8. GEOLOGY, SOILS AND HYDROLOGY

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INTRODUCTION

8.1. This chapter presents an assessment of the potential impacts of the proposed Brechfa Forest West Wind Farm on geology, hydrology, hydrogeology and water resources. The assessment methodology is described, followed by the criteria used in the assessment of potential impacts, and planning policy which relates to the water environment.

8.2. A section on baseline conditions, describing hydrology, geology, soils, hydrogeology, water resources and water use, is followed by assessments of potential impacts during the construction and operation of the proposed scheme, as well as during decommissioning. Mitigation measures are described which will be applied to minimise any impacts.

8.3. The following key issues were identified for consideration either at the scoping stage, or during the baseline studies and the environmental impact assessment:

<table>
<thead>
<tr>
<th>Key Issues</th>
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<tbody>
<tr>
<td>• Potential erosion and sedimentation of drainage systems and watercourses;</td>
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<tr>
<td>• Pollution risks to water quality, for both surface water and groundwater;</td>
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<tr>
<td>• Potential pollution risks to public and private water supplies;</td>
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<tr>
<td>• Increased runoff rates and flood risks, resulting from increases in areas of tracks, other developed areas and forestry felling;</td>
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<tr>
<td>• Impediments to flow at watercourse crossings on access tracks;</td>
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<tr>
<td>• Changes in natural surface water drainage patterns;</td>
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<tr>
<td>• Groundwater vulnerability, changes in groundwater levels and groundwater movement.</td>
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<tr>
<td>• Presence of historical sites of mining; and</td>
</tr>
<tr>
<td>• Impacts of the borrow pit on geology.</td>
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</tbody>
</table>

8.4. The cumulative impact assessment considered sedimentation and pollution risks, impacts on private water supplies, and increased runoff rates and flood risk of the proposed wind farm in combination with other proposed and consented sites.

ASSESSMENT METHODOLOGY

8.5. To inform the assessment of impacts, consultation was undertaken with statutory and non-statutory bodies to establish the hydrological, geological and hydrogeological conditions and the use of water resources in and around the site.

8.6. Desk studies and field surveys were undertaken to determine the current baseline conditions. Field surveys were also carried out to inform the assessment of watercourse crossings on existing forestry tracks and new tracks which will form part of the scheme, and to assess the scope for implementing sustainable drainage systems (SuDS) with the scheme.
8. Geology, Soils and Hydrology

**Private Water Supplies**

8.7. One particular issue to be addressed in areas within and surrounding the site is the presence of private water supplies which may be affected by construction and/or operation of the wind farm. Properties in rural areas frequently have private water supplies sourced from watercourses or springs. If these sources originate from within the site, then water quality or yields could potentially be affected by the wind farm.

8.8. Information on locations of private water supplies in the rural areas surrounding the site was provided by the Public Health Section of Carmarthenshire County Council. However, it was not known whether the information was complete for all rural properties with private water supplies. In many cases, there are other isolated properties, located in the vicinity of those properties known by the Council to have private water supplies. It may be that no mains water supply is available in the area, and these other isolated properties also have private water supplies. The other properties need to be visited to discuss and assess the full extent of private water supplies, or owners’ occupiers need to be contacted for details.

8.9. Areas within which properties with private water supplies could be affected by the wind farm were defined from topographical mapping. The areas extend from the site to major roads or villages/communities on watercourses several kilometres downstream of the site. Below these downstream points, it was considered that surface water quality could already be affected by road runoff or urban drainage. Wind farm site activities should have no additional incremental impact of significance for the water quality of any private water supply sources located downstream of major roads or villages/communities.

8.10. Listings of current and deregulated abstraction licences were also obtained from the Environment Agency for use in the assessment of baseline conditions.

8.11. During field investigations, many of the properties were visited which might have private water supplies, and which could be affected by the scheme. Information collected was used to gauge the likely extent of use of private water supplies in the area, and the potential impacts of the wind farm. A survey of all private water supplies which might be affected will be completed prior to the start of construction of the scheme.

**Data Sources**

8.12. The following data sources were used in the compilation of baseline data:

- Welsh Water information on public water supply infrastructure, including abstraction sources;
- Environment Agency groundwater vulnerability mapping;
- Environment Agency website, for information on aquifer status and water quality;
- Environment Agency listings of current and deregulated abstraction licences and discharge consents. Abstraction licence and discharge consent details were obtained for an area covering the zones within which any private water supplies could be affected by the wind farm;
- Water quality and gauging station flow data obtained from the Environment Agency;

**Consultation**

8.13. Account has been taken of the scoping responses set out in Table 8.1.

### Table 8.1: Summary of Consultee Responses – Geology and Hydrology

<table>
<thead>
<tr>
<th>Consultee</th>
<th>Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carmarthenshire County Council</td>
<td>• Developer advised to contact the Environment Agency regarding potential impacts on the water environment, as well as the Council’s technical contact.</td>
</tr>
<tr>
<td></td>
<td>• Pollution prevention and clean-up measures to be considered for all stages of the development.</td>
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<tr>
<td></td>
<td>• Developer to identify protective/mitigation measures in relation to all private water supplies, and consult local residents.</td>
</tr>
<tr>
<td></td>
<td>• The impact assessment should cover water quality in relation to erosion, sedimentation, discoloration and pollution, flood risk, and geology and soils.</td>
</tr>
<tr>
<td></td>
<td>• Design to minimise watercourse crossings and use bridges where crossings cannot be avoided. Culverting considered the least desirable option.</td>
</tr>
<tr>
<td></td>
<td>• Developer to identify water supply for concrete works and the intended source for rock or fill material. Information should be provided on borrow pit dimensions and reinstatement.</td>
</tr>
<tr>
<td></td>
<td>• If relevant, the Environmental Statement should include impacts on peat deposits and a peat slide assessment.</td>
</tr>
<tr>
<td>Environment Agency</td>
<td>• The developer should undertake a preliminary site assessment comprising a water features survey, study of past land use, and likely impact of turbines on recharge and water balance.</td>
</tr>
<tr>
<td></td>
<td>• The developer should provide risk assessments and method statements relating to design and construction, and detailing pollution prevention measures to be applied.</td>
</tr>
<tr>
<td></td>
<td>• Monitoring should be undertaken to establish any impacts on the water environment. It is the developer’s responsibility to ensure that any existing legal water interests are not affected.</td>
</tr>
<tr>
<td></td>
<td>• Sustainable drainage techniques should be applied.</td>
</tr>
</tbody>
</table>
Field Survey Methodology

8.14. The following field surveys were undertaken to inform the assessment of impacts on geology and hydrology:

- Hydrological reconnaissance and surveys of private water supplies (3 to 7 August 2009);
- Assessment of watercourse crossings (22 and 23 February 2010);
- A peat/soil profile survey (31 May to 2 June 2011);
- Assessment of the scope for implementing sustainable drainage systems (SuDS) (29 and 30 June 2011).

8.15. During the hydrological reconnaissance, a selection of properties, generally those properties closest to the site, were visited to obtain details of any private water supplies. As an indication of location, the properties visited were generally within approximately 3km of the site. The survey was undertaken to assess the private water supply sources and whether these could be affected by wind farm construction. In some cases where the occupants of properties were not available at the time of the visits, a questionnaire and map were left at the property with a request to complete and return the documents. Approximately three-quarters of the questionnaires were completed and returned. The information received was used in the assessment.

8.16. Details of private water supplies obtained from occupants of properties are given in Appendix 8.1. Some additional properties were also visited during the field investigations.

However, in these cases, in response to a question either asked during the visit or included on the questionnaire, the occupiers indicated that they did not want any details to be included in reporting.

**SIGNIFICANCE CRITERIA**

8.17. The baseline conditions described in this report were used in the EIA as the basis for an assessment of the significance of potential impacts on the water environment.

8.18. The significance of potential impacts on the water environment was assessed by evaluating the sensitivity of the baseline environment and the potential magnitude of predicted impacts. The methodologies for assessing the sensitivity of receptors and impact magnitudes are described below. The criteria used for determining significance are then set out, based on sensitivity and magnitude.

**Sensitivity of Receptors**

8.19. The sensitivity of the water environment is determined through a combination of professional judgement and the environmental value of receptors, as recognised or determined by criteria such as Environment Agency water quality ratings, ecological designation and groundwater vulnerability. Each element of the water environment, or receptor, may be categorised as being of low, moderate or high sensitivity. Guidance and examples of the sensitivity of the receptors are outlined in Table 8.2.

8.20. The Environment Agency currently uses two classification systems for water quality. A new classification system is being phased in to replace the ‘General Quality Assessment’ (GQA) scheme as a result of implementation of the Water Framework Directive (WFD). The GQA scheme assessed water quality in terms of chemistry, biology and nutrients and was aimed at identifying point sources of pollutants. The WFD system looks at the wider environment by introducing a more detailed assessment using over 30 measures. The new system classifies the status of a waterbody in terms of ‘ecological status’, which includes biology as well as nutrient and general water quality parameters such as phosphorus and pH, and ‘chemical status’.

8.21. The WFD assessment is not available for all surface waters. The Environment Agency website provides information on past GQA assessments and, where it has been carried out, the new WFD assessment. In this assessment for the Brechfa Forest West Wind Farm, the sensitivity of a receptor (in terms of water quality) is based on the WFD assessment where available. Where the WFD assessment is not available, the GQA scheme is used. However, all information available from the Environment Agency website is included in the baseline section.

8.22. The WFD ecological status is based on the poorest graded individual assessment taken from a wide range of assessments for water environment indicators. In contrast, individual GQA grades result from a more limited assessment of parameters, for example for water quality or biology. As a result, the overall WFD ecological status is frequently classified as being worse than the individual GQA grades for the same river reach. This is evident in the information on water quality given in the descriptions of existing conditions for the site.

8.23. The assessment of sensitivity is based on the current status of the waterbody. If the aquatic environment is of existing poor quality it is likely to be less sensitive to any changes which occur as a result of construction, for example an increase in silt content from site discharge. Therefore the sensitivity is considered to decline with poorer water quality.
8. Geology, Soils and Hydrology

8.24. Soil types are categorised in the sensitivity assessment. Peat soils and associated high soil moisture levels, particularly in extensive areas as found in blanket bog, are considered to be of high sensitivity.

Table 8.2: Sensitivity of receptors

<table>
<thead>
<tr>
<th>Sensitivity</th>
<th>Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>• Receptor is of high environmental importance or national or international value (e.g. water dependent SSSI, SAC, UK or County BAP, or other habitat for protected species, WFD ‘ecological status’ high/good or GQA biological grade very good/good).</td>
</tr>
<tr>
<td></td>
<td>• Receptor is important for fisheries regionally or nationally.</td>
</tr>
<tr>
<td></td>
<td>• Receptor is at high risk of flooding. Any increase in the risk of flooding could affect an urban area or a major road.</td>
</tr>
<tr>
<td></td>
<td>• Receptor is used for public water supply.</td>
</tr>
<tr>
<td></td>
<td>• Groundwater/aquifer vulnerability classified as high in groundwater vulnerability mapping.</td>
</tr>
<tr>
<td></td>
<td>• Soil type and associated land use are highly sensitive (e.g. peat/blanket bog).</td>
</tr>
<tr>
<td>Moderate</td>
<td>• Receptor is of medium environmental importance or regional value (e.g. WFD ecological status moderate or GQA biological grade fairly good/fair).</td>
</tr>
<tr>
<td></td>
<td>• Receptor is at moderate risk of flooding, with existing flooding being confined to an area close to the watercourse.</td>
</tr>
<tr>
<td></td>
<td>• Receptor is used as a private water supply.</td>
</tr>
<tr>
<td></td>
<td>• Moderate classification of groundwater/aquifer vulnerability.</td>
</tr>
<tr>
<td></td>
<td>• Soil type and associated land use are moderately sensitive (e.g. commercial forestry).</td>
</tr>
<tr>
<td>Low</td>
<td>• Receptor is of low environmental importance (e.g. WFD ecological status poor/bad or GQA biological grade poor/bad).</td>
</tr>
<tr>
<td></td>
<td>• Receptor not important for fisheries.</td>
</tr>
<tr>
<td></td>
<td>• Receptor is at low risk of flooding.</td>
</tr>
<tr>
<td></td>
<td>• Receptor not used for water supplies (public or private).</td>
</tr>
<tr>
<td></td>
<td>• Soil type and associated land use not sensitive to change in hydrological regime (e.g. intensive grazing).</td>
</tr>
</tbody>
</table>

Impact Magnitude

8.25. The criteria for assessing the magnitude of potential impacts (Table 8.3) reflect the extent of the change produced. The assessment of impact magnitude is based on technical judgement and, where possible, scientific quantification.

Table 8.3: Criteria for assessing impact magnitude

<table>
<thead>
<tr>
<th>Magnitude</th>
<th>Increase in peak flood flow (as a % of the 1 in 100 year current flood flow)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major</td>
<td>Total loss of or alteration to, key features of the baseline resource such that post-development characteristics or quality will be fundamentally or irreversibly changed.</td>
</tr>
<tr>
<td>Medium</td>
<td>Loss of, or alteration to, key features of the baseline resource such that post-development characteristics or quality will be partially changed.</td>
</tr>
<tr>
<td>Low</td>
<td>Small changes to the baseline resource. The changes are detectable but the underlying characteristics or quality will be similar to pre-development conditions.</td>
</tr>
<tr>
<td>Negligible</td>
<td>A very slight change from the baseline conditions. The change is barely distinguishable, and approximates to the ‘no-change’ situation.</td>
</tr>
</tbody>
</table>

Table 8.4: Criteria for assessing impact magnitude due to increased peak flow

<table>
<thead>
<tr>
<th>Magnitude</th>
<th>Increase in peak flood flow (as a % of the 1 in 100 year current flood flow)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major</td>
<td>&gt;10%</td>
</tr>
<tr>
<td>Medium</td>
<td>&gt;3% and &lt;10%</td>
</tr>
<tr>
<td>Low</td>
<td>&gt;1% and &lt;3%</td>
</tr>
<tr>
<td>Negligible</td>
<td>&lt;1%</td>
</tr>
</tbody>
</table>

8.26. Specific criteria were defined for assessing the impact magnitude of increased peak flood flow due to changes in runoff rates. These criteria are shown in Table 8.4.

