8 HYDROLOGY AND HYDROGEOLOGY

8.1 INTRODUCTION

This Chapter of the Environmental Statement (ES) assesses the hydrological and hydrogeological effects of the proposed Spicer Hill Wind Farm ('the Development') during the proposed construction, operation and decommissioning phases. Reference is made to Chapter 6: *Ecology* of this ES where appropriate.

This chapter contains the following sections:

- Consultations - a summary of consultation undertaken in relation to this assessment;
- Methodology - describing both the methods used in baseline surveys and in the assessment of the significance of effects;
- Baseline Description - a description of the hydrology and hydrogeology of the site based on the results of surveys, desk information and consultations;
- Information Gaps - a summary of the main uncertainties encountered in the assessment;
- Potential Effects - identifying the ways in which the site could be affected by the Development;
- Mitigation - a description of measures recommended to off-set potential effects;
- Residual Effects - an assessment of the significance of the effects of the development, after mitigation measures have been implemented;
- Summary of Effects; and
- Statement of Significance.

The predominant effects on local hydrology and hydrogeology in wind farm developments are typically associated with borrow pit construction. In order to eliminate this risk, J G Pears Ltd ('the Developer') has elected not to excavate borrow pits at the site, and instead, to import stone from local quarries for foundation material.

All remaining potentially polluting construction activities will be controlled through a Pollution Prevention Plan (PPP).

8.2 CONSULTATION

Information has been provided by a range of organisations during this assessment, and this is summarised in Table 8.1.

Table 8.1 Consultation Communications

Consultee	Key Points in Response
The Meteorological Office	Information provided on meteorological conditions at Sheffield and regional climatic averages.
Environment Agency	Information provided on flood risk, watercourse designations and local fisheries.
Barnsley Metropolitan Borough Council	Information provided on private water supplies. Listed planning requirements, and consultees who would and wouldn't respond to scoping.
Natural England	Information provided on local Watercourse Designations.
The British Geological Survey	Details provided on solid and drift geology, and groundwater.

8.3 GUIDANCE

The assessment has been undertaken in accordance with the following policy and guidance:

- Water Framework Directive (2000/60/EC)[1]. The Water Framework Directive (WFD) establishes a framework for the protection, improvement and sustainable use of all water environments;
- PPS 25[2]: Development and Flood Risk. This states that for development sites over one hectare, the vulnerability to flooding or the potential to add to flooding elsewhere should be incorporated in a Flood Risk assessment (FRA);
- The Construction Industry Research and Information Association (CIRIA) Environmental Good Practice On Site (C502) (1999)[3]. C502 provides guidance on how to avoid causing environmental damage when on a construction site; and
- CIRIA Control of Water Pollution from Construction Sites (C532) (2001)[4]. C532 provides guidance on how to plan and manage construction projects to control water pollution.

8.4 METHODOLOGY

8.4.1 Desk Study

The desk study included

- Identification of catchments, watercourses, springs and water features;
- Collation of data provided through consultations;
- Collation of flood plain information and water quality data; and
- Compilation of soils, geological and hydrogeological information.

Reference was made to the following sources of information

- The British Geological Survey 1:50,000 Series Solid and Drift Edition (sheet 86);
- Hydrogeological Map of England and Wales 1:625,000, 1977;
- The Ordnance Survey 1:50,000 Landranger Map (Sheet 110);
- Water Framework Directive (2000/60/EC). The Water Framework Directive (WFD) establishes a framework for the protection, improvement and sustainable use of all water environments;
- The Construction Industry Research and Information Association (CIRIA) Environmental Good Practice on Site (C502) (1999). C502 provides guidance on how to avoid causing environmental damage when on a construction site; and
- CIRIA Control of Water Pollution from Construction Sites (C532) (2001). C532 provides guidance on how to plan and manage construction projects to control water pollution.

8.4.2 Site Walkover

A site walkover was carried out on 13th December 2007 to visually identify and assess surface water features and to obtain an understanding of the local topography and hydrological regime.

8.4.3 Significance Criteria

The significance of the potential effects of the Development has been classified by taking into account the sensitivity of receptors and the magnitude of the potential effect, combined with the likelihood of an event occurring.

