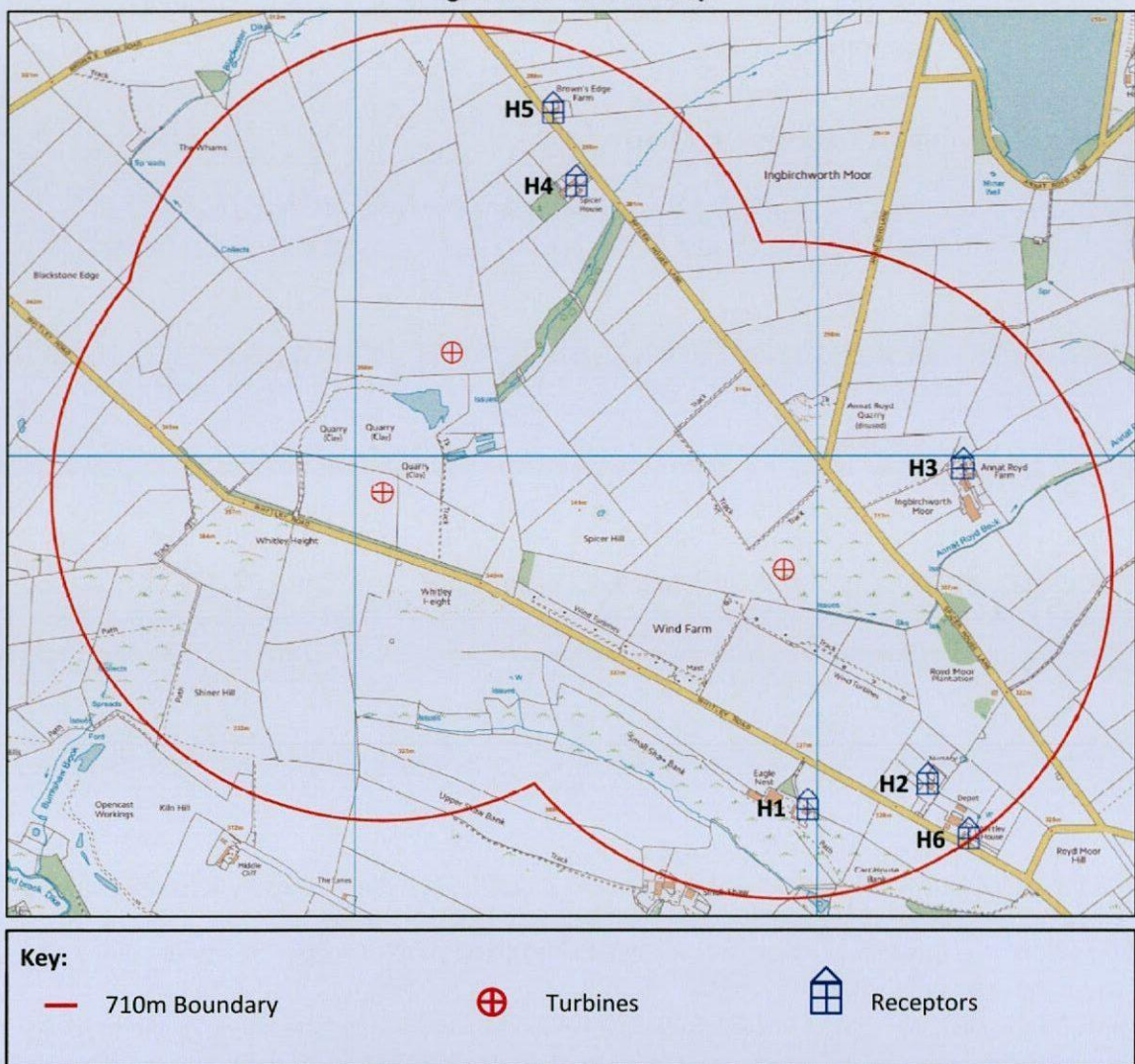
Details of the properties located within the 710m study area for the Spicer Hill Extension turbines are shown in **Table 12.3** and mapped on **Figure 12.1**.