8.27. Methods for hydrological analysis and the assessment of changes in peak runoff are unlikely to be accurate to within a few percent. Changes in runoff in different parts of a catchment will contribute to peak flows at different times, depending on the varying time of travel to the point of assessment on the watercourse. As a result, the overall effect of small changes in runoff in different parts of a catchment cannot be predicted with great accuracy. In this assessment, an increase in calculated peak flow of up to 3% is regarded as being of low magnitude. A change of up to 3% is likely to be within the limits of accuracy of the prediction of change in peak flow.

8.28. An increase in flood flow of less than 1% could not be detected at a flow gauging station. It is therefore considered to be negligible.

Impact Significance

8.29. The significance of an impact is defined by the sensitivity of the receiving water environment and the magnitude of the impact, as set out in Table 8.5. The table provides a guide to assist in decision making. However, it should not be considered as a substitute for professional judgement and interpretation.
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### Table 8.5: Significance criteria

<table>
<thead>
<tr>
<th>Magnitude of Impact</th>
<th>Sensitivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>Moderate</td>
</tr>
<tr>
<td>Major</td>
<td>Low</td>
</tr>
<tr>
<td>Medium</td>
<td>Moderate</td>
</tr>
<tr>
<td>Minor</td>
<td>Negligible</td>
</tr>
<tr>
<td>Negligible</td>
<td>Negligible</td>
</tr>
</tbody>
</table>

8.30. The EIA Regulations require a description of the likely significant effects of the development on the environment, and measures envisaged to prevent, reduce and, where possible, offset any significant adverse effects. For this assessment, ‘major’ and ‘moderate’ impacts are considered as ‘significant impacts’ which require assessment in greater detail. These ‘significant impacts’ require appropriate mitigation measures, to reduce the level of impacts to minor or negligible significance.

8.31. Impacts of minor and negligible significance are not considered generally to warrant mitigation. However, where it is possible or preferable to further minimise an impact, mitigation is proposed. For example, mitigation measures are included to account for increases in peak flow in watercourses, calculated as a result of increases in areas of tracks and other developed areas.

### PLANNING POLICY CONTEXT

#### National Policy Statements


8.33. EN-1 states that “Where the project is likely to have effects on the water environment, the applicant should undertake an assessment of the existing status of, and impacts of the proposed project on water quality, water resources and physical characteristics of the water environment as part of the ES or equivalent” (paragraph 5.15.2).

8.34. EN-1 also indicates that “The risk of impacts on the water environment can be reduced through careful design to facilitate adherence to good pollution control practice. For example, designated areas for storage and unloading, with appropriate drainage facilities, should be clearly marked” (paragraph 5.15.9).

#### Other Material Considerations

##### National Policy

8.35. Planning Policy Wales (Welsh Assembly Government, February 2011) indicates that, in development plans, “design approaches and techniques that …… minimise adverse impacts on water resources, surface water quality, the ecology of rivers and groundwater should be encouraged” (paragraph 12.3.1). In relation to flood risk, the policy states that:

- “Development proposals should seek to reduce, and certainly not increase, flood risk arising either from river and/or coastal flooding or from additional run-off from development in any location” (paragraph 13.2.4); and,

- “In determining applications for development, local planning authorities should work closely with the Environment Agency, drainage bodies, sewerage undertakers, prospective developers and other relevant authorities to ensure that surface water run-off is to be controlled as near to the source as possible by the use of sustainable urban drainage systems” (paragraph 13.4.2).

8.36. Technical Advice Note 15 (TAN15) on Development and Flood Risk notes that built development can lead to increasing peak discharge in watercourses. Development in one part of a catchment may increase runoff and hence flood risk elsewhere. The aim should be for new development not to create additional runoff when compared with the undeveloped situation, and for re-development to reduce runoff where possible. However, it is accepted that there may be practical difficulties in achieving this aim.

8.37. TAN15 also discusses sustainable drainage systems (SuDS) as a means for controlling any additional runoff from developments.

#### Carmarthenshire Unitary Development Plan

8.38. General Development Control policy, GDC1, indicates that measures should be taken in developments to minimise water use and to promote water conservation.

8.39. GDC19 indicates that all proposed development must, wherever practical, make appropriate provision for the retention and protection of landscape features such as watercourses and wetlands.

8.40. GDC30 states that the developer will need to demonstrate that the development will not give rise to increased flood risk elsewhere. Developers should seek the advice and, where appropriate, the consent of the Environment Agency Wales before any works are carried out on areas within or affecting river valleys or watercourses.

8.41. Nature and Landscape Conservation Policy EN10 (protection of controlled waters and water resources) states that ‘development which impacts upon controlled waters, wetlands, standing waters and other inland water resources will be permitted only where it can be clearly demonstrated that there would be no adverse effect on water conservation, the quantity and quality of watercourses, fisheries, inland navigation, recreation, sites of nature conservation interest and associated habitats, or on amenity interests dependent on such waters. In respect of any development which is permitted, watercourses will be protected by an undeveloped buffer zone, in order to protect riparian habitats and species, to provide flood plain capacity, to protect water quality and to seek to achieve the ecological requirements of the forthcoming Water Framework Directive.’

8.42. Environmental Quality and Utility Provision policies include the following:

- UT5 on renewable energy indicates that ‘proposals which develop, generate or capture energy from naturally sustainable sources will be permitted provided that proposals do not have a significant adverse impact in terms of ……… water or air pollution.’

- UT8 on surface water requires that ‘development proposals take account of the impact of surface water drainage and water quality, and accordingly include measures to acceptable manage its disposal. In particular encouragement will be given to the inclusion of soakaways,
8. Geology, Soils and Hydrology

SuDS (sustainable drainage systems), ………. and other measures to minimise/control surface water run-off as part of any development proposal.’

- UT12 on pollution states that: ‘development proposals which would cause air, soil, water, noise or other form of environmental pollution will only be permitted where they do not pose an unacceptable risk to public health, safety and the natural environment.’

- UT14 (culverting watercourses) indicates that the Council will 'oppose the culverting of watercourses due to the adverse ecological, flood defence and other effects that are likely to arise. Wherever practical, the council will seek to return culverted watercourses to open channels.' However, the latter statement suggests that this policy applies to extensive lengths of culverting, where watercourses are covered over in the urban environment, and is not referring to culverts used just for access crossings.

**Carmarthenshire Local Development Plan Deposit Draft**

8.43. The Deposit Draft of the Carmarthenshire Local Development Plan makes the following references to the water environment:

- Policy SP2 – Climate Change seeks to ensure that development proposals avoid, or where appropriate, minimise the risk of flooding, including the incorporation of measures such as SuDS and flood resilient design,

- Policy SP14 – Protection and Enhancement of the Natural Environment ensures that during consideration of development proposals “due consideration is given to …natural assets, including controlled waters and water resources”.

**EXISTING CONDITIONS**

8.44. The study area for hydrology and geology encompasses the site itself, including the access route from the public highway, as well as a wider area that may be affected by the development. The study area is shown on **Figure 8.1**. It includes watercourses which either originate on the site, or are located close to the access route to the site. It extends downstream of the site as far as road crossings or villages. The downstream areas are included in order to assess the potential impacts on downstream floodplain areas, on flood flows at road crossings and in villages, and any private water supplies which are reliant on the watercourses.

**Topography and Land Use**

8.45. The site is located in upland coniferous forest approximately 3km northwest of the village of Brechfa. As shown in **Figure 8.1**, the area comprises flat topped uplands which are dissected by deep narrow valleys. The highest point on the site itself is 358m AOD. The lowest elevation in the forest is in the west, at about 200m AOD, where the site dips towards the Nant Aolllawis river valley.

8.46. The access track to the site from the A485 is located in land used for sheep grazing. The route of the access track rises from an elevation of just under 200m AOD at the A485, to about 345m AOD at the forest boundary. The landowner has confirmed that a sheep dip, located about 300m from the access track at approximate grid reference SN 471 341 (shown on the OS basemap on **Figure 1.2**), is no longer there. No sheep dip has been in use at the location for about 50 years.

8.47. The solid bedrock geology and superficial drift geology of the site, taken from published geological mapping (British Geological Survey, 2007 Sheet 211), is illustrated in **Figure 8.2**. The northern half of the site is underlain mainly by thinly interbedded Silurian turbidite sandstone and mudstone of the Rhuddant Grits Formation. The southern part is underlain by thinly interbedded Silurian sandstone and mudstone turbidites of the Glanyrafon Formation.

8.48. The only superficial deposits shown in the site comprise a small area of Head deposits in the uppermost reaches of the Nant Cwm-marydd watercourse on the eastern side of the site, near Turbine 22. Head deposits comprise undifferentiated sandy clay, with variable gravelly deposits and stratified gravels.

8.49. There are no peat deposits shown within the site boundary on the published geological map (Figure 8.2). In addition, the geological mapping indicates that there is little peat present in the general area around the site.

8.50. The bedrock underlying the access route from the public highway (A485) in the northwest comprises mainly Silurian mudstones with thinly interbedded turbidites and hemipelagites (mixed deep ocean and land-derived sediments with grain size varying generally from silts to gravels) of the Claerwen Group. Rhuddant Grits underlie the southeasterly section of the access track.

8.51. A small area of Head deposits is present along part of the access track. There are also more extensive areas of Glacial Till, comprising gravel, sandy clay, overlying the bedrock in the area of the access track. The Glacial Till deposits are located within about 700m of the A485.

8.52. From the topographical and geological maps, and information on mineral extraction provided by the Public Health Section of Carmarthenshire County Council, there is no evidence of mining within the site. The published geological map sheet explanation document (BGS, 2007) suggests that there has been no metaliferous or other mining in the area of the site. In addition, consultations with Forestry Commission have revealed no information on former mining activities in Brechfa Forest.

8.53. The Countryside Council for Wales has confirmed that there are no Geological Conservation Review (GCR) sites within the site boundary, and that there will be no impact on any protected geological sites as a result of the proposed scheme. Neither the British Geological Survey nor Carmarthenshire County Council Biodiversity Officer has any information relating to Regionally Important Geological Sites (RIGS) in the site boundary. Details of RIGS provided by the Carmarthenshire County Council indicated that the closest RIGS is located about 5km to the south west of the site boundary.

**Hydrogeology**

8.54. The groundwater vulnerability map for the area indicates that the site is underlain by a non-aquifer with negligible permeability (Environment Agency, 1998). No aquifers of either major or minor importance underlie the site. However, the bedrock is classified on the Environment Agency website as secondary aquifer. The definitions for a secondary aquifer indicate that the more permeable formations underlying part of the site are capable of supporting water supplies, but only at a local level. In some cases, the formations may also form an important source of base flow to rivers. The less permeable secondary aquifer formations underlying the site may yield limited amounts of groundwater from localised features such as fissures, thin permeable horizons and weathered zones.
Soils

8.55. The soils of the site are described using information available from the Soils Map of Wales (Soil Survey of England and Wales, Sheet 2, 1983). Following the consultation response from the Countryside Council for Wales, and after consultation with staff in the Soils Department at Cranfield University, reference was also made to the publication 'Soils and Their Use in Wales' (Soil Survey of England and Wales, 1984). It should be noted that the soils descriptions, given in these references, apply to the occurrence throughout Wales of the soil types found on the wind farm site. The soil descriptions are therefore generalised descriptions which may vary locally.

8.56. According to the soil descriptions, the site is dominated by soil types comprising well drained loamy soils, or loamy permeable upland soils, over rock. These soil types have a humose or peaty surface horizon in many areas of Wales. There are also some peaty topped, slowly permeable, seasonally waterlogged, loamy soil types in the southern part of the site. Some soil types contain thin ironpan, comprising a high percentage of iron oxide. There may be rock outcrops and scree at some locations. One of the soil descriptions indicates that peat may be present on higher ground. However, as indicated in paragraph 8.49, there are no peat deposits shown on geological mapping for the area of the site.

8.57. Fine loamy and silty soils are present around the western part of the access track from the A485.

8.58. Soils mapping obtained from Forestry Commission Wales indicates that there are no peat soils present on Forestry Commission land within the site boundary. Peaty gley soils are present in approximately half of the site. Soil descriptions were not available with the mapping. However, a soils classification issued by the Forestry Commission Research and Development Division (Research Information Note 68 82 SSN) indicates that peaty gley soils have a maximum peat thickness of 0.45m. Peat overlies gley in the soil profile. The term gley indicates a poorly draining soil which is subject to periodic or permanent waterlogging.

8.59. A peat survey was undertaken at the site to validate the findings from the desk study. The report on the survey is included in Appendix 8.3. Auger samples were taken at a total of 94 locations. The locations were alongside the existing access tracks, at approximate 200m intervals, and, where possible, at proposed turbine locations and new access tracks. Where it was not possible to access proposed turbine locations and new tracks through the forest, samples were taken at locations which were as close as possible to the target locations.

8.60. Peat was found to be present at only a few of the locations at which augering was undertaken. The average depth of peat, where found to be present, was 0.10m. The maximum depth of peat was 0.14m.

Rainfall and Hydrology

8.61. The site is located in the catchments of the Afon Gwili, Afon Cothi and the Afon Talog/Afon Tywi, as indicated in Figure 8.3.

