Planning Ref.: 08.PA0044

Grousemount Wind Farm County Kerry

Additional Information

March 2016

Part 1 of 3

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Grousemount Wind Farm, County Kerry

Additional Information

Part 1 of 3

Contents

Grousemount Wind Farm, County Kerry

Client: ESB Wind Development Limited

Planning Ref.: 08.PA0044
Response to Additional Information Request

Document No.: QR-320171-11-GK0316-R001

Date: March 2016

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Contents

Introduction

A Strategic Infrastructure Development (SID) application for planning permission (Ref.: 08.PA0044) for Grousemount Wind Farm was lodged by ESB Wind Development (ESBWD) with An Bord Pleanála (ABP) on 7th September 2015.

In summary, the proposed development involves construction of a wind farm comprising 38 wind turbines (maximum overall dimension of 126 m), all associated access tracks and other infrastructure.

The application represents a revision and amalgamation of two existing planning permissions on the site, as follows:

- Kerry County Council Reg. Ref. 10/0197 granted on 25th November 2010 – 10 year permission for 14 wind turbines and associated development.
- Kerry County Council Reg. Ref. 10/1333 granted on 26th January 2012 – 10 year permission for 24 wind turbines and associated development.

In correspondence dated 14th January 2016, in accordance with section 37(F)(1) of the Planning and Development Act, 2000, as amended, An Bord Pleanála sought further information in relation to the effects on the environment of the proposed development.

This report responds to the issues raised in An Bord Pleanála's request.

For ease of comprehension, issues are addressed in the sequence in which they were raised and the text of the Board's request is presented in addition to the response.

1 Site Suitability Tests

The Preliminary Peat Stability Risk Assessement contained in the EIS is not a detailed geological site investigation. Peat depths at specific locations have been ascertained and some exceed 0.5m, it is not clear how the scores were allocated or weighted in the PPSRA, and a number of slopes face N, NW and NE. Further site specific analysis is therefore required in relation to peat and slope stability throughout the application site.

Please provide details of the exact locations of the proposed internal access tracks, turbines, met masts and borrow pits along with a complete and comprehensive assessment of peat and slope stability acros the entire site and at the aforementioned locations. The Peat Stability Risk Assessment should be undertaken in accordance with the Scottish Executive document "Peat Landslide Hazard and Risk Assessments - Best Practice Guide for Proposed Electricity Generation Developments" (2006).

Response

The EIS provided a summary of exhaustive site investigations and subsequent extensive analysis of the raw data regarding site stability at Grousemount. Information provided in the EIS sought to limit the presentation to relevant information, an overview of the methodology employed in the peat stability assessment and an outline of the results derived. For the purposes of clarity and to ensure the Board has the raw data from the site investigations available to it, a full copy of the following is now submitted separately:

- Report W78035-F105-018-R-0001: Grousemount Wind Farm, Peat Stability Risk Assessment, August 2015.

The above comprises the following Volumes:

- Volume 1: Main Report
- Volume 2: Appendix A (Drawings) & Appendix C (PSRA Sheets – Turbines, Access Tracks & Other Infrastructure)
- Volume 3: Appendix B (Barnastooka Wind Farm – Site Investigation Report & Grousemount Wind Farm – Site Investigation Report) & Appendix D (Correspondence from Byrne Looby)

Full details of the project in terms of the exact loactions of internal access tracks, turbines, met masts and borrow pits are shown in the planning application (drawings and EIS). It is also confirmed that the assessement that was undetaken regarding site stability was fully in accordance with the Scottish guidelines (p. 14.6 of the EIS (Volume 1) refers).

The Executive Summary of the Peat Stability Risk Assessment report outlined as follows:

> *The proposed Grousemount Wind Farm is located on private land approximately 8 km south-east of the village of Kilgarvan in County Kerry. It is proposed to construct 38 wind turbines and associated infrastructure on the site. ESBI were engaged to carry out a Peat Stability Risk Assessment (PSRA) for the wind farm.*
>
> *The ground conditions across the Grousemount Wind Farm site generally consist of peat overlying glacial till over sandstone and siltstone bedrock. Peat depths are*

generally less than 1.0 m with only a few locations with peat depths of greater than 2.0 m and a maximum peat depth of 2.5 m.