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[1] European Parliament (2000). "Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy" ("The Water Framework Directive). http://ec.europa.eu/environment/water/water-framework/index_en.html

[2] Department for Communities and Local Government (DCLG) (2006). "Planning Policy Statement 25: Development and Flood Risk". http://www.communities.gov.uk/publications/planningandbuilding/pps25floodrisk

[3] CIRIA (2005). "Environmental Good Practice On Site". C650. http://www.ciria.org/acatalog/c650.pdf

[4] CIRIA (2001). "Control of Water Pollution from Construction Sites". http://www.ciria.org/acatalog/c532.pdf

The **sensitivity** of the receiving environment can be defined as its ability to absorb an effect without perceptible change and can be classified as either low, moderate or high.

Sensitivity is dependent on factors such as the quality of local receiving waters; their purpose (*e.g.*, whether used for drinking, fisheries); and existing influences.

The **magnitude** takes into account the timing, scale, size and duration of the potential effect resulting from the Development. The magnitude of potential effects is classified as negligible, minor, moderate or major.

The significance of the unmitigated effect is defined as shown in Table 8.2.

Table 2.2 Matrix for determining the significance of potential effects

Degree of alteration	Sensitivity of receptor	High	Medium	Low	Negligible
Large		Major	Major	Moderate	Negligible
Medium		Major	Moderate	Minor	Negligible
Small		Moderate	Minor	Minor	Negligible
Negligible		Negligible	Negligible	Negligible	Negligible

The **likelihood** of an event occurring is then assessed, and classified as unlikely, possible or likely.

Finally, the residual (or overall) significance after implementation of mitigation measures is a function of the unmitigated significance combined with the likelihood of an event occurring (with mitigation taking place), as shown in Table 8.3.

Table 8.3 Residual Significance Criteria after Mitigation

	Likelihood		
Unmitigated Significance	**Likely**	**Possible**	**Unlikely**
Major	Major	Moderate	Minor
Moderate	Moderate	Minor	Negligible
Minor	Minor	Negligible	Negligible
Negligible	Negligible	Negligible	Negligible

Conclusions of this Chapter state whether residual significance has been assessed as major, moderate, minor or negligible, once appropriate mitigation has been implemented. This assessment relies on professional judgment to ensure that the effects are appropriately assessed. Effects of moderate or major significance are considered significant in terms of the EIA Regulations.

8.5 BASELINE DESCRIPTION

8.5.1 Topography and Land Use

The closest settlements to the site are Penistone, located approximately 3.2 km to the south east of the application boundary and Stocksbridge, approximately 9 km to the south east of the application boundary.

The proposed turbine locations, access tracks and associated infrastructure are illustrated in Figure 1.2 of this ES.

The 1:50,000 Ordnance Survey Landranger Map (Sheet 89) shows the turbine envelope to lie in an elevated plateau rising from elevations of approximately 310 m AOD to 362 m AOD. Topography is broadly defined by a ridge sloping from north to south towards Small Shaw Dyke. The majority of the land is used for livestock grazing and land to the east for arable farming. Habitats are described in detail in Chapter 6: *Ecology* of this ES.

Surface watercourses and catchments are illustrated on Figure 8.1.

8.5.2 Solid Geology

The British Geological Survey Digital Mapping shows the main part of the study area is underlain by sandstone, siltstone and mudstone rocks from the Westphalian period, identified as Pennine Lower Coal Measures. Rhythmic bands of Grenoside sandstone, Greenmore Rock and 80 Yard Rock also lie in the southern section of the site. Solid geologies are shown on Figure 8.2.

8.5.3 Superficial Geology

The British Geological Survey 1:50,000 Series Solid and Drift Edition (sheet 86) shows the dominant superficial geology to comprise of undifferentiated mudstones, silt, weathered clay and Alluvium from the Quaternary period. Trial pit investigations, undertaken by Donaldson Associates, revealed sandy gravel and cobbles to overlay sandstone to a depth of 0.7 m at the proposed location of Turbine 2. Stiff slightly sandy clay to depths of approximately 2 m was encountered at Turbine 1. The trial pit at Turbine 3 contained stiff slightly sandy clay with occasional sandstone and shale gravel to a depth of 1.75 m. Very weak weathered shale was encountered underlying the clay.