8.62. Average annual rainfall for subcatchments located within the site is approximately 1750mm (for the period from 1961 to 1990), as determined from the Flood Estimation Handbook (FEH) CD-ROM v2.0 (NERC, 2006). For comparison, the average annual rainfall in Wales is just over 1400mm. Average monthly rainfall values are not available using FEH. However, typically for Wales, the months of highest rainfall are from October to January, as indicated from statistics available from the Met Office. On average, about 45% of the annual rainfall occurs in this four month period. The driest months are from April to July when, on average, just under 25% of the annual rainfall occurs.

8.63. The average monthly rainfall data for Wales should give an indication of the approximate rainfall distribution which is likely to be applicable to the Brechfa Forest West Wind Farm site. Further information on hydrological conditions in the area was gained from hydrographs for river flow gauging stations located close to the site.

8.64. Gauging stations on the Afon Gwili at Glanwgili and the Afon Cothi at Felin Mynachdy are both located approximately 15km downstream of the site. Runoff records obtained from the Environment Agency for the period 2006 to 2011 indicate that on average the period of lowest runoff, and hence, rainfall, is in the three months from April to June. In general, significantly higher runoff occurs in July. The months of highest runoff are from November to January, as a result of winter rainfall combined with high levels of soil moisture or saturated ground conditions. Therefore winter rainfall and runoff, and to an extent, rainfall and runoff events in mid summer, are important factors to account for in the design of site drainage.

8.65. Subcatchment watercourses which either drain areas of the site, or originate very close to the site boundary, are shown on Figure 8.3. The Afon Pib, Nant Cwm-marydd and Afon Marlas feed into the Afon Cothi. The Nant Hafren and Nant Aerau are tributaries of the Afon Gwili. The Afon Gwydrddug, Afon Gorwydd and an unnamed tributary feed into the Afon Talog.

8.66. The watercourse which rises close to the access track from the A485 at grid reference SN 4647 3450 is a tributary of the Afon Gorwydd. Downstream of the reach shown on Figure 8.3 the tributary has been diverted along field boundaries and away from the course shown on 1:25 000 scale OS mapping. The tributary discharges to the Afon Gorwydd below Lan Farm.

8.67. Road crossings on the Afon Gwili and Afon Talog, downstream of all the confluences of the Afon Gwili, the river is crossed at this point by a major road (A485). The Afon Talog/Afon Tywi is a tributary of the Afon Gorwydd downstream of the reach shown on Figure 8.3. The Afon Gwili and the Afon Cothi are tributaries of the Afon Tywi. The Afon Talog/Afon Tywi is a tributary of the Afon Teifi.

8.68. The first road crossing points on watercourses downstream of the site are shown on Figure 8.4. Details of the subcatchments, upstream of the crossings, and properties in the vicinity of the crossings, are shown in Table 8.6. Most crossings are in or close to small villages/communities, or in rural locations, in some cases with farms or other buildings nearby.

8.69. Road crossing points on the Afon Gwili and Afon Talog, downstream of all the confluences of the tributary watercourses influenced by the site, are also shown on Figure 8.4. In the case of the Afon Gwili, the river is crossed at this point by a major road (A485). The Afon Talog crossing is on the A485 in the village of Pencader. The details of the catchments upstream of these crossing points are also shown in Table 8.6.

8.70. Road crossings on the Afon Marlas and Afon Pib in or close to the village of Brechfa, are also shown on Figure 8.4.

8.71. Environment Agency Wales indicated there has been little flow monitoring in the subcatchments surrounding the site over the past ten years. Spot flow measurements were taken on three occasions in dry weather on the Afon Marlas and the Afon Cothi near Brechfa, in 2004, 2005 and 2007. Otherwise no recent flow monitoring data is available for the area.
8. Geology, Soils and Hydrology

8.72. The standard percentage runoff values (SPRHOST), included in Table 8.6, are an indicator of the average percentage of precipitation that contributes to short term runoff in a subcatchment. SPRHOST values were obtained for these subcatchments using the Flood Estimation Handbook (FEH) CD-ROM v2.0 (NERC, 2006). They indicate that rapid transfer of 30 to 40% of rainfall occurs, by runoff, directly into local watercourses.

Table 8.6: Subcatchment details

<table>
<thead>
<tr>
<th>Watercourse</th>
<th>Location of downstream limit at road crossing</th>
<th>Subcatchment area (km²)</th>
<th>Standard percentage runoff</th>
<th>Conditions at Crossing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Afon Marlais</td>
<td>SN 518 310 (at Felin Marlais)</td>
<td>10.43</td>
<td>38</td>
<td>Rural, with a few buildings nearby</td>
</tr>
<tr>
<td>Nant Cwmmarydd</td>
<td>SN 503 303</td>
<td>2.08</td>
<td>35</td>
<td>Rural, close to access to building</td>
</tr>
<tr>
<td>Afon Pib</td>
<td>SN 503 301 (minor road near site)</td>
<td>5.01</td>
<td>36</td>
<td>Rural, close to building</td>
</tr>
<tr>
<td>Afon Gwili</td>
<td>SN 486 293</td>
<td>0.86</td>
<td>34</td>
<td>Rural road</td>
</tr>
<tr>
<td>Nant Hafren</td>
<td>SN 464 293</td>
<td>2.94</td>
<td>34</td>
<td>Rural road</td>
</tr>
<tr>
<td>Nant Aerau</td>
<td>SN 458 294</td>
<td>3.90</td>
<td>34</td>
<td>Rural, close to building</td>
</tr>
<tr>
<td>Nant Alltwalis</td>
<td>SN 445 316</td>
<td>5.63</td>
<td>36</td>
<td>In Alltwalis village</td>
</tr>
<tr>
<td>Afon Gorwydd</td>
<td>SN 463 355</td>
<td>2.54</td>
<td>38</td>
<td>In Gwyddgrug village</td>
</tr>
<tr>
<td>Afon Gwyddgrug</td>
<td>SN 465 358</td>
<td>2.93</td>
<td>36</td>
<td>In Gwyddgrug village</td>
</tr>
<tr>
<td>Unnamed Tributary (of the Afon Talog)</td>
<td>SN 474 369</td>
<td>1.25</td>
<td>33</td>
<td>In New Inn village</td>
</tr>
<tr>
<td>Afon Pib (Brechfa village)</td>
<td>SN 523301</td>
<td>13.42</td>
<td>35</td>
<td>In Brechfa village</td>
</tr>
<tr>
<td>Afon Marlais (Brechfa village)</td>
<td>SN 525 303</td>
<td>12.01</td>
<td>38</td>
<td>In Brechfa village</td>
</tr>
<tr>
<td>Afon Gwili (Afon Gwili Catchment)</td>
<td>SN 443 287</td>
<td>17.44</td>
<td>34</td>
<td>Crossing on A485</td>
</tr>
<tr>
<td>Afon Talog</td>
<td>SN 446 363</td>
<td>21.27</td>
<td>37</td>
<td>In Pencadog village</td>
</tr>
</tbody>
</table>

* see paragraph 8.72 for definition

8.73. The Environment Agency River and Coastal Flood Map gives a general overview of flood risk, detailed in Figure 8.4. The map shows those areas estimated to have a 1% or greater chance of flooding each year. It indicates that the area at risk from flooding extends over a total width of 50m to 100m for several hundred metres upstream of many of the crossings. The flood risk area extends over a width of about 200m just downstream of the crossings on the Afon Pib and the Afon Marlais in Brechfa village. There is a substantial area of flood plain indicated by the 1% flood risk in the Afon Gwili subcatchment.

Water Quality

8.74. The ‘ecological status’ of the Afon Marlais, Afon Cothi, Afon Gwili, Afon Talog, and part of the Afon Pib have been classified by the Environment Agency using the new WFD classification systems. The WFD classification and GQA grades are included in Table 8.7 and shown on Figure 8.5.

8.75. The WFD ‘ecological status’ of most reaches of three of the watercourses listed in Table 8.7 at Brechfa village is poor or bad. The other two watercourses are of moderate status. Only the Afon Pib downstream of Brechfa has good ecological status. This contrasts markedly with the biological GQA which, where classified, was considered to be very good (see discussion of water quality in the section on Significance Criteria, paragraphs 8.20 to 8.22).

8.76. The watercourses in the area of the proposed wind farm have not been assessed for their current chemical quality under the WFD classification system. Figure 8.6 displays the Environment Agency’s GQA classifications, also included in Table 8.7. Only the Afon Talog and parts of the Afon Marlais, Afon Pib, and Afon Gwili have been assessed. The watercourses have been classified as ‘very good’ for the chemical assessment, which is based on analyses for ammonia, biochemical oxygen demand and dissolved oxygen. Phosphate levels are classified as ‘good’ or ‘very good’. Nitrate levels are classified as ‘low’ or ‘moderately low’.

Table 8.7: Environment Agency Water Quality Assessments

<table>
<thead>
<tr>
<th>Watercourse</th>
<th>Chemical GQA</th>
<th>Phosphate GQA</th>
<th>Nitrate GQA</th>
<th>Biology GQA</th>
<th>WFD Ecological Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Afon Marlais</td>
<td>Very Good</td>
<td>Very Good</td>
<td>Low</td>
<td>Very good</td>
<td>Bad</td>
</tr>
<tr>
<td>Afon Pib</td>
<td></td>
<td></td>
<td></td>
<td>Poor/Good</td>
<td>Moderate</td>
</tr>
<tr>
<td>Afon Cothi</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Poor</td>
</tr>
<tr>
<td>Afon Gwili</td>
<td>Good</td>
<td></td>
<td></td>
<td></td>
<td>Moderate</td>
</tr>
<tr>
<td>Afon Talog</td>
<td></td>
<td></td>
<td></td>
<td>Very Good</td>
<td>Moderate</td>
</tr>
</tbody>
</table>

8.77. Water quality data for watercourses in the area of the proposed wind farm was obtained from Environment Agency Wales for the past five years, from January 2006 onwards. Water quality data for five monitoring sites in the area is included in Appendix 8.4. The sampling locations are shown on Figures 8.5 and 8.6.

8.78. The sites on the Afon Gwili, the Afon Talog and the Nant Gwen are all downstream of crossings on the A485. They are therefore very likely to receive runoff from the A485 which may at times affect water quality. In addition to the water quality parameters listed in the table in Appendix 8.4, Environment Agency Wales also analyses samples from the Afon Gwili for copper and zinc. These are metals typically associated with road runoff.
8.79. Water quality sampling has been undertaken in the past by Environment Agency Wales at a site on the River Gwili, upstream of the A485 near Llanllawddog (at NGR SN 462 292). However, no data is available for the site for the past five years.

8.80. Nitrate can be an important determinant in relation to forestry felling (see paragraph 8.124). Concentrations vary between sampling periods, but some overall patterns are evident from the data. Existing levels are classified as very low (less than 1.13 mg/l as nitrogen, N) at the two sites in the Afon Marlais subcatchment, according to the Environment Agency’s classification. Nitrate levels are generally low (1.13 to 2.26 mg/l as N) for the Nant Gwen and Afon Gwili. Levels reduced generally in the Afon Talog, from moderately low (2.26 to 4.52 mg/l) in 2007/08, to low in 2009/10.

8.81. Felling may also increase levels of aluminium, and possibly iron and manganese, in surface water, as discussed in paragraphs 8.122 and 8.123. Existing records for aluminium are available for the tributary of the Afon Marlais, upstream of the Brechfa water treatment works. However, although close to the proposed wind farm, the tributary does not drain the wind farm site and is not located in a forested subcatchment. The results indicate low levels of dissolved aluminium in the range 15 to 33 µg/l. Iron and manganese concentrations were also low, in almost all cases below the detection limits.

8.82. Analyses for suspended solids are available for the Afon Gwili. The data indicates that suspended solids are generally up to 20 mg/l at the sampling point in the river. Occasional higher levels of suspended solids were found, with a maximum value of 138 mg/l. The maximum value occurred at a time of high flow, as indicated by flow data for the gaging station at Glanwgwili. On the day of sampling (14 July 2010), statistics available on the Centre for Ecology & Hydrology website indicate that the flow was at a level where it would only be exceeded for 20% of the time on an annual basis, and for about 5% in the period June to September. The next highest measurement for suspended solids (79.6 mg/l on 26 August 2009) occurred when the flow would only be exceeded about 2% of the time annually, and for less than 1% of the time in the period June to September.

8.83. Flows are not measured at the sampling sites by Environment Agency Wales in association with the water quality sampling. Comments on rainfall and/or the water level or clarity of water in the watercourse are generally provided with the analyses.

8.84. The Environment Agency’s River Basin Management Plan for the Western Wales River Basin District (December 2009) covers the catchments of the Afon Teifi and the Afon Tywi in which the site is located. The plan has been prepared under the Water Framework Directive (2000/60/EC). It describes the river basin district, the pressures on the water environment and what actions will be taken to address the pressures.

8.85. The plan indicates that one of these pressures is acidification of surface water. A combination of poorly buffered soils and rocks, high acid deposition and large-scale forest cover has contributed to widespread surface water acidification and the decline or loss of fish populations and other aquatic life. The plan indicates that acidification needs to be addressed in both the Afon Teifi and the Afon Tywi catchments.

8.86. The Tywi, Taf & Gwendraeth Catchment Abstraction Management Strategy (Environment Agency Wales, March 2006) also states that one of the concerns for water quality in the Tywi catchment is with acidification. Acidification is exacerbated by confier plantations. However, the document indicates that the main problem with acidification is not in the area of the Afon Cothi around Brechfa, but in the Afon Tywi downstream of Llyn Briane. Llyn Briane is located on the Afon Tywi about 40 km upstream of the location at which the Afon Cothi joins the Afon Tywi.