A peat stability risk assessment was carried out based on the Natural Scotland Scottish Executive "Peat Landslide Hazard and Risk Assessment: Best Practice Guide for Proposed Electricity Generation Developments" (2006) which has also been recommended in the Irish Wind Energy Association (IWEA) "Best Practice Guidelines for the Irish Wind Energy Industry" (2008), and is supplemented by the experiences of ESBI on previously developed sites. Information on the ground conditions, topography, hydrology, ecology, land use and other factors were used to determine the likelihood of peat failure at each location analysed. The impact of a potential peat slide was also considered. The likelihood and impact of a peat failure at different areas of the site were combined to form the risk.

The results of the PSRA show that prior to risk mitigation measures being applied there is an insignificant[1] to substantia[1] peat stability risk rating on Grousemount Wind Farm.

Preliminary design stage, detailed design stage and construction stage mitigation measures have been specified for the project. All peat excavated on the site will be securely stored in excavated borrow pits and peat repositories with engineered rock berm containment that act as a shear key. A portion of the excess peat will be sidecast at suitable locations on the site which will be identified at detailed design stage.

The peat risk has been minimised by optimising the design of the wind farm and will be further mitigated by choosing a safe and controlled construction methodology; having a rigorous documentation and quality control system during construction and by controlling construction activities carefully.

It has been demonstrated within this report that after mitigation measures are applied at the preliminary, detailed design stage and construction stage that the risk rating range will reduce to insignificant[1] or significant[1].

As outlined in the EIS (p. 14.14), an independent peer review of the PSRA by specialists with adequate experience in construction on upland peat sites was commisssioned. The letter of review, which was presented in the EIS (Appendix H.1, Volume 2), confirmed that the approach adopted had used "*best indusry practice in line with the recommendations of the Scottish Executive document.."* It further noted as follows: *"For the purposes of the planning stage high level review, ByrneLooby are satisfied that the PSRA carried out by ESBI is generally adequate."*

[1] Terminology from Scottish Executive Guidelines

2 White-tailed Sea Eagle Breeding Programme

The EIS (p 9.25) refers to one eagle sighting (2 eagles) over 108 hours of observation during 2014/15 winter. This is insufficient evidence to conclude that the site is not well used especially as it lies between likely breeding areas in Kenmare Estuary, Killarney Valley, Glengarriff and the Lee Valley.

According to the NPWS, the eagle re-introduction programme is at a very critical phase, the production of sufficient wild bred eagles over the next few years will determine the survival of the population and the success of the project, and the importance of controlling mortality in the early phases is well documented.

The NPWS states that given the risk of collision demonstrated by the previous wind turbine fatalities at adjacent wind farms, the reduction in mortality being critical for the success of the eagle re-introduction project, and the uncertainty as to whether the Roughty Valley will be used by juveniles in the future (as it has been previously), the application is premature and should be refused permission.

Please comment in detail on this issue and provide the results of any other relevant peer reviewed scientific studies undertaken in relation to the effects of wind turbines on White tailed sea eagle.

Response

Prior to addressing the principal issues, the following points are noted:

- It is stressed that the points raised by the NPWS regarding the importance of the White-tailed Sea Eagle Reintroduction Programme are fully accepted by the applicant and, indeed, the high conservation value of the species has been highlighted in the EIS (p. 9.24).
- It is accepted that the White-tailed Sea Eagle is known to be sensitive to wind farms and this is especially the situation where eagle breeding territories and turbines co-exist, such as in the well documented breeding location at Smøla, Norway (Dahl et al. 2012). In the EIS (p. 9.34) it is noted that *"White-tailed eagle is listed as being vulnerable to disturbance displacement and collision with wind turbines".*

2.1 Sufficiency of Survey Evidence to Draw Conclusions

It is believed that the combined evidence from the surveys undertaken, the White-tailed Sea Eagle Reintroduction Programme's own assessment of its current status and the Golden Eagle Trust's assessment of the the site's potential indicate that the site is not "well used" by White-tailed Sea Eagle.

Since the survey work in the 2014/15 winter (as reported on in the EIS), further survey was carried out in late-winter 2015/16. The 2015/16 survey comprised a total of 60 hours of systematic observation over 10 days between 26th January and 9th March 2016. One White-tailed Sea Eagle observation was made as follows:

- Adult on 26th February 2016 flying northwards along north-east boundary of site (adjoining Sillahertane conifer forest), observed for approximately 300 seconds at varying height of between 10 m and 100 m. Continued in a north to northeast direction until out of sight.