^[1] Update of UK Shadow Flicker Evidence Base, DECC (2011)
<http://www.decc.gov.uk/assets/decc/What%20we%20do/UK%20energy%20supply/Energy%20mix/Renewable%20energy/ORED/1416-update-uk-shadow-flicker-evidence-base.pdf>
^[2] Best Practice Guidance to Planning Policy Statement 18: Renewable Energy, Department of the Environment (Northern Ireland), (2009).
http://www.planningni.gov.uk/index/policy/policy_publications/planning_statements/planning_policy_statement_18_renewable_energy_best_practice_guidance.pdf

Table 12.3 – Potentially sensitive receptors

ID	Property Name	Distance to nearest turbine	Orientation of façade 1 (degrees from north)	Glazing area and height on façade 1	Orientation of façade 2 (degrees from north)	Glazing area and height on façade 2
1	Eagle Nest	~520m	~300°	2m x 2m @2m	~30°	2m x 2m @2m
2	Windmill Nursery	~560m	~310°	2m x 2m @2m	-	-
3	Annat Royd Farm	~440m	~245°	None	-	-
4	Spicer House	~450m	~230°	2m x 2m @2m	~140°	2m x 2m @2m
5	Brown's Edge Farm	~570m	~250°	None	~160°	2m x 2m @2m
6	Whitley House	~710m	~300°	2m x 2m @2m	-	-

Figure 12.1- Baseline Map



12.5.1 Assessment of Predicted Impacts and Effect

The calculation results, both theoretical and realistic, along with the resulting impact assessment based on the assessment matrix above, are given in **Table 12.3**.

Table 12.3 – Impact Assessment

ID	Days per year	Max. hours per day	Mean hours per day	Total hours per year		Impact (based on Realistic)
				Theoretical	Realistic	
1 – Eagle Nest	0	0.00	0.00	0.0	0.0	None
2 – Windmill Nursery	0	0.00	0.00	0.0	0.0	None
3 – Annat Royd Farm	0	0.00	0.00	0.0	0.0	None
4 – Spicer House	103	0.68	0.46	47.6	8.6	Medium / low
5 – Brown's Edge Farm	55	0.54	0.44	24.4	4.4	Medium / low
6 – Whitley House	0	0.00	0.00	0.0	0.0	None

12.6 Cumulative Baseline

Figure 12.2 shows the baseline map used to assess the cumulative shadow flicker impact of the Spicer Hill Extension turbines with the existing Spicer Hill turbines and Blackstone Edge.