8.87. The Teifi Catchment Abstraction Management Strategy (Environment Agency Wales, January 2004) indicates that biological water quality in the upper catchment may also be affected by acidification problems. There is, however, no indication that this is a problem with tributary watercourses which drain from the area of the site.

Public water supplies

8.88. Welsh Water does not have any infrastructure within the site, or any surface water or spring abstraction sources in the study area downstream of the site.

Private water supplies

8.89. Appendix 8.1 details the information obtained on Private Water Supplies (PWS) from the site visit for 14 properties where residents have given permission for details to be published. Figure 8.7 shows the locations of the PWS sources.

8.90. Results from the PWS survey showed spring source to be the most common PWS type. Detailed information has been obtained for a total of 23 properties, located in or close to the study area. In summary:

- 21 properties are supplied by a spring or groundwater from a well or borehole, or a combination of these types of sources. All but two of the spring and groundwater sources (Coedlannau Fawr spring, source reference 10 and Lan Farm well, reference 14) are located away from the site, as indicated on Figure 8.7. Coedlannau Fawr also has a mains water supply. The spring water at Coedlannau Fawr is used for livestock.
- Five of the 21 properties supplied by a spring or groundwater from a borehole also have abstractions from surface watercourses.
- Two properties are supplied by a stream source only.

Discharge Consents

8.91. Details of 23 discharge consents were obtained from Environment Agency records for the study area shown in Figure 8.1. About 80% of the discharge consents are for treated wastewater from single properties or small sewage treatment works. There are some additional consents for wastewater pumping station emergency overflows. One consent is for discharge of trade effluent.

8.92. About 70% of the consented discharges from single properties are to land, from septic tanks. The remaining discharges are to watercourses.

MODIFICATIONS TO SCHEME DESIGN

8.93. A number of constraints were considered in modifications to the scheme design, to reduce impacts on the hydrology, hydrogeology and water resources of the site. For the purpose of these constraints, watercourses and other waterbodies are defined as the water features shown on published 1:25000 scale OS mapping. The constraints included the following:

- The track layout was designed to minimise the number of watercourse crossings.
8. Geology, Soils and Hydrology

- Turbine bases and other wind farm infrastructure, including associated works, were located at least 50m from all watercourses and other waterbodies.
- New tracks and associated works are generally located at least 50m from watercourses, except where the new tracks link into existing tracks which are already located within 50m of watercourses, and at locations close to watercourse crossings. The associated works will include any temporary working areas used during the period of construction.
- Delineating nominal protection zones around any springs used for private water supplies. The protection zones extend from 200m upgradient of the springs to 100m downgradient, and to 100m along the slope to either side of the spring. The protection zones are not a requirement specified in legislation for protection of springs. Application of a protection zone was, however, considered to be a sensible measure to avoid any disruption to small spring supplies.
- No new construction works, or temporary working areas, are to be located within the spring protection zones.
- Where existing infrastructure is located within the area of a spring protection zone, the source of the spring will be investigated prior to any potential upgrading works taking place. In these cases, it may be found necessary to relocate the infrastructure to avoid the risk of disrupting the spring water supply.

8.94. The 50m wide buffer zones along watercourses, and the spring protection zones, are shown on Figure 8.8. Only in one case was the protection zone for a spring, which forms the source of a private water supply, found to be located close to any of the wind farm infrastructure. This is for private water supply reference 10, indicated on Figure 8.7 and in Appendix 8.1.

ASSESSMENT OF CONSTRUCTION IMPACTS

Predicted Impacts

8.95. The main potential concerns for hydrology, hydrogeology and water resources during felling, removal of timber and construction relate to:

- Erosion and sedimentation in drainage systems and watercourses;
- Impediments to flow in watercourses resulting from changes or blockages to the channel at watercourse crossings;
- Risk to surface water quality from pollution;
- Changes to water chemistry resulting from felling;
- Impacts on private water supplies.

8.96. As indicated in the section on Existing Conditions (above), the bedrock is classified on the Environment Agency website as secondary aquifer. The more permeable formations underlying part of the site are capable of supporting water supplies, but only at a local level. As a result, groundwater vulnerability is unlikely to be a concern, except possibly at a local level where there are springs or wells/boreholes. Therefore no further assessment was made of the environmental impact of borrow pit and other excavations on the general geology/hydrogeology of the area.

8.97. As discussed in paragraph 8.58, indications from available soils mapping, provided by Forestry Commission Wales, are that peat is only likely to be present on the site as an upper soil layer overlying gley soils. No peat deposits are shown on geological mapping. There is no indication of peat deposits on FCW soils mapping, other than in combination with gley soils. A peat survey undertaken along existing access tracks, and in the vicinity of new tracks and turbine locations, indicated that there is very limited peat present across the site. The maximum depth of peat recorded from sampling was only 0.14m.

8.98. As no significant areas or depths of peat have been found along tracks and at turbine locations, the scheme will have a negligible impact on peat hydrology. In addition, the risk of the occurrence of problems associated with peat stability during construction of the scheme is not considered to be a concern.

8.99. Welsh Water does not have any infrastructure within the site, or any surface water or spring abstraction sources in the study area downstream of the site. Therefore impacts on public water supplies were not considered further.

8.100. The following paragraphs describe the potential for impacts if no mitigation was proposed. Proposed mitigation is described subsequently, together with the level of residual impact following mitigation.

Erosion and sedimentation

8.101. During construction of the wind farm there will be considerable disturbance to soils and near surface superficial geology, in particular due to excavations for foundations, construction and use of tracks and drainage, including watercourse crossings, and extraction of stone from the borrow pit. Runoff from disturbed soils and unconsolidated sediments may cause increased sediment loads in watercourses.

8.102. Erosion and sedimentation are also likely to occur during forestry felling and removal of timber. In the absence of any controls, construction traffic movements and felling operations could lead to soil erosion and sediment entering surface water. Felled areas will be exposed to rainfall and surface runoff and, as a result, further soil erosion may occur. In addition, erosion may occur in existing drains as flows increase following the felling and removal of timber.

8.103. Soil erosion can occur wherever flows are artificially concentrated, especially when soil is disturbed. Erosion may occur within drainage ditches, due to water flowing at high velocities and scouring exposed soil within the drains. The potential for elevated sediment loads in runoff will continue until the tracks and drains are fully established and bedded in. This may be for a period of two or three years after construction.

8.104. Increased sediment load and settlement could have a direct or indirect impact on the ecological quality of the watercourses. Loss of macro-invertebrates could occur as a result of silt settlement and changes to the oxygenation state of stream beds.

8.105. Without appropriate mitigation in place, erosion and sedimentation could give rise to a predicted impact of moderate significance in surface water.
**Impediments to flow in watercourses**

8.106. Locations of watercourse crossings are shown on Figure 8.8. Two crossings on watercourses shown on 1:25,000 scale topographical mapping (references W001 and W002) were investigated during the site reconnaissance in February 2010. Photographs and details for these crossings are given in Appendix 8.2. In addition nine further existing crossings were identified during the site reconnaissance, also shown on Figure 8.8, as discussed further below.

8.107. Various levels of flow were calculated to illustrate the flow regime for the crossing points W001 and W002. The estimated flows are summarised in Table 8.8, together with the grid references for the crossing locations. The flows include the 1 in 10 year and 1 in 100 year flood peaks calculated using the standard methodology available in the Flood Estimation Handbook (NERC, 2006).

### Table 8.8: Details of watercourse crossings

<table>
<thead>
<tr>
<th>Crossing Reference (see Figure 8.8)</th>
<th>Status (new crossing or existing crossing)</th>
<th>Estimated flows (m³/s)</th>
<th>Flow exceeded 95% of the time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1 in 100 year</td>
<td>1 in 10 year</td>
</tr>
<tr>
<td>W001</td>
<td>Existing crossing</td>
<td>1.1</td>
<td>0.6</td>
</tr>
<tr>
<td>W002</td>
<td>Existing crossing</td>
<td>1.0</td>
<td>0.6</td>
</tr>
</tbody>
</table>

8.108. Mean flow and flow exceeded 95% of the time are presented in Table 8.8, to give an approximate indication of a normal level of flow and the flows which are present after an extended period of dry weather. Mean flow is calculated from the standard average annual rainfall (SAAR) and an estimate of potential evapotranspiration of 430 mm/year derived using long term average data available for gauged catchments in the area (Marsh T and Hanniford J., 2008). Low flows were derived very approximately using a formula provided in the Institute of Hydrology Report 108 on low flow estimation in the United Kingdom (Institute of Hydrology, 1992).

8.109. The crossings installed during construction will be designed to be permanent and suitable for long term use.

8.110. The type of crossing proposed at W001 and W002, and the reasons for the choice of crossing, are summarised in Table 8.9.

### Table 8.9: Summary of proposed construction at watercourse crossings

<table>
<thead>
<tr>
<th>Reference (see Figure 8.8)</th>
<th>Watercourse</th>
<th>Type of crossing proposed</th>
<th>Reasons for choice of crossing</th>
</tr>
</thead>
<tbody>
<tr>
<td>W001</td>
<td>Afon Pib</td>
<td>Culvert</td>
<td>Very minor flow in dry weather and low mean flow, due to the location near the top of the catchment. Presence of an existing culvert at the site.</td>
</tr>
</tbody>
</table>

8.111. As indicated above, the crossings included in Tables 8.8 and 8.9 are located on watercourses shown on 1:25,000 scale OS mapping. Existing culverts at these locations will either be upgraded or replaced.

8.112. Nine additional existing culverts were identified during the site reconnaissance. The culverts were located close to or at the upstream limit of watercourses shown on the 1:25,000 scale mapping, or on other minor watercourses or drains not shown on the 1:25,000 scale mapping. These additional culverts are also indicated on Figure 8.8. Culverts will either be upgraded or replaced at these nine locations, and any other locations along existing access tracks where existing culverts are found, in the event that the tracks at the culverts need upgrading. On new tracks, culverts will be installed on any additional channels that are not large enough to be shown on 1:25,000 scale OS mapping. However, these additional culverts will only be installed where there is a need to prevent significant disruption to the natural drainage pattern.

8.113. An existing culvert shown on Figure 8.8 on the access track about 750m northwest of crossing point W002 is located on a field drain which discharges to the northwest. The culvert is not on the watercourse shown on Figure 8.8 but is located within a few metres of the upstream limit of the watercourse. The watercourse is also located along the western boundary of an area of wet ground which extends over about 0.5 ha. Track alignment and drainage in this area will be designed to avoid any direct discharge to the watercourse, which is a tributary of the Afon Gorwydd (see paragraph 8.66 and Figure 8.3), or to the area of wet ground.

8.114. Individual assessments of existing culverts will be completed prior to construction, and a decision made as to whether to replace or upgrade each culvert. Appropriate consents will be sought for replacing or upgrading existing culverts and for construction of any new culverts.

8.115. Felling close to watercourses could result in the partial blockage of watercourses by tree branches (brash) and other debris, particularly at watercourse crossings. The presence of debris could result in watercourses overtopping at the crossings at high flow, and flooding the crossings. Overtopping could lead to erosion and damage to tracks. In turn, this could give rise to high sediment loads and additional erosion in the watercourses downstream of the crossings. Alternatively, dams comprising woody debris can also sometimes hold back flood waters temporarily within headwater streams, thereby reducing the impact of flooding further downstream. However, the benefits of these debris structures are very difficult to assess.

8.116. In terms of impediments to flow during forestry felling, an impact of moderate significance is predicted without appropriate mitigation in place.
8. Geology, Soils and Hydrology

Water pollution

8.117. Surface water quality may be affected by pollution incidents resulting from the accidental spillage of fuels, oils or lubricants during operation or refuelling of plant, or during emergency repairs.

8.118. Cement is highly alkaline when mixed for concrete. Any accidental spill of cement or concrete into watercourses during construction, or site runoff contaminated with cement, may lead to changes of pH in surface water. A change in pH to more alkaline conditions could affect the watercourse ecology adversely.

8.119. Uncontrolled accidental discharge of sewage from the construction compound could cause pollution of surface water.

8.120. Without appropriate mitigation in place, pollution incidents could give rise to a predicted impact of moderate significance in surface water.

Water chemistry

8.121. Water chemistry can vary considerably with levels of runoff in upland catchments. Regardless of whether catchments are forested or felling has taken place recently, waters are generally more acidic following heavy rainfall, as a higher proportion of runoff is derived from the more acidic shallow soil layers. Greater acidity leads to greater dissolution of metals from the soils.

8.122. Research by the Environment Agency in mid Wales (Neal, C and Reynolds, B. 1998) indicated that forestry felling can have an impact on water quality in streams over a period of about three years following felling. Levels of aluminium, in excess of the regulatory limit for private water supplies of 0.2 mg/l (Private Water Supplies (Wales) Regulations 2010), were found in water samples for some streams both prior to and following felling. However, there was also evidence that felling produced a significant temporary increase in aluminium, albeit in a limited number of cases.

8.123. The Forests & Water Guidelines (Forestry Commission, 2003) indicate that, in some areas, high iron and manganese levels can result from soil disturbance and erosion following forestry operations.

8.124. The Forests & Water Guidelines also discuss the impacts of forestry felling on the acidification of streams, mainly through the release of nitrate into the water environment. In areas in which the concentrations of substances contributing to the acidity of surface waters exceed a threshold, referred to as the critical load, felling may need to be managed to control nitrate loss. Subject to the results of a site impact assessment, management may involve limiting areas of felling to less than 20% of watercourse catchments over any three year period.

8.125. The site area is not located within one of the 100km² grid squares, indicated in the Guidelines, in which the threshold for acidity is exceeded. However, the site is in an adjacent grid square. The Guidelines indicate that areas in adjacent grid squares should also be assessed according to the same methodology applied to grid squares in which the threshold is exceeded.