With only two sightings of eagles (involving three individuals), during a total of 168 hours of observation over 28 days in two winters, it is considered that this indicates that the site is not being used by eagles on a regular basis. Of particular relevance is that there is no flight-path, such as between feeding and roost sites, over the site or surrouding area that the eagles are using on a daily basis.

Furthermore, it is noted that the Golden Eagle Trust has been monitoring the movements of released eagles by radio and satellite telemetry since the re-introduction programme commenced. No tagged birds have been recorded in the area of the site (see www.goldeneagle.ie).

2.2 Prematurity of Application and Recommended Refusal

It appears that the recommendation for refusal of the wind farm project at Grousemount by the NPWS is largely on a precautionary basis due to the collisions with turbines at nearby wind farms in the 2011-12 period.

Detailed below are key points in support of the conclusion in the EIS that the proposed development will not result in signficant adverse impacts on the White-tailed Sea Eagle Reintroduction Programme.

Firstly, background information is presented on the Reintroduction Programme which is relevant to the response to the issues raised by NPWS.

2.2.1 Background

The following is based on information collated for the EIS for Grousemount Wind Farm, the website of the Golden Eagle Trust (www.goldeneagle.ie) and information contained in the Derringcullig Wind Farm (PL 08.243129) First Party Appeal to An Bord Pleanála (specifically the ecology report prepared by Fehily Timoney, dated March 2014).

Release Phase 2007-2011

Between 2007 and 2011 a total of 100 young White-tailed Sea Eagles were released into the wild in Killarney National Park. These was released in small groups of 20-25 birds per year. Typically, eagles take about 4-6 years before they are mature enough for breeding, although pair bonding and establishing breeding territories can take place before this. Due to the slow maturation to adulthood, low mortality is a key factor in establishing a viable wild population.

The diet of the White-tailed Sea Eagle consists of carrion and small to medium sized fish, as well as small birds and mammals. When the birds were initially released in Killarney National Park, they were supported through supplementary feeding stations for the first few months after their release. This gave the birds an opportunity to develop their independence and to familiarise themselves with the local landscape. It is understood that supplementary feeding has been phased out, other than for the breeding pair in the National Park. An outcome of the supplementary feeding was that it encouraged a relatively large number of immature eagles to persist in the area of the Park. As the release site served as the 'natal' site for a large number of birds, this also served to concentrate the activities of all young birds around the Park during the 'release phase' of the programme.

The last releases were in 2011 and no further releases are planned in County Kerry.

Recent Developments and Progress of the Reintroduction Programme

Since 2012, a number of reintroduced eagles have started to pair bond, set up breeding territories and attempt breeding (see www.goldeneagle.ie). There are now approximately 15 breeding territories established at coastal areas and at large lakes in Counties Kerry, Cork, Clare and Galway. The first two chicks to be successfully fledged occurred in July 2013 at a site in Mountshannon, Co. Clare (widely publicised in the media at the time). As expected, breeding attempts were made in Killarney National Park by 2013. By 2014, 14 breeding territories had been established, although only one pair successfully fledged young .

Apart from the established territories, White-tailed Sea Eagles were recorded at many other locations throughout the country in 2014 and 2015, some of which may be future breeding sites, such as in Fermanagh, Longford and Cavan (Golden Eagle Trust 2014 & website). The 2014 Project Report also notes that one Irish 2007 released female bred and hatched three chicks at nest in Argyll, Scotland with a Scottish male. The report notes as follows:

> *"The expansion of the breeding population to counties Cork and Galway, as well as Kerry and Clare is very encouraging. Pairs have settled predominantly in a northerly direction (up to 150 km) as opposed to along the south coast (30 km).*

Regrettably, there have been a total of 30 White-tailed Sea Eagle fatalities beween 2007 and 2014, as follows (data from WTSE Project Report 2014):

Year	No. Recovered Dead	Cause of Death
2007	1	Poison
2008	3	Poison (3)
2009	7	Poison (1), shooting (1), natural (1), unknown (4)
2010	4	Poison (4)
2011	4	Wind turbine (2), unknown (2)
2012	5	Poison (2), wind turbine (1), unknown (2)
2013	3	Poison (1), unknown (2)
2014	3	Shooting (1), powerline (1), TBD (1)

Non-breeding White-tailed Sea Eagles and Roosting Patterns

Immature eagles tend to disperse widely during their pre-breeding stage, roosting at communal roost sites that can be used on relatively consistent or more transient basis. The roosts are usually in mature trees, often in commercial conifer plantations.