Figure 12.2 – Cumulative Baseline Maps

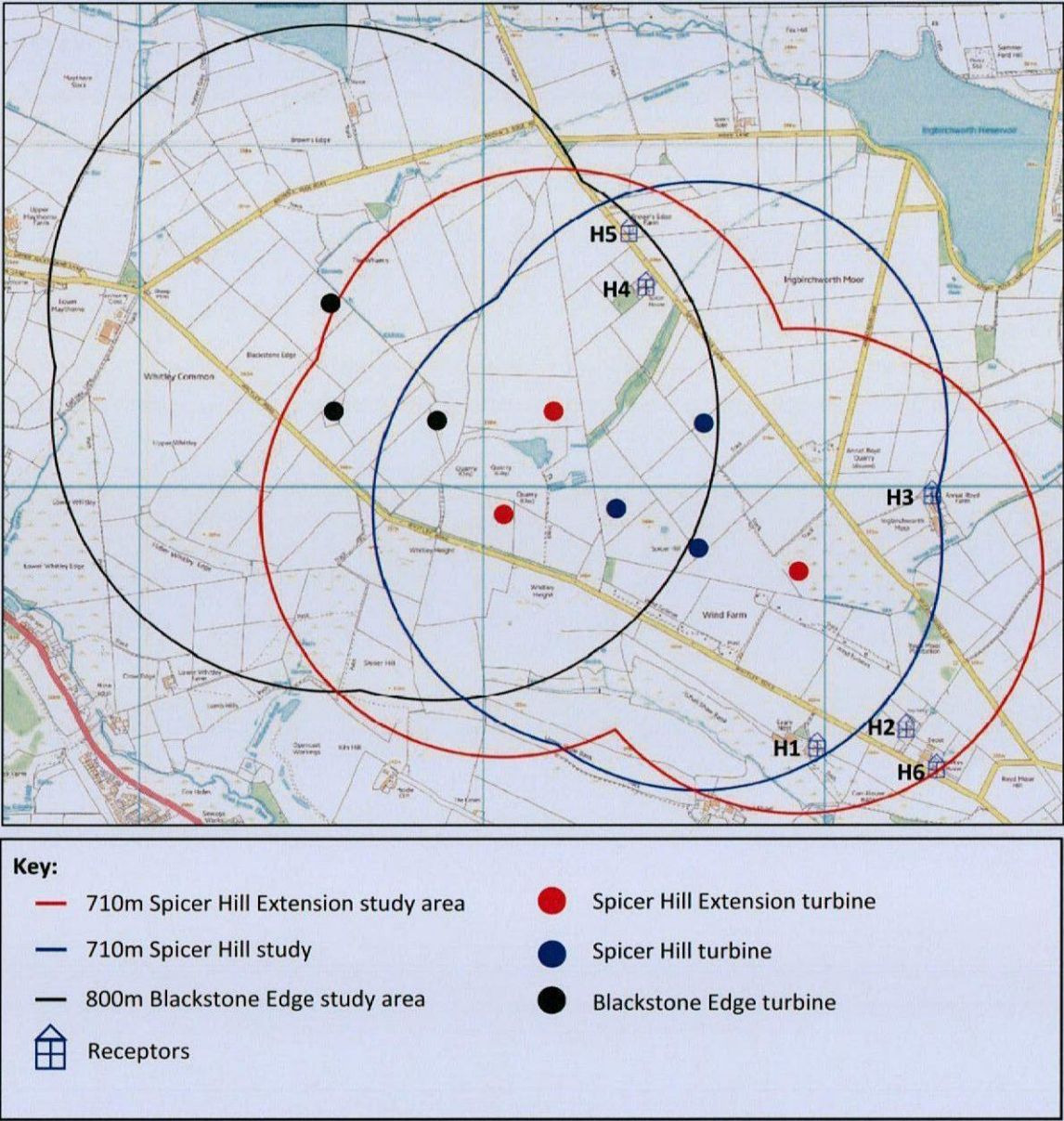


Table 12.4 shows how the properties considered within the cumulative assessment were selected.

Table 12.4 – Receptors considered within the cumulative assessment

Receptor ID	Predicted impact from Spicer Hill Extension?	Within 710m of Spicer Hill built turbines	Within 800m of Blackstone Edge?	Considered within cumulative assessment?
1 – Eagle Nest	No	Yes	No	No
2 – Windmill Nursery	No	No	No	No
3 – Annat Royd Farm	No	Yes	No	No
4 – Spicer House	Yes	Yes	Yes	Yes
5 – Brown’s Edge Farm	Yes	Yes	Yes	Yes
6 – Whitley House	No	No	No	No

12.6.1 Assessment of Predicted Cumulative Impacts and Effect

Table 12.5 presents the calculated results, both theoretical and realistic. The resulting impact assessment is based upon realistic figures, and has been assessed using the matrix presented in **Table 12.1**. The results take into account any receptors with more than one affected façade.

Table 12.5 – Cumulative Impact Assessment

ID	Days per year	Max. hours per day	Mean hours per day	Total hours per year		Impact (based on Realistic)
				Theoretical	Realistic	
4 – Spicer House	134	1.22	0.79	106.0	19.1	Medium / low
5 – Brown’s Edge Farm	99	0.90	0.53	52.9	9.5	Medium / low

Table 12.5 shows that predicted levels of shadow flicker increase when cumulative effects from other developments in the area are considered. The overall impact has remained as **Medium / Low**.

12.7 Mitigation

12.7.1 Screening effects

The results presented above assume that there is no local screening between each property and the turbines considered within this assessment. The discussion below considers mitigation factors for properties 4 and 5.

H4 – Spicer House

Spicer House has a financial interest in both the built Spicer Hill turbines and the proposed Spicer Hill Extension turbines. This property will be partially screened from

the effects of shadow flicker by mature vegetation which lies between the house and the nearest turbines. These trees provide some screening, particularly in the summer months.

H5 – Brown’s Edge Farm

The property at Brown’s Edge Farm is orientated on a north-east to south-west axis and has no windows on the gable end walls. As such, the south-west façade of the property will experience no shadow flicker. Shadow flicker will be reduced on the south-east facing façade of the property due to the presence of vegetation which can be seen in **Figure 12.3**.

Figure 12.3 – Aerial photograph of Brown’s Edge Farm



12.8 Summary and Conclusion

All of the potentially sensitive residential properties surrounding the site have been identified and a mathematical model was run using conservative assumptions to calculate the theoretical potential effect of shadow flicker at the identified receptors.

An assessment of the impact was derived based on the predicted magnitude of impact before and after taking into account certain correction factors.

Spicer House (H4) and Brown’s Edge Farm (H5) are predicted to experience a **Medium / Low** significance of shadow flicker impact from the Spicer Hill Extension turbines alone with 8.6 and 4.4 hours respectively when realistic climatic factors are considered.