8.126. The Guidelines state that the catchment boundary for assessing the impact of felling should, in most cases, be based on the presence of salmonid fish. In the absence of fish data, the catchment outlet should be taken as the point at which the principal watercourse receiving drainage from the area of proposed felling joins another principal watercourse.

8.127. As fish data are not available, the assessment was made for a set of nine subcatchments which include a substantial amount of felling, based on watercourses shown on 1:25,000 scale OS mapping. The subcatchment areas, labelled A to I, outlet points and proposed areas of forestry felling, are indicated on Figure 8.9.

8.128. For three of the subcatchments, the felled area is in excess of the 20% criterion. The maximum percentage felled area is just under 30%, in subcatchment C. For all other subcatchments, felling is less than 20%. The felled area is just under 20% in subcatchment I on the Afon Pib, which includes the area of subcatchments C, D, E, F and G, and is about 12% in subcatchment A. Therefore the 20% criterion is met for the larger subcatchments for which calculations were made.

8.129. For some subcatchments the proposed felling area falls outside the guideline requirement for felling in a three year period. However, as already discussed, the site area is not located within one of the 100km² grid squares in which the threshold for acidity is exceeded. The adjacent grid square also has the lowest category of exceedence of the critical load for acidity, as indicated in the Forests & Water Guidelines. It is concluded therefore that the level of exceedence of the 20% criterium in some subcatchments is acceptable.

8.130. Impacts on water chemistry as a result of felling are predicted to be of minor significance.

Private water supplies

8.131. There is potential for pollutants from any spillage of hydrocarbons to move rapidly through the various watercourses on the site. Pollutants could then discharge from the site. Further downstream, the pollutants have the potential to affect any private water supplies which are reliant on the watercourse as a source of water.

8.132. High sediment loads in watercourses, caused by ground disturbance during felling and construction, have the potential to also affect private water supplies with intakes downstream of the site.

8.133. As indicated in paragraph 8.11, many of the properties were visited which might have private water supplies, and which could be affected by the scheme. Although information was not obtained for all properties which might be affected, the data collected was used to gauge the likely extent of use of private water supplies, and the potential impacts of the wind farm. The information is summarised in paragraph 8.90.

8.134. Data collected indicates that there are private water supplies from watercourses for several properties investigated in the area. These include surface water abstraction points on the Nant Aerau, Afon Gwyddgrug and Afon Gwili, and water from the Afon Pib used for livestock. Water quality in these watercourses could be affected by the scheme.

8.135. Part of a new track to Turbine 17 is located just within the protection zone for a spring which supplies water for livestock at Coedlannau Fawr (see Figures 8.7 and 8.8, and Appendix 8.1). There is a risk that construction work in upgrading the track could affect the supply to the spring.

8.136. The access track from the A485 is located about 25m from the well which supplies Lan Farm (Ref 14 on Figure 8.7). The source of water for the well is assumed to be seepage from surrounding wet ground as there is no evidence of the presence of a spring in the base of the well. Therefore the yield of the well should not be affected by the access track. However,
8.137. The yields of all other spring, well or borehole sources, for which information has been obtained, should not be affected by the scheme.

8.138. Based on the spring supplying water for livestock at Coedlannau Fawr, an impact of moderate significance is assigned for potential impacts on spring yield.

8.139. In terms of erosion and sedimentation, and also pollution incidents, an impact of major significance is assigned for private water supplies which could be affected, without appropriate mitigation in place.

8.140. There may be some private water supplies which are dependent on surface water originating, in part, from areas of subcatchments where forestry felling will occur. Felling would be expected to have an impact of minor significance on water chemistry. However, monitoring of water quality will be undertaken, as discussed in paragraphs 8.245 and 8.248.

**Summary of Predicted Impacts without Mitigation**

8.141. The significance of predicted impacts on the water environment during construction, without mitigation, is summarised in Table 8.10. Private water supplies are included as receptors for potential impacts arising from erosion and sedimentation and pollution of waters as well as the disruption to spring flows.

**Table 8.10: Impacts during felling and construction without mitigation**

<table>
<thead>
<tr>
<th>Potential impact</th>
<th>Receptor</th>
<th>Sensitivity</th>
<th>Magnitude (without mitigation)</th>
<th>Significance (without mitigation)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Erosion and sedimentation</td>
<td>Surface water</td>
<td>High</td>
<td>Medium</td>
<td>Moderate</td>
</tr>
<tr>
<td></td>
<td>Private water supplies</td>
<td>Moderate</td>
<td>Major</td>
<td>Major</td>
</tr>
<tr>
<td>Impediments to flow</td>
<td>Watercourses</td>
<td>Moderate</td>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td>Water pollution</td>
<td>Surface water</td>
<td>High</td>
<td>Medium</td>
<td>Moderate</td>
</tr>
<tr>
<td></td>
<td>Private water supplies</td>
<td>Moderate</td>
<td>Major</td>
<td>Major</td>
</tr>
<tr>
<td>Changes to water chemistry</td>
<td>Surface water</td>
<td>High</td>
<td>Low</td>
<td>Minor</td>
</tr>
<tr>
<td></td>
<td>Private water supplies</td>
<td>Moderate</td>
<td>Low</td>
<td>Minor</td>
</tr>
<tr>
<td>Disruption to spring yield</td>
<td>Private water supplies</td>
<td>Moderate</td>
<td>Medium</td>
<td>Moderate</td>
</tr>
</tbody>
</table>

8.142. As there are a number of significant potential impacts (either major or moderate) on the water environment, measures are required to mitigate against the impacts of construction.

**Proposed Mitigation Measures**

8.143. An environmental specialist will be appointed to oversee the construction phase. The specialist will be based on site. The specialist will assist in ensuring that all the proposed mitigation is planned and undertaken to minimise or prevent impacts on the water environment.

8.144. Relevant legislation and guidance taken into account in assessing suitable mitigation includes:

- Pollution Prevention Guidelines provided by the Environment Agency;
- Connolly, S., Charles, P. (2005) Environmental Good Practice on Site (C650). CIRIA;

**Control of erosion and sedimentation**

8.145. Felling will be carried out in accordance with the Forests & Water Guidelines (2003). Soil disturbance and runoff with a high sediment load will be reduced by measures which include:

- Careful planning of operations, choosing suitable methods for felling and removal, taking account of the ground conditions;
- Protecting heavily used access points with brash, logs or stone;
- Identifying drier areas for storing timber and brash;
- Avoiding long straight extraction routes on steep slopes, and reducing the amounts of water running down any wheel ruts by digging offlets on tracks;
- Avoiding the formation of worn trails by the repeated dragging of tree tops;
- Inspecting watercourses regularly for evidence of sediment and, if necessary, applying remedial action by modifying operations or constructing silt traps.

8.146. The Forestry Commission Technical Note ‘Protecting the Environment during Mechanised Harvesting Operations’ (December 2005), provides practical guidance for reducing erosion and discharge of drainage water with a high sediment load to watercourses. It includes detailed advice on the selection of felling machinery, brash mat construction and maintenance, drain and watercourse crossings, and use of silt traps. The guidance will be applied during felling operations.
8. Geology, Soils and Hydrology

8.147. Construction will also be managed to minimise erosion and sediment generation. Any road cutting profiles will be engineered to reduce the potential for soil erosion, for example, by assessing the angles for stable slopes and installing drainage to prevent instability resulting from seepage at the base of slopes. The extent of exposed soil will be minimised. Stockpiles will be placed in locations where sediment rich runoff cannot discharge to watercourses. Track drainage will be designed to avoid concentrating flows and increasing runoff velocities.

8.148. A high quality, durable stone material will be used in the surfacing of access tracks. Use of a durable material means that crushing and compaction of the track surface by construction vehicles is kept to a minimum. Hence the levels of sediment in track runoff are reduced considerably during heavy rain.

8.149. Sediment rich runoff from construction work, and any shallow groundwater from dewatering needed during construction of turbine foundations, will be controlled to prevent it entering watercourses. Bunded attenuation/settlement areas and silt traps will be provided to remove or filter out sediment originating from access tracks or construction site drainage, before discharge to a watercourse. The most appropriate control measures will be designed prior to excavation during the construction period, and will be dependent on site-specific characteristics. Silt fencing will be installed where required, to filter out fine sediment from debris.

8.150. Where access track drainage is constructed, the sediment control measures will include use of easily installed materials such as straw bales as a filter medium. Permeable check dams, made from coarsely graded rock fill, will be used to slow the discharge velocity in the drainage channels. Particular care will be taken at and close to watercourse crossings, and when upgrading sections of existing tracks which are located close to watercourses.

8.151. Silt traps will be installed downstream of watercourse crossings during construction. Any work in watercourses will be avoided as far as is practicable in periods of heavy rainfall.

8.152. If required, mobile silt trap units will be used to reduce the sediment load of water pumped from turbine base excavations or the borrow pit. Cut off drains will be installed immediately up-gradient of excavations, if needed to direct natural runoff on hillsides away from the working areas.

8.153. Control measures, such as those described above, will be located as close to each construction area as possible. This will minimise the amount of water that has to be contained for sediment removal by settlement. Minor and ephemeral flow channels will be taken into account when designing measures to protect watercourses from high sediment loads during construction.

8.154. One borrow pit will be located on the site, as indicated on Figure 8.8. The borrow pit comprises an extension to an existing pit which is located close to the Afon Pib. Effective sediment control measures will be particularly important at the borrow pit, as excavation will continue throughout the period of construction. Flatter lying ground in the existing excavation may be used for a bunded attenuation/settlement area to contain sediment and prevent any significant impact on water quality in the Afon Pib.

8.155. Site environmental management will include ensuring that adequate measures to control silt-laden drainage water are in place right from the start of construction, taking account of weather forecasts during the construction programme, checking that settlement lagoons are emptied prior to the occurrence of heavy rain, patrolling the site on a regular basis to check that mitigation is working, correcting any defects, and monitoring watercourses.

8.156. The specific measures relating to erosion, sediment control and drainage will be set out in the Construction Method Statement (the draft Construction Method Statement is included in Appendix 3.1).

Impediments to flow

8.157. Guidance set out in the Forests and Water Guidelines (Forestry Commission, 2003) will be applied during felling. Trees will be felled away from watercourses and branches and other brash kept out of watercourses. Watercourses indicated on 1:25 000 scale mapping, and all culverts, will be inspected regularly in the vicinity of areas of felling, to ensure they are clear of debris.

8.158. Individual assessments of existing culverts W001 and W002 will be completed prior to construction, and a decision made as to whether to replace or upgrade each culvert. Any extension to the existing culvert at site W001 (see Figure 8.8 for location) will take into account existing continuity in the bed of the Afon Pib at the site. Alternatively, if the culvert is replaced at site W001, the new culvert will be designed to allow for continuity in the bed.

Water pollution

8.159. The risks associated with pollution incidents during construction of the wind farm are similar to the risks associated with many engineering construction projects. The risks associated with felling and clearance of timber are normal risks associated with these forestry activities. Risks will be managed by implementation of good pollution prevention practices. Many of these practices are concerned with avoiding or containing incidents that could otherwise lead to pollution of watercourses.

8.160. Advice given in the following Pollution Prevention Guidelines (PPG), published by the Environment Agency, will be applied:

- PPG 1: General Guide to the Prevention of Pollution
- PPG 2: Above Ground Oil Storage Tanks
- PPG 5: Works and Maintenance in or near Water
- PPG 6: Working at Construction and Demolition Sites
- PPG 7: Refuelling Facilities
- PPG 8: Safe Storage and Disposal of Used Oils
- PPG 18: Managing Fire Water and Major Spillages
- PPG 21: Pollution Incident Response Planning.

8.161. Guidance given in other construction industry manuals covering environmental good practice will also be followed. These include the Construction Industry Research and Information Association (CIRIA) Control of water pollution from construction sites - guide to good practice (CIRIA, 2002) and the Guide to controlling water pollution from linear construction projects (CIRIA, 2006).
8.162. The former document covers site drainage, treatment of site water, water disposal, material storage, silt, fuel and oil, watercourses and spill response. The information is in a form which can be used as the basis for instruction of site staff.

8.163. Other CIRIA publications on control of pollution and environmental good practice on site, as listed in paragraph 8.144, will also be used.

8.164. Prior to works commencing, the contractor will be responsible for developing a Pollution Prevention and Response Plan to be included in the Construction Method Statement. The Pollution Prevention and Response Plan will include clear guidance for management of all potentially polluting activities on the site, covering surface water and groundwater protection. It will provide instructions for actions in the event of a spillage, and emergency procedures should a pollution incident occur. Pollution response equipment will be available on site. The plan will include the locations of all pollution response equipment.

8.165. The Pollution Prevention and Response Plan will be produced following consultation and agreement with Carmarthenshire County Council and the Environment Agency. All appropriate personnel working on site will be trained in its implementation. As a minimum, the Pollution Prevention and Response Plan will comply with the Environment Agency’s Pollution Prevention Guidelines, and best practice as advocated by CIRIA. It will include site specific measures, and will specify emergency contacts.

8.166. All fuels, oils and lubricants stored during construction will be located away from any permanent or ephemeral watercourse. PPGS indicates that oil storage tanks should not be located within 10m of a watercourse. The construction compound areas, where all fuel and fuel storage will be located, will be a minimum of 50m from the nearest watercourse marked on 1:25,000 scale topographical mapping. There will be secure bunding of all fuels, oils and lubricants during storage and refuelling, and use of drip trays with standing machinery. Only emergency maintenance and repairs to plant will be undertaken on site, with routine maintenance taking place offsite.