The use of radio and satellite telemetry has monitored the movements of the released birds, initially in Kerry and then nationwide (see www.goldeneagle.ie for examples of journeys taken by eagles). The following summarises the pattern that has emerged from the monitoring:

- The birds tend to stay close to their release sites (within 25 km) during their first winter after release.
- Then the birds disperse further away from the release sites, during the following late-spring / early-summer period.
- The birds then return to their release sites during the next late-autumn / early-winter period for their second winter.
- Finally, during the next-spring / early-summer period the birds embark on a significantly larger and long-term dispersal event (typically greater than 100 km) as they look to settle into their future breeding territory. At this point, they are in their third year of age.

The monitoring demonstrated that during the release period 2007-2011, large numbers of immature eagles were concentrated at and around the Killarney National Park area. There was a peak in numbers during the 2009-2011 period, as several groups of released birds were present together. As noted earlier, at that time the birds were attracted to the supplementary feeding stations that had been established within the Park. Since about 2013, there has been a relatively low level of roost usage within the Killarney area, with the cessation of released birds and as the expected long-term dispersal of the eagles has occurred.

2.2.2 Grousemount Site and Distribution & Ecology of White-tailed Sea Eagle

Proximity to SPA

The location of Grousemount Wind Farm is approximately 12 km from the boundary of the Killarney National Park SPA, which has been the core area for the eagle Reintroduction Programme.

Breeding Potential

The Grousemount site does not contain suitable breeding habitat for eagles and this is acknowledged in the Department's submission (pg. 2, para. 6) to An Bord Pleanála (dated 2 November 2015). This is of prime significance as it means that there is no potential for breeding within or around the site during the lifetime of the wind farm. In its submission (dated 2 February 2010) in relation to the then proposed Barnastooka Wind Farm (Planning Ref. 10/0197) the Golden Eagle Trust noted as follows (see Appendix A hereto):

> *"We do not believe that the proposed wind farm site, in this application, will be a future breeding area for White-tailed Sea Eagles. Adult White-tailed Sea Eagles nest within five kilometres of large waterbodies with a good source of fish, which makes up 80-90% of the diet of Sea Eagle nestlings (Halley et al. 2006; Helander & Stjernberg 2003)."*

The above of course is still the case. The Grousemount site is not within 5 km of any such large waterbodies and it would appear that the nearest possible breeding site is Lough Guitane, which is approximately 12 km to the north-northwest of the Grousemount site.

Feeding Potential

Grousemount Wind Farm site (and its surrounding area) contains no water bodies to attract feeding eagles.

The well documented presence of immature eagles in the Barnastooka area from December 2009 into early 2010 was due to the presence of animal carcasses dumped near Lough Nabuddoga (just over 1 km north of wind farm). In its submission (dated 2 February 2010) in relation to the then proposed Barnastooka Wind Farm (Planning Ref. 10/0197) the Golden Eagle Trust noted as follows (see Appendix A hereto):

> *"The proposed wind farm site at Barnastooka has been used by immature White-tailed Sea Eagles recently. This wind farm lies eight km southeast of the boundary of, what appears to be, a key foraging area for immature White-tailed Sea Eagles.......*
>
> *Eagles have consistently used the Mangerton area from October 2008 where they have found good foraging areas and suitable overnight roost sites. The Golden Eagle Trust believes that the White-tailed Sea Eagles only began to use the Barnastooka upland area initially due to the concentration of dead livestock at one location on a regular basis. We believe that if the concentration of dead livestock ceased, there would be no other dietary attraction to entice White-tailed Sea Eagles onto the proposed wind farm site. As a result, the source of this recent attraction would cease."*

Since 2010, there have been no known further instances of White-tailed Sea Eagles feeding on dead livestock in the vicinity of Barnastooka or Grousemount.