8.5.4 Hydrogeology

The Hydrogeological Map of England and Wales 1:625,000 (1977), shows the site to be underlain by the Yordale Series and Coal Measures consisting of rhythmic sequences of shales, sandstones, coals and limestones. Mine waters from coal measures tend to be ferruginous and acidic.

8.5.5 Climate

The Hydrogeological Map of England and Wales 1:625,000 (1977), shows the Average Annual Rainfall to be 635 mm to 716 mm per annum. The Meteorological Office reports regional Average Annual precipitation for the Sheffield area to be 824.7 mm per annum (1971 to 2000).

8.5.6 Hydrology

Figure 8.1 shows the main surface watercourses and their associated catchments.

One unnamed watercourse dissects the northeast section of the study area and drains north towards Ingbirchworth Reservoir. Annat Royd Beck issues in the northeast of the site and drains north towards Royd Moor Reservoir, whilst Small Shaw Dyke issues in the south of the site and drains in accordance with topography towards Lee Lane Dyke before convening with the River Don, approximately 2.5 km to the southeast of the study area boundary.

8.5.6.1 Hydrological Regime

In terms of hydrological regime, steeper sections of watercourses will naturally respond more quickly to rainfall. Watercourses, on the Spicer Hill Wind Farm site, are on a moderate incline or are relatively flat and slow flowing and the steeper sections tend to be outwith the turbine envelope. Watercourses on-site are therefore likely to have more capacity to absorb rainfall, with corresponding slower response rates.

8.5.6.2 Surface Water Continuity

Surface watercourses appear to be relatively continuous, with no obvious blockages evident during the site visit.

8.5.6.3 Surface Water Morphology

From what was observed on-site, morphology is relatively typical of parallel drainage network watercourses, which are flatter in their upper reaches and become increasingly steep and faster flowing as they progress downslope.

8.5.7 Designations

No statutory designations pertaining to watercourses exist within a 5 km radius of the site. However, two tributaries of neighbouring reservoirs dissect the site. Emphasis would need to be given to protecting the integrity of watercourses in proximity to the Development, particularly by mitigating against impacts during construction.

8.5.8 Fisheries

Consultation responses have highlighted the importance of local fisheries as salmonid feeder rivers, particularly the River Don. Construction of wind farms, if poorly controlled, can lead to increased run-off, sedimentation, compaction, and changes to soil flow patterns. In this instance, run-off would drain in accordance with the existing surface run-off regimes on site, predominantly towards Annat Royd Beck and Small Shaw Dyke.

8.5.9 Water Supplies Public and Private

Consultation responses have indicated that there are no private or potable water supplies or abstractions within a 2 km radius of the study area.

8.5.10 Flooding

The Environment Agency (EA) has no records of flooding at the site and the Flood Map shows the site located in an area described as Flood Zone 1 in PPS 25[5]. This zone is categorised as being the lowest flood risk and comprises land assessed as having a less than 1 in 1000 (0.1%) annual probability of river or sea flooding in any year. The EA Flood Map shows that marginal flooding in low lying areas located beyond the north of the study area (in proximity to Ingbirchworth Reservoir) may be possible during heavy and prolonged precipitation events. A Flood Risk Assessment (Technical Appendix 8.1) concludes that the hardstanding associated with the Development will not increase flood risk within the catchment. Areas at risk from marginal flooding are shown on Figure 8.1.

8.5.11 Information Gaps

A Pollution Prevention Plan (PPP) is not required to complete this assessment, however it is likely to be necessary prior to construction.

8.6 ASSESSMENT OF POTENTIAL EFFECTS

The effect of the Development on hydrological receptors has been considered for the construction, operation and decommissioning phases of the Development.