8.167. In the event of a spillage of hydrocarbons, a rapid assessment of any ground contamination will be undertaken to identify measures to limit the spread of pollutants in the soil or to groundwater. Methods for containing pollutants will include the excavation of hydrocarbon impacted material for appropriate off-site disposal.

8.168. Toilet facilities will be located within the temporary construction compound. The effluent from these facilities will be tankered away for off-site disposal.

Private water supplies

8.169. Mitigation measures included under erosion and sedimentation and water pollution will also protect the private water supplies dependent on surface water. Prior to the start of construction, the investigations of private water supplies will be extended to include all properties in the study area, as discussed in paragraph 8.11.

8.170. In the case of private water supplies which could be affected, the residents will be contacted to explain the potential issues. Actions to be implemented in the event that the supply was affected would be discussed with the residents.

8.171. As indicated in paragraph 8.135, there is potential for the spring used for livestock watering at Coedllannau Fawr to be affected by the construction of the access track to Turbine 17. A study of the spring will be undertaken before any construction starts to assess more precisely the risk to the spring discharge, and the measures that may need to be taken to minimise the risk. The measures will be discussed with the residents at Coedllannau Fawr before any work is undertaken. Actions will also be set out by the developer, to be implemented in the event that the supply was affected.

8.172. Turbine 17 is also located very close to the catchment divide shown on 1:25,000 scale topographical mapping between the Afon Gorwydd and a tributary of the Afon Gwyddgrug. The tributary is used as a private water supply for Landdu (Reference 13 on Figure 8.7). The working area, turbine base and drainage at Turbine 17 will be set out to minimise or prevent any discharge of water from the site to the subcatchment of the Afon Gwyddgrug tributary. In addition, any impacts on the private water supply due to forestry felling around Turbine 17 will be minimised. Forestry drains will be used to divert runoff from cleared areas away from the source of the Afon Gwyddgrug tributary. Mitigation measures included under erosion and sedimentation and water pollution will be used to protect water quality in the subcatchment of the Afon Gorwydd, and any private water supplies which are dependent on stream flows in the subcatchment.

8.173. As indicated in paragraph 8.136, the access track from the A485 is located about 25m from the well which supplies Landu (Reference 14 on Figure 8.7). There is a risk that discharge from access track drainage could affect the water quality in the wet ground surrounding the well and, hence, the water quality in the well. However, as indicated in paragraph 8.113, track drainage in this area will be designed to avoid any direct discharge to the area of wet ground, or to the watercourse which is located along the western boundary of the area of wet ground. As a result, the risk to the water quality of the well supply will be minimised.

Residual impacts

8.174. The residual impacts, after adoption of the mitigation measures described in this section, are summarised in Table 8.11. With appropriate mitigation in place, all residual impacts are of minor or negligible significance.

Table 8.11: Impacts during felling and construction with mitigation

<table>
<thead>
<tr>
<th>Potential impact</th>
<th>Receptor</th>
<th>Sensitivity</th>
<th>Magnitude (with mitigation)</th>
<th>Residual significance (with mitigation)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Erosion and sedimentation</td>
<td>Surface water</td>
<td>High</td>
<td>Low</td>
<td>Minor</td>
</tr>
<tr>
<td></td>
<td>Private water</td>
<td>Moderate</td>
<td>Low</td>
<td>Minor</td>
</tr>
<tr>
<td>Impediments to flow</td>
<td>Watercourses</td>
<td>Moderate</td>
<td>Negligible</td>
<td>Negligible</td>
</tr>
<tr>
<td>Water pollution</td>
<td>Surface water</td>
<td>High</td>
<td>Low</td>
<td>Minor</td>
</tr>
<tr>
<td></td>
<td>Private water</td>
<td>Moderate</td>
<td>Low</td>
<td>Minor</td>
</tr>
<tr>
<td>Changes to water chemistry</td>
<td>Surface water</td>
<td>High</td>
<td>Low</td>
<td>Minor</td>
</tr>
<tr>
<td></td>
<td>Private water</td>
<td>Moderate</td>
<td>Low</td>
<td>Minor</td>
</tr>
<tr>
<td>Disruption to spring yield</td>
<td>Private water</td>
<td>Moderate</td>
<td>Low</td>
<td>Minor</td>
</tr>
</tbody>
</table>
8. Geology, Soils and Hydrology

Cumulative impacts

8.175. To have the potential to produce cumulative effects in the water environment during construction, other wind farm schemes would have to meet the following criteria:

- Construction would have to be at the same time or in a period overlapping the period of construction of the Brechfa Forest West Wind Farm;
- The schemes would need to be located in one of the same catchments in which the Brechfa Forest West Wind Farm is located.

8.176. Two proposed wind farms have the potential to fulfil both these criteria. They are the Brechfa Forest East Wind Farm (submitted) and the Bryn Llwyelyn Wind Farm (submitted). The locations of these wind farm sites are shown on Figure 15.52 in Chapter 15: Landscape and Visual Amenity.

8.177. Subcatchments originating in the development areas of the Brechfa Forest East Wind Farm and the Bryn Llwyelyn Wind Farm contribute to the Afon Cothi in the vicinity of Brechfa. A part of the Bryn Llwyelyn Wind Farm is also located in the subcatchment of the Afon Talog. The site entrance to the Bryn Llwyelyn wind farm is located in the catchment of the Afon Marlais. As indicated in the section on Existing Conditions, some subcatchments originating in the development area of the Brechfa Forest West Wind Farm contribute to the Afon Cothi, the Afon Talog and the Afon Marlais.

8.178. Therefore, there is potential for a cumulative impact in relation particularly to sediment discharge and pollution on the Afon Cothi, Afon Talog or Afon Marlais downstream of the confluences with subcatchment tributaries originating on the other wind farm sites. However, the significance of the cumulative effect would at most be minor. The points of confluence of the Afon Cothi and the Afon Talog with the tributaries are all several kilometres downstream of the wind farm sites. Only a short section of track for the Bryn Llwyelyn Wind Farm, about 300m long, is located in the Afon Marlais catchment. Assuming that appropriate mitigation is applied at all three wind farm sites, there will not be a significant cumulative impact on the watercourses.

8.179. It is unlikely that any private water supplies draw on the Afon Cothi, the Afon Talog or the Afon Marlais downstream of the confluence with the tributary subcatchments located in the area of the Bryn Llwyelyn Wind Farm. There are roads in the vicinity of the watercourses, as well as villages in the case of the Afon Cothi and Afon Talog, indicating that water quality may already be affected by development. Two properties visited close to the Afon Marlais are supplied by a spring and a well, as indicated on Figure 8.7 and in Appendix 8.1. Therefore the cumulative impact on private water supplies is predicted to be negligible.

8.180. Impediments to flow will affect only the wind farm site areas themselves, and possibly the tributaries within a few hundred metres downstream. There will therefore be no cumulative impact in combination with other wind farm construction.

ASSESSMENT OF OPERATIONAL IMPACTS

Predicted Impacts

8.181. The main potential impacts for hydrology, hydrogeology and water resources during operation relate to:

- Water quality, for both surface water and groundwater, as a result of pollution risk and residual sediment load from site drainage, including potential impacts on private water supplies;
- Changes to natural surface water drainage pattern;
- Changes to groundwater levels and groundwater movement;
- Runoff rates and resultant changes to flooding patterns.

Water quality (pollution risk and sediment load)

8.182. The risks of a pollution incident affecting surface water (or groundwater) quality will be substantially lower during operation of the windfarm than during construction. Once construction works are complete, vehicles will only visit the site to carry out routine checking and maintenance or emergency repairs. Only limited potential pollutants will be present, including lubricants for the turbine gearboxes, transformer oils and fuels/oils in maintenance vehicles and in the control room facilities.

8.183. As for construction, all operations personnel will receive site-specific training with regard to pollution incidents, as part of a pollution prevention and response plan. The plan will take into account any private water supplies which are dependent on watercourses in the area.

8.184. Once construction activities have ceased, the risk of the occurrence of high sediment loads in watercourses in the area will decline considerably. The main potential source of sediment will be from the permanent access tracks and drainage during a period of final, full stabilisation of the surface materials. This is likely to take two to three years from the completion of the works. Initially, temporary structures installed to trap sediment, as described in the mitigation measures during construction, will remain in place. They will be inspected on a regular basis, monthly or more frequently in periods of heavy rain. The temporary structures will be removed only when the operators are satisfied that no further significant sediment movement is occurring.

8.185. On steep gradients, shallow surface cross drains will be installed in continuous straight sections of new track to direct runoff into the adjacent track drainage. If necessary, shallow surface cross drains will also be installed at the entrance to the site from the public highway. The cross drains will prevent any additional runoff occurring from the access track to the public highway.

8.186. Operational impacts on water quality are predicted to be of minor significance.

Natural surface water drainage pattern

8.187. Access tracks have the potential to impact on surface water flows in the long term during operation. However, considerable effort will be made on site during construction to avoid disruption to features in the natural drainage pattern, to ensure impacts are minimised. The environmental specialist, appointed for the construction stage, will advise on maintaining areas of wet ground or open water fed by flows or seepages on the hillsides.

8.188. As discussed in paragraph 8.112, where appropriate, culverts will be constructed beneath new tracks to maintain continuity in minor channels and wet ground crossed by the tracks. An individual assessment of all existing culverts will be completed prior to construction, and a decision made as to whether to replace or upgrade each culvert. The objective in installing,
8.189. Overall, the operational impacts on drainage patterns are considered to be of minor significance.

Groundwater levels and groundwater movement

8.190. Groundwater is generally restricted to shallow depths above unweathered bedrock. Flow contributions to streams come mainly from surface runoff and saturated soils or sub-soils, or possibly in some places from a thin upper layer of weathered bedrock. There is no regional aquifer in which the groundwater flow pattern to major springs or other discharges could be disrupted.

8.191. Excavation and fill for the access tracks could compact the ground and have a localised impact on shallow groundwater movements in the long term. Clay bunds will be installed at intervals within cable trenches to prevent excessive drainage along the line of the trenches and dewatering of areas of wet ground.

8.192. In periods of dry weather, surface water flows are dependent on base flow. The base flow is provided by the release of water from saturated soil and subsoil, and by any shallow groundwater which is discharged into the watercourses. The base flows may make an important contribution to maintaining in-stream ecology in dry periods.

8.193. As the tracks and other developed areas will constitute only a very small part of the subcatchment areas for any of the watercourses, the reduction in infiltration, changes to groundwater conditions and the decline in the contribution to base flows in any of the stream subcatchments will also be very small. This is considered to be an impact of negligible significance.

Runoff rates and changes to flooding patterns

8.194. Increases in runoff rates from the scheme will result from:
- Felling and removal of timber;
- An increase in development, comprising increased areas of access tracks, working areas and foundations at turbine locations and other operational wind farm infrastructure (substation etc).

8.195. The potential impacts on flood flows, and methods of assessment, are discussed in the following sections. Assessments were made for all the subcatchments which originate within the site boundary at the road crossing points indicated in Table 8.6.

Felling Effects

8.196. The Forestry Commission (2003) indicates that the impacts of felling on peak flows are often difficult to detect, although there is limited field research from which to define the impacts clearly. The most comprehensive study applicable to the impacts of felling in the Brechfa area is described by Robinson et al (2003). Research at Plynlimon in mid-Wales indicated that partial felling produced little increase in peak flows, possibly as a result of the brash cover remaining after felling. Felling debris partially blocking stream channels may also contribute to the attenuation of flood flows.

8.197. Both Robinson et al (2003) and the Institute of Hydrology (1991) conclude that forestry generally has little impact on peak flows on all but a local scale. The Institute of Hydrology states that upland floods in excess of the mean annual flood are scarcely affected by land use. Any flood levels of concern should be well in excess of the mean annual flood.

8.198. Based on the conclusions of Robinson et al (2003) and the Institute of Hydrology (1991), it seems reasonable to assume that there would be no significant long-term impact on flood flows in the Brechfa area due to felling. However, peak runoff might be expected to increase for all events over a period of several years following felling. This would be a result of the reduced vegetation cover at this stage.

8.199. Robinson (1986) produced a paper on changes in catchment runoff following drainage and forestry planting. The paper concluded that peak flows were increased by an order of 20% as a result of the drainage of moorland. Although the increase in peak flows declined with time, after 10 years peak flows were still 10% higher than for the original moorland.

8.200. The potential impacts on flood flows after felling at the Brechfa Forest West Wind Farm site was estimated for the environmental impact assessment using the findings presented by Robinson (1986). It was assumed that a change from forested areas to cleared ground after felling had the same impact on flood flows as the change from vegetated moorland to cleared ground, prepared prior to the planting of forestry. Without mitigation, there could therefore be a 20% increase in peak flood flows emanating from felled areas.

8.201. In the longer term, once conifers are re-established in parts of the cleared areas over a period of several years, or vegetation starts to regrow, there will be no significant difference to flooding in major storm events. The increase in major flood flows as a result of forestry felling can be assumed to reduce to zero.

Increase in areas of tracks and other developed areas

8.202. Access tracks and other developed areas will give rise to increased surface runoff during rainfall events. In addition, any drainage associated with the access tracks can reduce the time of transfer to watercourses, of runoff originating on and around the tracks. The change in the time of concentration of the runoff, together with the increase in volume, may affect peak flood flows in downstream reaches.

8.203. The overall increase in runoff is likely to be small since the areas of tracks and other developed areas form only a small percentage of the subcatchment areas. Runoff can be calculated approximately using the standard methodology available in the Flood Estimation Handbook (NERC, 1999). The increase in runoff is the difference in peak flow for the subcatchment in the current conditions, and in a future situation with the additional areas of tracks and other developed areas.

8.204. A standard approach in carrying out the assessment is to consider the increase in flood peak for an event with a return period of 1 in 100 years. The results are expressed as a percentage increase in flood peak in the catchment. Similar percentage increases would be expected for other flood events with a high return period, for example a 1 in 200 year flood.