Roosting Potential

Grousemount Wind Farm site does not contain suitable mature trees to support roosting White-tailed Sea Eagles. In its submission (dated 2 February 2010) in relation to the then proposed Barnastooka Wind Farm (Planning Ref. 10/0197) the Golden Eagle Trust noted as follows (see Appendix A hereto):

> *"Because some White-tailed Sea Eagles have been foraging nearby in an area of grassland and heather during the day, they have tended to settle, perch and roost at night time at two particular areas, within 3 and 7 kilometres respectively, of the proposed wind farm. The proposed wind farm itself does not hold any potential sites for birds to perch on (either on mature trees or cliff ledges) and roost overnight (A. Mee pers. obs.). The roost sites of immature, non-breeding White-tailed Sea Eagles is closely linked to local food availability and availability of undisturbed roosting sites."*

The above is still the situation regarding the roosting of White-tailed Sea Eagles and there are no known reported instances of eagles roosting in the vicinity of Barnastooka or Grousemount since 2009 / 2010.

2.2.3 Potential Collision

The basis for the recommendation by the Department that the application is premature and should be refused permission lies largely in the fact that there were three collisions between White-tailed Sea Eagles and turbines at nearby operational wind farms in 2011 and 2012, and hence, according to the Department, collisions can be expected at the Grousemount development site.

As details for two of these collisions were not readily available on the internet or elsewhere, details of all three collisions have been obtained from Dr Allan Mee (Golden Eagle Trust - allanmee@goldeneagle.ie, in e-mail to B. Madden on 29th January 2016, see below).

In the same e-mail, Dr Mee confirms that there have been no further known eagle fatalities in Ireland from collision with turbines since 2012.

Hi Brian,

Yes three collisions, two in 2011 and one in 2012, the first one at Sillahertane and the other two at Kilgarvan windfarm (Lettercannon):

bird ID	BTO	sex	release year	recovery date
N	ZZ1670	female	2008	09/03/2011
7	ZZ1664	female	2007	01/06/2011
•5	ZY1650	female	2011	07/06/2012

There have been no known collisions since in Ireland.

Hope that's the info you need.

Allan

Sillahertane Wind Farm (10 turbines) is located immediately to the east of the Grousemount site and is within conifer forest plantation. Lettercannon Wind Farm (7 turbines) is located approximately 3 km to the north and is on open bog and heath habitat.

While the applicant fully recognises the seriousness of the three fatalities as a result of collision, the following points are made in relation to the potential for collision:

Period in Which Collisions Occurred

The three collisions occurred between March 2011 and June 2012. At that stage of the Reintroduction Programme, the released eagles were still centred in the Killarney region, with immature birds roosting regularly in the Mangerton Mountain area. Since then, the population has been in the dispersal phase of the programme (as was predicted), with breeding territories being established in several counties. By 2016-2017, all of the released eagles will have reached maturity.

As reported by the Golden Eagle Trust, wandering birds liable to visit any part of the island of Ireland, as well as Scotland).

With a changing situation since the 2011/12 period, fewer eagles can now be expected in the Grousemount area than previously (and this is borne out by the results of the winter surveys in 2014/15 and 2015/16) and hence the potential for collision with turbines in the locality of the Grousemount development is reduced. Of particular relevance is that all of the eagles are now adult (apart from future offspring of the released birds) and will be associating with breeding territories. The nearest suitable breeding sites to Grousemount are the Killarney lakes, Lough Guitane and the Kenmare inlet (all greater than 10 km distance from Grousemount).

Impacts of Wind Farms on White-tailed Sea Eagle Populations

While NPWS refers to large losses of White-tailed Sea Eagles at the Smøla Wind Farm in Norway (Dahl et al. 2011), it is important to note that the Norwegian example is not directly comparable to the situation at Grousemount and, indeed, has no known parallels elsewhere.

The Smøla Wind Farm is located along the coast of central Norway on a large island where Norway's densest population of sea eagles occurs. It is in a flat and open landscape at 10 - 40 metres above sea level. The wind farm comprises 68 turbines over an area of almost 18 km². Smøla holds a large and dense breeding population of White-tailed Sea Eagles, with approximately 60 territories present in the archipelago (May *et al*. 2010, Dahl *et al*. 2011). Research regarding deceased adult sea eagles has shown that one-third of recorded fatalities were as a result of collision with the rotor blades of a wind turbine. Between 2005 and 2010, 39 eagles were found killed by turbines.