[5] Planning Policy Statement 25: Development and Flood Risk
http://www.communities.gov.uk/documents/planningandbuilding/pdf/planningpolicystatement25.pdf

8.6.1 *Description of Construction Activities*

All construction activities are described in Chapter 3: *Project Description* of this ES. Construction activities that could give rise to potential hydrological and hydrogeological effects are:

- Construction of access tracks and cabling;
- Construction of site compound and substation;
- Chemical handling; and
- Excavation works.

8.6.2 *Sensitivity of Receptors to Construction Effects*

The components of the hydrology system have been associated with specific categories of sensitivity to the potential effects, as outlined in Table 8.4.

Table 8.4 Receptors' Sensitivity to Potential Effects

Receptor	Possible Effects	Sensitivity
Watercourses	Increased run-off, erosion and sedimentation, stream flow impediments and pollution as a result of track construction and chemical handling/storage.	High
Groundwater	Pollution as a result of track construction and chemical handling/storage.	High
Soils	Pollution as a result of track construction and chemical handling/storage.	High

Prior to assessing individual effects, it must be recognised that the predominant effects on local hydrology and hydrogeology in wind farm developments are typically associated with borrow pit construction. No borrow are proposed as part of the Development and all stone will be imported from local quarries therefore this risk is eliminated.

8.6.3 *Potential Construction Effects*

The types of effects that could result from the construction activities outlined in Chapter 3: *Project Description* of this ES are described below, along with the likelihood of their occurrence. In cases where the likelihood of the effect occurring is considered to be "Possible" or "Likely", mitigation and the subsequent residual effects are outlined at sections 8.7 to 8.8.

8.6.3.1 Chemical Pollution

Turbine 1 is located within the catchment of the Annat Royd Beck draining towards the northeast of the Development. Turbines 2 and 3 are located within the catchment of the unnamed watercourse draining towards Ingbirchworth Reservoir. The construction compound is located within the catchment of Small Shaw Dyke. These watercourses could therefore be at risk from a pollution incident during construction, if not properly managed.

Potential risks include the spillage or leakage of chemicals, unset cement, foul water, fuel or oil, during use or storage onsite. These pollutants have the potential to adversely affect soils, surface water quality and groundwater, and hence impact on the biodiversity of receiving watercourses. All surface watercourses are, therefore, considered to be of high sensitivity. Due to the low permeability of the underlying geology and the lengthy attenuation processes associated with hydrocarbon-based construction materials, these effects, unmitigated, have the potential to be of moderate magnitude and, therefore, (in accordance with Table 8.2) of moderate significance.

8.6.3.2 Erosion and Sedimentation

Erosion and sedimentation can occur from excavations, ground disturbance and poor design of drainage ditches. Sediment entering watercourses has the potential to affect flood storage capacity, water quality, and ecology. Therefore, if unmitigated, increased sedimentation could have an indirect effect on local watercourses, and ultimately the receiving river systems such as the River Don.

The magnitude of such effects, unmitigated, is considered to be moderate and, therefore, (in accordance with Table 8.2) of moderate significance.

8.6.3.3 Change to Soil Interflow Patterns

Some turbine base excavations may need temporary sub-surface water controls such as physical cut-offs or de-watering. These divert flows away from the excavation, and de-watering temporarily lowers the local water table. Localised temporary changes to soil interflow patterns may therefore arise.

The magnitude of the unmitigated effect could be moderate, and the significance of the potential effect is therefore also moderate.

8.6.3.4 Impediments to Flow

The access tracks will not cross any watercourses.

No watercourse crossings and the lack of substantial felling removes the main activities that could give rise to these effects, however, these effects may still occur through general construction activities and the movement of vehicles. As a result, these effects are considered to be of moderate magnitude and therefore of moderate significance, in accordance with Table 8.2.

8.6.3.5 Compaction of Soils

Construction of access tracks and movement of construction traffic can lead to compaction of the soil. This can reduce soil permeability, potentially leading to increased run-off and increased erosion. The geology underlying Spicer Hill is generally of low permeability and the site has gently sloping topography (1:22 within the turbine envelope), so the effects of compaction would not result in a significant increase in runoff. Furthermore, the proportion of area affected is relatively small in relation to the unaffected area. For these reasons, the magnitude of this effect will be minor before mitigation. Given the high sensitivity and minor magnitude of effect, the significance of effects associated with the compaction of soils is assessed as moderate.