8.205. The Flood Estimation Handbook (FEH, 1999) model for calculation of runoff is a standard methodology used by hydrologists throughout the UK. The Flood Estimation Handbook (FEH) CD-ROM v2.0 (NERC, 2006) provides catchment descriptors such as soil parameters, slope, length, existing urban extent and rainfall. The standard FEH methodology is then applied with
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these descriptors to define critical storms of specified return periods, and runoff profiles resulting from the storms. The model is used to indicate the peak runoff of a specified return period, in this case 1 in 100 years, in current conditions.

8.206. The additional area of tracks and other developed areas are added to the urban extent obtained from the FEH CD-ROM v2.0 (NERC, 2006), to provide catchment conditions following construction of the scheme. The FEH model is re-run with the revised urban area, to determine the peak runoff following construction with the same specified return period (1 in 100 years).

8.207. The subcatchments considered in the assessment all experience similar climatic and topographic influences. Therefore, the increased peak runoff produced by the small additional areas of tracks and other developed areas, expressed as a percentage of peak runoff in current conditions, will be similar for all the subcatchments.

8.208. A detailed assessment was made of three subcatchments in the areas in and around the Brechfa Forest West Wind Farm to derive a relationship between additional areas of tracks and other developed areas, and increased peak runoff. The results for the three catchments indicated a similar and approximately linear relationship for a range of additional areas of tracks and other developed areas of up to 3% in the subcatchment. The percentage increase in peak runoff for a 1 in 100 year flood is about four times the percentage increase in areas of tracks and other developed areas. In all subcatchments the increase in areas of tracks and other developed areas is less than 3%.

8.209. It is therefore reasonable to apply the following approximate relationship in all subcatchments:

\[
\text{percentage} \text{ (\%)} \text{ increase in peak runoff in the catchment} = 4 \times \text{percentage} \text{ (\%)} \text{ additional areas of tracks and other developed areas.}
\]

8.210. The following assumptions were made in calculating the additional areas of tracks and other developed areas in each subcatchment:

- Developed areas for each feature of the infrastructure are as detailed in Chapter 3: Scheme Description and Design Evolution. The developed area at each turbine includes the turbine base itself, plus the area for the crane base.
- The total width developed for new tracks is assumed to be 8m, allowing for a width of 5m for the carriageway, 1m wide ‘shoulders’ on either side, and a drain 1m in width on one side.
- It is assumed that on average the developed width associated with existing tracks would be increased to 5m, to accommodate a wider carriageway, increasing on average from 3m to 5m, plus 1m wide ‘shoulders’ and a drain.
- Runoff from the developed area at the substation and anemometer mast are included in the subcatchments in which these components are located.

8.211. As there is some uncertainty concerning the infiltration properties of the drains located alongside the access tracks, two cases with differing infiltration were considered, as follows, giving rise to a range in the assessment of runoff:

- No infiltration over the total width of the track including carriageway, verges and the drain.
- No infiltration through the carriageway, but infiltration through the verges and the drain remains as for natural ground conditions.

8.212. It is assumed in runoff calculations that there is no infiltration over the other developed areas.

8.213. The track carriageway will be widened in bends, and passing places will be provided. Allowance has been made in the calculations for these.

8.214. It is assumed that the temporary compounds and the borrow pit will not contribute to any increased runoff. Attenuation basins and other runoff attenuation features will be in place in and around the compounds and borrow pit during the period in which they are in use, in order to prevent the discharge of water with a high sediment load. The attenuation features will also act as sustainable drainage systems. They will prevent any temporary increase in runoff rate from the developed areas.

8.215. Following reinstatement of the temporary compound areas, runoff rates in high rainfall events will return to pre-development levels. If needed, permanent runoff attenuation features will be incorporated in the borrow pit. The features will be designed to ensure that rates of runoff from the area do not increase above pre-development levels, as also discussed in paragraph 8.232.

8.216. The criteria for assessing the sensitivity of subcatchments to flooding, and the magnitude of the impact resulting from an increase in flood flow, are set out in Tables 8.2 and 8.4.

8.217. The assessments of the magnitude and significance of impacts for each of the subcatchments is presented in Table 8.12. With the exception of two subcatchments, all the impacts on peak runoff are negligible or minor. The exceptions are:

- The Afon Gorwydd at the crossing on the A485 in Gwyddgrug;
- The Afon Pib, at the upstream point of assessment on the minor road between Brechfa and Llanllawddog.

8.218. For the Afon Gorwydd at the crossing on the A485 in Gwyddgrug village, the increase in peak runoff is calculated to be between 2 and 4%. This would reduce to 2 to 3% in time, as the impact of forestry felling reduces. Much of the additional runoff is a result of the location within the Afon Gorwydd subcatchment of a substantial section of the site access track from the A485. Details of flood risk on Figure 8.4 indicate that the 1 in 100 year flood remains within the banks of the Afon Gorwydd in Gwyddgrug. Nonetheless, there may be concerns over increasing runoff at a crossing on a major road in a village.

8.219. At the upstream point of assessment on the Afon Pib, the increase in peak runoff is calculated to be between about 6 and 8%. This would reduce to 3 to 6% in time, as the impact of forestry felling reduces. Figure 8.4 indicates that there is a farm located close to the crossing. The 1 in 100 year flood spreads out from the watercourse close to the dwelling. There is therefore a moderately increased risk of flooding to part of the dwelling.

8.220. In addition, the downstream points of assessment for the Afon Pib and the Afon Marlais are both within Brechfa village. There are separate crossings for the two watercourses in the village. The magnitude of impacts for both crossings is minor. Increases in peak runoff in both watercourses are calculated to be a maximum of about 3%. The combined increase in peak runoff...
runoff at the confluence of the two watercourses, located about 200m downstream of the crossings, is also about 3%. The increase in peak runoff should reduce to about 1% once replanted tree cover or natural vegetation has re-established in the areas of felling.

8.221. Sensitivity to flood risk is high in Brechfa village. The flood mapping in Figure 8.4 indicates that the watercourses comes out of bank over a total width of about 100m in a 1 in 100 years flood downstream of the two watercourse crossings. The increase in peak runoff might be expected to raise the flood level by something of the order of a few millimetres or centimetres, but cannot be assessed accurately.

8.222. As well as the subcatchments indicated in Tables 8.6 and 8.12, additional runoff from the lower section of the site access track could occur via field drains to a culvert on the A485, although it was not possible to verify this fully due to access rights. The location of the culvert is shown on Figure 8.4. The increase in runoff at this culvert is estimated very approximately to be 3 to 5% of current peak flow. The small size of the area of contributing runoff (less than 0.5 km²) makes estimation very approximate. However, as a result of the presence of the access track, it is assumed that there will be a moderate impact on flows at the culvert on the A485.

8.223. The significance of potential impacts on the water environment (including for flood levels at each road crossing) during operation are summarised in Table 8.12.

Table 8.12: Assessment of impacts during operation

<table>
<thead>
<tr>
<th>Potential impact</th>
<th>Receptor</th>
<th>Sensitivity</th>
<th>Magnitude</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water quality (sediment load and pollution)</td>
<td>Surface water</td>
<td>High</td>
<td>Low</td>
<td>Minor</td>
</tr>
<tr>
<td></td>
<td>Private water supply</td>
<td>Moderate</td>
<td>Low</td>
<td>Minor</td>
</tr>
<tr>
<td>Change to drainage pattern</td>
<td>Natural surface water drainage</td>
<td>Moderate</td>
<td>Low</td>
<td>Minor</td>
</tr>
<tr>
<td>Change to subsurface flow and discharge</td>
<td>Groundwater</td>
<td>Minor</td>
<td>Low</td>
<td>Negligible</td>
</tr>
<tr>
<td>Runoff rates and flood levels at existing road crossings in subcatchments</td>
<td>Afon Marlais (at Felin Marlais)</td>
<td>Moderate</td>
<td>Low</td>
<td>Minor</td>
</tr>
<tr>
<td></td>
<td>Nant Cwmmarydd</td>
<td>Moderate</td>
<td>Low</td>
<td>Minor</td>
</tr>
<tr>
<td></td>
<td>Afon Pib (minor road near site)</td>
<td>Moderate</td>
<td>Medium</td>
<td>Moderate</td>
</tr>
<tr>
<td></td>
<td>Afon Gwili (near Tyllwyd)</td>
<td>Moderate</td>
<td>Negligible (zero)</td>
<td>Negligible</td>
</tr>
<tr>
<td></td>
<td>Nant Hafren</td>
<td>Moderate</td>
<td>Low</td>
<td>Minor</td>
</tr>
<tr>
<td></td>
<td>Nant Aerau</td>
<td>High</td>
<td>Low</td>
<td>Minor</td>
</tr>
<tr>
<td></td>
<td>Nant Ailerllais</td>
<td>High</td>
<td>Negligible</td>
<td>Negligible</td>
</tr>
<tr>
<td></td>
<td>Afon Gorwydd</td>
<td>High</td>
<td>Low/Medium</td>
<td>Minor/Moderate</td>
</tr>
</tbody>
</table>

Proposed Mitigation Measures

Runoff rates and changes to flooding patterns

8.224. Measures will be implemented with respect to the forestry felling and increase in runoff from areas of tracks and other developed areas to reduce the impact of the scheme. In some areas of felling, it may be possible to block existing forestry drainage networks at intervals in order to slow the rate of runoff to the drains. However, the blocking of drains will also depend on the extent of the catchment upgradient of the cleared area which is contributing runoff to the drains. Drains which could convey a large flow from upgradient of the area of felling will not be blocked, to avoid a risk of flooding in the cleared area.

8.225. As discussed in paragraph 8.201, runoff should also decline naturally as re-vegetation of the felled areas occurs. Therefore there will be no significant long term impact on flood flows as a result of felling.

8.226. The surface water drainage will be designed taking into account sustainable drainage measures included in the SUDS Manual (CIRIA C697, 2007). The objective will be to delay the contribution to flows in watercourses during periods of heavy rainfall. In theory, there will be an increase in the total volume of runoff as a result of the increase in developed areas in subcatchments. However, flow attenuation features incorporated in the drainage will be designed to ensure that, as a result of the construction/upgrading of tracks and the presence of other developed areas, the peak flows at the receptors indicated in Table 8.12 would not exceed the peak flows prior to development of the wind farm. The temporary runoff storage provided by flow attenuation features, and rates of release from storage, will be designed to prevent any increase in peak flows or flood risk.

8.227. SuDS features are illustrated in the figures in Appendix 8.5. Figure 2 shows a typical layout for a turbine base and associated crane base. The runoff volume for a 1 in 100 year rainfall event of six hours duration (with allowance for climate change), which is standard for SuDS.
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design, can be obtained using the Flood Estimation Handbook (FEH) CD-ROM (NERC, 2006). 
The runoff data is then used to determine the volume of the attenuation basin and the size of 
outlet required in order to control the discharge to a level which is acceptable to the 
Environment Agency Wales. Preliminary calculations indicate that a storage volume of about 
100m$^3$ would be applicable for each combined turbine and crane base. This would be 
equivalent to an attenuation basin 10m by 10m with a depth of 1m.

8.228. Check dams will be installed within the drainage system to temporarily retain a part of the 
flow in periods of high flow. The check dams will be gabion structures, as illustrated in 
Figure 1 of Appendix 8.5. An outlet pipe in the base of the gabion structure allows low 
and normal levels of flow to be maintained in the drainage system. In time, the drainage 
channels will be allowed to transform naturally into vegetated swales, where this is feasible for 
drainage management.

8.229. Parts of the drainage system may be widened to accommodate additional storage in shallow 
attenuation basins fitted with check dams. Depending on topography, attenuation basins may 
also be constructed close to the drainage system. The basins will be fed by the drainage 
system at high levels of flow, with a controlled low level of discharge back into the 
watercourse.

8.230. Existing field drains and open ditches, which cross the line of the access track, will generally be 
conducted under the track in cross drains to avoid adding to the flow in the access track 
drains. Catchpits and possibly orifice plates will be incorporated as SuDS features on the 
upstream side of cross drainage culverts to control high levels of runoff.

8.231. Drain lengths will also be limited to prevent rapid transfer of the drainage discharge to 
watercourses. The water may be discharged into areas of open ground, or to minor 
ephemeral or seasonal flow channels on the hillsides, upstream of the watercourses, wherever 
this is possible.

8.232. The borrow pit will be made safe at the end of construction. A decision on the form and 
layout of the borrow pit, together with any soil and unused weathered rock, will be made 
following discussion and agreement with FCW. If needed, runoff attenuation features will also 
be incorporated to ensure rates of runoff from the borrow pit area do not increase above 
pre-development levels.

8.233. The sustainable drainage measures will be designed when the detailed design of the wind farm 
is also undertaken. All drainage features will be designed to the standards set out in the SuDS 
Manual and agreed with Environment Agency Wales and FCW prior to implementation.

Other impacts

8.234. The significance of all other potential impacts on the water environment during operation are 
either minor or negligible. No mitigation is considered necessary for these other impacts.

Residual Impacts

8.235. The residual impacts, after adoption of the mitigation measures described in this section, are 
summarised in Table 8.13. With appropriate mitigation in place, all residual impacts are of 
minor or negligible significance. There would be no increase in peak runoff and flood levels 
as a result of the presence of the scheme.