It was observed that eagles did not significantly change their flight behaviour when inside the wind farm, possibly explaining the relatively high collision fatality. A before-construction and after-construction study found that territories within 500 m from the turbines in the post-construction period experienced significantly lower breeding success than the same territories before construction (Dahl *et al.* 2011). However, the study found that the effect dropped considerably by 1 km. The study recommended that avoiding central breeding areas for species such as White-tailed Sea Eagle is crucial when locating wind farms. (It is noted that the wider population around Smøla as a whole has remained stable, despite the fatalities.)

In Scotland, White-tailed Sea Eagles have been re-introduced in several phases over a 40 year period since 1975. By 2010, at least 52 pairs bred and fledged 46 young along the west coast (Balmer *et al.* 2013). While the breeding success in Scotland was initially low, it has increased as individuals gained experience and more wild-reared birds entered the population. By 2015, there were about 100 pairs. The first known White-tailed Sea Eagle fatality in Scotland attributed to a wind farm was as recently as February 2014 (see www.rspb.org.uk & widely publicised in media after first reported in Sunday Herald, 25 May 2014). Of the reported 21 deaths of White-tailed Sea Eagle in Scotland from the east coast release programme since 2007, 8 died at power lines (most, if not all, due to electrocution at power poles), 6 through being hit by trains, 6 through poisoning or shooting incidents and 1 through collision with a wind turbine. Despite the hundreds of birds in the west coast population, to date there has been no reported collision with a wind turbine.

From the above review, it can be reasonably argued that the situation of White-tailed Sea Eagles and wind farms in Ireland is more similar to that in Scotland rather than to Smøla in Norway (where a large wind farm is located within a dense breeding population of eagles).

2.3 Mitigation

The Department's submission to An Bord Pleanála (dated 2 November 2015) notes the mitigation recommended in the EIS in respect of the programme to remove carcases from the site as these can attract feeding eagles. The Department also writes *"But if carcases are not involved, then no further measures are proposed".* To address this concern, the following measures, which have been developed following consultation with an internationally recognised expert in this field, are proposed (in addition to the measures in the EIS):

2.3.1 Employment of a Project Ecologist

A Project Ecologist will be employed and the associated principal tasks will be as follows:

- Report annually to the relevant stakeholders including NPWS, the White-tailed Sea Eagle Reintroduction Programme, the applicant and any other participants deemed necessary by the Department.
- Ensure, by regular checks, that no carrion is present within the wind farm site that could possibly serve as an attractant for feeding White-tailed Sea Eagles. Because dead sheep are likely to be the main source of carrion, effort will be concentrated during times when such death is most likely, i.e. seasonally and climatically. (It is noted that, for practical reasons, the landowners' lambing practice is that this takes place in controlled conditions close to the farmsteads rather than at dispersed locations. This ensures that there is no prospect of any afterbirth, still-born lambs, or congenitally weakened young lambs being available as a potential food source for eagles.)
- Detect any regular or temporally frequent use of the site by White-tailed Sea Eagles, with a view to avoiding any unanticipated risk of a strike with turbine blades. To this end, the Ecologist will be responsible for regular systematic visual monitoring of use of the site by birds, with a focus on White-tailed Sea Eagle. This would be an extension of the recommended monitoring programme for breeding birds (as described in the EIS) to the winter period, where the focus would be on White-tailed Sea Eagle. The monitoring programme would be agreed with NPWS and/or the White-tailed Sea Eagle Reintroduction Programme prior to the commencement of turbine erection works.

2.3.2 GSM/GPS Tagging

It is proposed that visual monitoring of use of the site by White-tailed Sea Eagles will be supplemented and enhanced by a programme of remote monitoring of those birds considered to be potentially most likely to use the site, i.e. birds fledged from the nearest nest sites. As described earlier, now that the release programme has finished and that the Killarney National Park is no longer the locus for a large number of young eagles, the birds most likely to access the wind farm site are young birds that have dispersed from the closest nest sites.