8.6.3.6 Migration of Pollutants from Contaminated Land

Desk studies have not identified any areas of contaminated land within the study area. Should potentially contaminated land be encountered during excavations, however, this would be tested and disposed of in line with appropriate guidelines and legislation.

8.6.3.7 Increase in Runoff

Increased run-off has the potential to influence a range of factors discussed in this section (sedimentation, chemical pollution, soil flow changes, etc), particularly in relation to surface watercourses (see below).

The increase in hard standing could increase the volume and rate of localised surface run-off. The impermeable nature of the underlying geology, however, means there would be limited infiltration and relatively high run-off rates, which suggests that the increase in hard standing would be unlikely to have a significant effect.

There are also no active floodplains, either on or nearby the study area, and the Environment Agency has no records of flooding within the study area. Additional drainage is not proposed outside the study area but the principles of Sustainable Urban Drainage for the Development site will be implemented in order to circumvent any additional drainage affecting any existing risk areas.

8.6.4 Potential Operational Effects

Potential medium and long term effects associated with Development infrastructure such as access tracks, turbine bases and areas of hard-standing could potentially include:

- Increased run-off rates and volume;
- Further erosion and sedimentation;
- Alterations to natural flow pathways; and
- Increased pollution risk.

These effects have been discussed in relation to the construction phase, and as there would be significantly less activity during the operation phase, the magnitude and likelihood of these occurring is low. This will be further ensured through the mitigation measures outlined in Section 8.7.

8.6.5 Potential Decommissioning Effects

The potential effects of the decommissioning phase of the Development are also similar and generally less than those during construction outlined above, and are not repeated here.

8.7 MITIGATION MEASURES

Mitigation measures are broadly divided into those that are “embedded” into the detailed design of the Development and those which will be implemented through best practice and a Pollution Prevention Plan (PPP).

8.7.1 Embedded Mitigation Measures

A fundamental “embedded” mitigation measure is the use of interceptor drains, silt traps and balancing ponds in proximity to access tracks to avoid introducing silt to the site watercourse.

Sustainable Urban Drainage (SUDS) relates to the management of run-off in urban areas. However, the principles of sustainable drainage and site management would be implemented on site in order to minimise the risk to the surface watercourse and groundwater.

These measures will be identified in a detailed drainage design to be developed prior to the commencement of construction activities.

8.7.2 Good Practice

Good Practice will be followed in all aspects of construction and operation, specifically through a Pollution Prevention Plan (PPP).

The PPP would set out measures to be employed in order to avoid or mitigate potential effects for all phases of the Development. This would include an Incident Plan to be followed, in the event that a pollution incident occurs. The construction engineer would have specific responsibility for implementation of the PPP.

Method statements will also be applied, which will follow the principles laid out in relevant EA Pollution Prevention Guidelines.

Micrositing (up to 50 m) will be employed to ensure that the 50 m buffer between turbine bases, ancillary structures and other site infrastructure is maintained. Written consent will also be sought from the EA, prior to working in the vicinity of a watercourse.

Access tracks would have adequate crown or cross-slope to allow rainwater to be shed and where gradients are present lateral drainage would intercept flow. A drainage ditch would be formed on the upslope side of the track (dependent on a detailed drainage design).

Drainage cross pipes would be laid as required in areas where the position of the site track could lead to ponding on one side. As far as possible these would coincide with naturally occurring drainage channels. When the track slopes downhill 'waterbars' would be placed to divert the flow into naturally occurring channels. Advice would be sought from the site ecologist in order to ensure that the location and outfall of cross pipes and waterbars minimises vegetation damage or change.

In order to further reduce surface water pollution potential, concrete batching during construction will be carried out off-site, with the final material being imported onto site for immediate use.

Mitigation measures for construction, operation and decommissioning are listed in Tables 8.5 and 8.6. The tables also provide an overall analysis of the significance of the effects, both pre and post mitigation. This is based on the preceding discussion, and demonstrates that with the appropriate mitigation the likelihood and magnitude of each potential effect has been reduced.