Table 8.13: Assessment of impacts during operation with mitigation

<table>
<thead>
<tr>
<th>Potential impact</th>
<th>Receptor</th>
<th>Sensitivity</th>
<th>Magnitude</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water quality (sediment load and pollution)</td>
<td>Surface water</td>
<td>High</td>
<td>Low</td>
<td>Minor</td>
</tr>
<tr>
<td></td>
<td>Private water supply</td>
<td>Moderate</td>
<td>Low</td>
<td>Minor</td>
</tr>
<tr>
<td>Change to drainage pattern</td>
<td>Natural surface water drainage</td>
<td>Moderate</td>
<td>Low</td>
<td>Minor</td>
</tr>
<tr>
<td>Change to subsurface flow and discharge</td>
<td>Groundwater</td>
<td>Minor</td>
<td>Low</td>
<td>Negligible</td>
</tr>
<tr>
<td>Runoff rates and flood levels at existing road crossings in subcatchments</td>
<td>Afon Marliais (at Felin Marliais)</td>
<td>Moderate</td>
<td>Negligible</td>
<td>Negligible</td>
</tr>
<tr>
<td></td>
<td>Nant Cwm-marydd</td>
<td>Moderate</td>
<td>Negligible</td>
<td>Negligible</td>
</tr>
<tr>
<td></td>
<td>Afon Pib (minor road near site)</td>
<td>Moderate</td>
<td>Negligible</td>
<td>Negligible</td>
</tr>
<tr>
<td></td>
<td>Afon Gwili (near Tyllwyd)</td>
<td>Moderate</td>
<td>Negligible</td>
<td>Negligible</td>
</tr>
<tr>
<td></td>
<td>Nant Hafren</td>
<td>Moderate</td>
<td>Negligible</td>
<td>Negligible</td>
</tr>
<tr>
<td></td>
<td>Nant Aerau</td>
<td>High</td>
<td>Negligible</td>
<td>Negligible</td>
</tr>
<tr>
<td></td>
<td>Nant Alltwalis</td>
<td>High</td>
<td>Negligible</td>
<td>Negligible</td>
</tr>
<tr>
<td></td>
<td>Afon Gorwydd</td>
<td>High</td>
<td>Negligible</td>
<td>Negligible</td>
</tr>
<tr>
<td></td>
<td>Afon Gwyddgrug</td>
<td>High</td>
<td>Negligible</td>
<td>Negligible</td>
</tr>
<tr>
<td></td>
<td>Unnamed Tributary (of the Afon Talog)</td>
<td>High</td>
<td>Negligible</td>
<td>Negligible</td>
</tr>
<tr>
<td></td>
<td>Afon Pib (Brechfa village)</td>
<td>High</td>
<td>Negligible</td>
<td>Negligible</td>
</tr>
<tr>
<td></td>
<td>Afon Marliais (Brechfa village)</td>
<td>High</td>
<td>Negligible</td>
<td>Negligible</td>
</tr>
<tr>
<td></td>
<td>Afon Gwili (at A485)</td>
<td>High</td>
<td>Negligible</td>
<td>Negligible</td>
</tr>
<tr>
<td></td>
<td>Afon Talog</td>
<td>High</td>
<td>Negligible</td>
<td>Negligible</td>
</tr>
<tr>
<td>Flow through culvert</td>
<td>Culvert at A485 near site entrance</td>
<td>High</td>
<td>Negligible</td>
<td>Negligible</td>
</tr>
</tbody>
</table>

Cumulative Impacts

8.236. One other wind farm, Bryn Llywelyn, is located partly in the Afon Talog catchment. The site 
entrance for Bryn Llywelyn and a track length of about 300m are also located in the Afon 
Marliais catchment. As a result, there will be a cumulative impact increasing peak runoff in the
Afon Talog catchment at the assessment point at Pencader, and in the Afon Marlais at Brechfa (see Figure 8.4).

8.237. As indicated in paragraphs 8.226 to 8.233, mitigation will be applied for the Brechfa Forest West Wind Farm, in order to reduce peak runoff in the long term from the scheme, to the pre-development level. Therefore any impacts on flows in the Afon Talog and the Afon Marlais will result just from the Bryn Llywelyn Wind Farm.

8.238. The Environmental Statement for the Bryn Llywelyn wind farm indicates that “under the ethos of SuDS it is proposed, where physically possible, to replicate natural drainage in the area.” The residual effect due to increased runoff is assessed as zero in the Environmental Statement for Bryn Llywelyn. Therefore, assuming that appropriate SuDS measures are applied at both wind farm sites, there will be no cumulative impact in terms of increased peak runoff.

8.239. Runoff from the Brechfa Forest West Wind Farm, the Bryn Llywelyn Wind Farm and also the Brechfa Forest East Wind Farm contributes to the Afon Cothi. As indicated in paragraphs 8.237 and 8.238, assuming appropriate SuDS measures are applied at the Brechfa Forest West and Bryn Llywelyn Wind Farms, there will be no cumulative impact in terms of increased peak runoff. The Environmental Statement for the Brechfa Forest East Wind Farm also indicates that mitigation will be applied in order to reduce peak runoff in the long term from the scheme to the pre-development level. Therefore no cumulative impact is predicted for the Bryn Llywelyn Wind Farm, the Brechfa Forest West Wind Farm and Brechfa Forest East Wind Farm on flows in the Afon Cothi.

MICROSITING

8.240. Micrositing within 50m will be possible from a hydrological perspective, provided the turbines, other associated developed areas and new access tracks are not moved to within the 50m buffer zones around watercourses, or to within any spring protection zones, shown on Figure 8.8.

DECOMMISSIONING

8.241. Decommissioning of infrastructure will lead to impacts of no greater significance than construction, as:

- the impacts of felling will not occur during decommissioning;
- access tracks will be left in place following completion of operations at the site.

8.242. Mitigation measures, similar to those used during construction, will be put in place as appropriate.

FUTURE SITUATION WITHOUT SCHEME

8.243. Current land use practices, mostly forestry but with areas of grazing along the access track to the site, would be expected to continue in the absence of construction of the wind farm. The hydrological conditions in the area of the scheme would therefore remain much as at present. Following the normal practice of felling and replanting, peak flood flows in watercourses could vary slightly as discussed in paragraphs 8.196 to 8.201. At times, water quality might also be affected by felling practices.

FUTURE MONITORING REQUIREMENTS

8.244. Specific monitoring requirements during construction and operation of the scheme will be agreed with CCC/EAW. Regular monitoring of sediment content in watercourses, and any private water supplies dependent on the sources, will be undertaken on and around the site. Some monitoring will also be undertaken prior to construction to establish detailed baseline conditions. Monitoring will continue during the early stages of operation until it is clear that no further significant erosion and resulting sediment movement is occurring in site drainage.

8.245. There may be private water supplies which are dependent on surface water originating, in part, from areas of subcatchments where forestry felling will occur. In the event that the water is used as domestic water supplies, samples will be taken from the surface water source prior to the start of felling. The samples will be analysed for a range of determinands which may be affected by felling. The sampling and analyses to be undertaken will be agreed with the Environment Agency Wales.

8.246. Water quality monitoring will also be undertaken in the well which supplies Lan Farm and is located close to the proposed access track (see Reference 14 on Figure 8.7). The monitoring will start prior to the start of construction of the access track. Monitoring will continue throughout the period of construction and into the early stages of operation.

8.247. Monitoring of nitrates will be undertaken in relation to subcatchments in which there is a high level of felling (see paragraphs 8.124 to 8.129). The subcatchments in which the area of felling exceeds 20% of total subcatchment area are all on the Afon Pib. A site for sampling for nitrates will be established on the Afon Pib between the outlets for subcatchments H and I shown on Figure 8.9. Sampling will be started prior to the start of felling. Onsite pH will also be monitored when sampling.

8.248. The water quality data for private water supplies and monitoring on the Afon Pib will be used as a baseline against which to judge water quality during and after the forestry felling. Research in mid Wales indicated that impacts on water quality can occur over a period of about three years following felling (Neal, C and Reynolds, B. 1998). Sampling will therefore continue for a period of about three years after the completion of felling in each area. Data will be reviewed at the end of each year to reassess the need for continuing monitoring. Monitoring will be continued beyond three years if considered necessary, following consultation with the Environment Agency Wales. However, as indicated in paragraph 8.130, any impacts on water quality are only expected to be of minor significance.

8.249. As indicated in paragraph 8.135, there is potential for the spring used for livestock watering at Coedlannau Fawr to be affected by the construction of the access track to Turbine 17. The spring will be monitored for yield, commencing six months prior to the start of any felling or construction activities in the spring protection zone. Monitoring will continue throughout felling and construction in the vicinity of Turbine 17, and also Turbine 18. Although outside the spring protection zone, Turbine 18 is located up-gradient of the spring, and close to the protection zone (see Figure 8.8). The monitoring will also continue for a period of up to a year following completion of construction in the area of Turbines 17 and 18.

SUMMARY OF IMPACTS

8.250. A summary of impacts during construction and operation, before and after proposed mitigation, is provided in Tables 8.14 and 8.15 below.
### Table 8.14: Summary of Impacts during Felling and Construction

<table>
<thead>
<tr>
<th>Potential Impacts</th>
<th>Receptor</th>
<th>Significance</th>
<th>Proposed Mitigation/Enhancement</th>
<th>Residual Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Erosion and sedimentation</td>
<td>Surface water</td>
<td>Moderate</td>
<td>Practices during felling to be in accordance with Forestry Commission guidelines. A high quality, durable stone material to be used in the surfacing of access tracks. Careful site environmental management will ensure that adequate measures to control silt-laden drainage water are in place right from the start of construction and throughout the construction period. Exposed soil to be minimised in cuttings, excavations and stockpiles. Control measures to include bunded attenuation/ settlement areas, silt traps and mobile silt trap units if needed. Check dams in track drainage. Control measures to be located close to excavations.</td>
<td>Minor</td>
</tr>
<tr>
<td></td>
<td>Private water supplies</td>
<td>Major</td>
<td></td>
<td>Minor</td>
</tr>
<tr>
<td>Impediments to flow</td>
<td>Watercourses</td>
<td>Moderate</td>
<td>Felling away from watercourses. Regular inspection to keep watercourses clear.</td>
<td>Negligible</td>
</tr>
<tr>
<td>Water pollution</td>
<td>Surface water</td>
<td>Moderate</td>
<td>Implement good pollution prevention practices based on Environment Agency guidelines and CIRIA documents. Store and dispense all fuels/oils and cement/additives away from watercourses. Prepare Pollution Prevention and Response Plan to include emergency procedures, with details of pollution response equipment on site.</td>
<td>Minor</td>
</tr>
<tr>
<td></td>
<td>Private water supplies</td>
<td>Major</td>
<td></td>
<td>Minor</td>
</tr>
<tr>
<td>Changes to</td>
<td>Surface water</td>
<td>Minor</td>
<td>None</td>
<td>Minor</td>
</tr>
</tbody>
</table>
### Table 8.15: Summary of Impacts during Operation

<table>
<thead>
<tr>
<th>Potential Impacts</th>
<th>Receptor</th>
<th>Significance</th>
<th>Proposed Mitigation/Enhancement</th>
<th>Residual Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water quality (sediment load and pollution)</td>
<td>Surface water</td>
<td>Minor</td>
<td>No specific mitigation. Operators will receive site-specific training with regard to pollution incidents</td>
<td>Minor</td>
</tr>
<tr>
<td></td>
<td>Private water supplies</td>
<td>Minor</td>
<td>None</td>
<td>Minor</td>
</tr>
<tr>
<td>Change to drainage pattern</td>
<td>Natural surface water drainage</td>
<td>Minor</td>
<td>No specific mitigation. Maintain continuity in minor channels and wet ground crossed by the tracks</td>
<td>Minor</td>
</tr>
<tr>
<td>Change to subsurface flow and discharge</td>
<td>Groundwater</td>
<td>Negligible</td>
<td>None</td>
<td>Negligible</td>
</tr>
<tr>
<td>Runoff rates and flood levels at existing road crossings</td>
<td>Afon Marlais (at Felin Marlais)</td>
<td>Minor</td>
<td>Block forestry drains where possible. Good practice track drainage measures and SuDS features.</td>
<td>Negligible</td>
</tr>
<tr>
<td></td>
<td>Nant Cwm-marydd</td>
<td>Minor</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Afon Pib (minor road near site)</td>
<td>Moderate</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Afon Gwili (near Tyllwyd)</td>
<td>Negligible</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nant Hafren</td>
<td>Minor</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nant Aerau</td>
<td>Minor</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nant Altwalis</td>
<td>Negligible</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Afon Gorwydd</td>
<td>Minor/Moderate</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Afon Gwyddgrug</td>
<td>Negligible</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unnamed Tributary (of the Afon Talog)</td>
<td>Negligible</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Afon Pib (Brechfa village)</td>
<td>Minor/Moderate</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Afon Marlais (Brechfa village)</td>
<td>Minor</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Afon Gwili (at A485)</td>
<td>Negligible</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Afon Talog</td>
<td>Negligible</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Culvert at A485 near site entrance</td>
<td>Moderate</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### REFERENCES

- Carmarthenshire County Council (July 2006). *Unitary Development Plan*.
- Carmarthenshire County Council (2011). *Carmarthenshire Local Development Deposit Draft*.
- NERC Connolly, S., Charles, P. (2005). *Environmental Good Practice on Site (C650)*. CIRIA.
- Forestry Commission Research & Development Division. *Research Information Note 68 82 SSN. Soil Classification (by Pyatt, DG)*.
8. Geology, Soils and Hydrology


Ordnance Survey 1:10000, 1:25000 and 1:50000 scale, current mapping.


Robinson, M et al (2003), Studies of the impact of forests on peak flows and baseflows: a European perspective.

Robinson, M (1986), Changes in catchment runoff following drainage and afforestation.

Soil Survey of England and Wales (1983), Map Sheet 2 Wales, Ordnance Survey (Southampton).

Soil Survey of England and Wales (1984), Soils and Their Use in Wales