Table 8.5 Mitigation Measures Construction (And Decommissioning)

Activity	Effect	Receptor(s)	Sensitivity	Mitigation	Effect Before Mitigation		Residual Effect	
					Magnitude	Significance	Likelihood	**Residual Significance**
1) Access Tracks (including cabling)	Increased run-off	Watercourses	High	1a) No borrow pits onsite 1b) Pollution Prevention Plan 1c) Method Statements (including onsite effluent disposal) and consent from Environment Agency 1d) Interceptor drains 1e) Silt traps 1f) Balancing ponds 1g) 50m buffer around all watercourses (and micrositing) 1h) Sustainable Urban Drainage (SUDS)	Moderate	Moderate	Possible	Minor
	Erosion and sedimentation	Watercourses	High	As 1a to 1h	Moderate	Moderate	Possible	Minor
	Stream flow impediments	Watercourses	High	1i) Construction best practice	Moderate	Moderate	Possible	Minor
	Soil flow changes	Soils	High	As 1a to 1i 1j) Drainage cross pipes and waterbars	Moderate	Moderate	Possible	Minor
	Soil loss and compaction	Soils	High	As 1a to 1j	Moderate	Moderate	Possible	Minor
2) Compound (and Substation)	As 1)	As 1)	As 1)	As 1)	As 1)	As 1)	As 1)	Minor
3) Crane Pads, Turbine Bases, and Other Hardstandings	As 1)	As 1)	As 1)	As 1)	As 1)	As 1)	As 1)	Minor
4) Activities Involving Chemical Handling and Storage (includes	Pollution	Watercourses	High	As 1a to 1j 4a) Storage in bunded compound 4b) Disposal via registered waste carriers 4c) Off-site concrete batching	Moderate	Moderate	Possible	Minor
	Pollution	Groundwater	High	As 1a to 1j As 4a to 4c	Moderate	Moderate	Possible	Minor

Activity	Effect	Receptor(s)	Sensitivity	Mitigation	Effect Before Mitigation		Residual Effect	
turbine erection, vehicle operations, *etc.*)	Pollution	Soils	High	As 1a to 1j As 4a to 4c	Moderate	Moderate	Possible	Minor

Table 8.6 Mitigation Measures Operation

Activity	Effect	Receptor(s)	Sensitivity	Mitigation	Effect Before Mitigation		Residual Effect	
					Magnitude	Significance	Likelihood	**Residual Significance**
1) Access Tracks (including cabling) compound, substation, crane pads, turbine bases and other hard-standings	Drainage modifications, including increased run-off	Watercourses	High	1a) Pollution Prevention Plan 1b) Fisheries management 1c) Regular inspections (part of PPP) 1d) Sustainable Urban Drainage (SUDS)	Minor	Moderate	Possible	Minor
	Erosion and sedimentation	Watercourses	High	As 1a to 1d	Minor	Moderate	Unlikely	Negligible
	Soil flow changes	Soils	High	As 1a to 1d	Minor	Moderate	Unlikely	Negligible
2) Activities Involving Chemical Handling and Storage	Pollution	Watercourses	High	As 1)	Minor	Moderate	Unlikely	Negligible
	Pollution	Groundwater	High	As 1)	Minor	Moderate	Unlikely	Negligible
	Pollution	Soils	High	As 1)	Minor	Moderate	Unlikely	Negligible

8.8 RESIDUAL EFFECTS

As indicated above, the residual significance of all effects will be minor (or lower).

8.9 SUMMARY OF EFFECTS

The effects are summarised in the previous tables, with residual significance for all issues being assessed as minor (or lower) for construction, operation and decommissioning.

8.10 STATEMENT OF SIGNIFICANCE

This chapter has assessed the likely significance of effects of the Development on hydrology and hydrogeology. Following adoption of the proposed mitigation measures (particularly through the implementation of "embedded" measures and a PPP , Spicer Hill Wind Farm has been assessed as having the potential to result in effects of a minor significance or lower.

Given that impacts of medium significance or greater are considered significant in terms of the EIA Regulations, the potential effects on hydrology and hydrogeology are considered to be *not significant*