Funds for 10 GSM/GPS ‘satellite’ tags, e.g. Microwave Technology 70 g GSM/GPS tags, including download costs (assuming each tag will last four years), will be transferred to the Reintroduction Programme prior to commencement of the wind farm’s operation. Responsibility for the tagging of birds would be handed to the Reintroduction Programme because: a) its staff has the necessary skills and licences for tagging; b) nestlings would be handled for more conventional marking by the Programme anyway; and c) it would prevent any duplication of effort and any undue disturbance of the birds.

Typically, these tags will provide accurate data on numerous locations per day, including when birds are in flight. With effective monitoring of several birds’ locations and movements “24/7”, availability of daily records will allow the relatively rapid detection of any regular use of the wind farm site by several ‘local’ birds and enable the Operations & Maintenance (O&M) Site Manager to focus visual observational efforts (and investigating any possible cause of regular use) before any activity builds to a level where collision risk becomes unacceptable.

2.3.3 Turbine Shut-down System

The O&M Site Manager will be responsible for managing and implementing a potential turbine shut-down system, which will be informed by the following:

- Visual monitoring of the site.
- Any sightings and information from third parties, notably the Reintroduction Programme (Golden Eagle Trust).
- The GSM/GPS tagging of those individuals that are more likely to use the site.

Based on these information sources, thresholds and a protocol for instigating a shut-down (turbine numbers, locations and stop duration) will be agreed with NPWS and/or the White-tailed Sea Eagle Reintroduction Programme prior to the commencement of turbine erection works on the site.

The applicant has considered and rejected the deployment of a remote / mechanised shut-down system using devices such as DTBird, for several reasons.

- Such devices in isolation cannot cover more than a small number of turbines and full coverage of the wind farm site would require a large number of devices. This would not provide the necessary reassurances that all parts of the wind farm would be routinely monitored.
- Their reliability is not especially noteworthy, if they are the sole mechanism employed. DTBird was tested at Smøla Wind Farm by the Norwegian Institute for Nature research (NINA) on White-tailed Sea Eagles and the NINA report was not especially complimentary. It is interesting to note that the further testing of DTBird suggested by NINA was not taken up by the manufacturer.
- Studies to date of turbine shut-down systems that have documented their success in scientifically robust outputs, e.g. southern Portugal, Tarifa in southern Spain, have deployed observers, and not remote technology.

Moreover, the use of a GSM/GPS tagging, as proposed, will bring benefits additional to assisting in the detection of any regular use of the wind farm site, which as described above is considered unlikely. The applicant recognises the importance of the reintroduction of White-tailed Sea, and funding for GSM/GPS tagging to document in detail the movements and fate of several young birds that are important for the success of the Programme will benefit the Programme over and above the tags' use in detecting any potential regular use of the Grousemount site by these birds. An automated shut-down system, using for example DTBird, as well as having the problems noted above, would not provide such a benefit to the Programme.

2.3.4 Review of Measures

It is proposed that the above measures would be applied initially for the first five years of operation. However, several tagged birds would still be providing data for years beyond this initial period and the applicant would have funded this data provision. Regular annual reviews of the mitigation measures will be undertaken with the relevant stakeholders, with the meeting after five years to consider if these, or other measures, would be necessary for continuation afterwards based on the results of the monitoring.

2.4 Conclusion on Submission by NPWS

In conclusion, it appears that the recommendation by NPWS for refusal of Grousemount Wind Farm project is based on the precautionary principle, simply because the site is within the wider range of the area used by White-tailed Sea Eagles (which as stated by NPWS extends from Killarney to Kenmare and east to the Lee Valley) and that there were collisions with turbines at nearby wind farms in the 2011-12 period.

The applicant considers that the proposed development at Grousemount would not pose a significant risk to eagles or to the success of the Reintroduction Programme, for the following main reasons (as discussed above):

- The Grousemount site is at the distance of 12 km from Killarney National Park SPA (where the release programme is focused) and is at least 10 km from a suitable breeding location.
- The Grousemount site does not have any physical potential as a breeding or roost site for eagles and has negligible potential as a feeding site (unless carrion is available). As noted in the EIS, and as confirmed and strengthened here, focussed efforts will be put in place to ensure no carrion is present.
- The Reintroduction Programme has advanced to the phase where no further releases of White-tailed Sea Eagle are planned in County Kerry. Further to this, all released birds are now approaching maturity and many have undertaken long-term dispersal from the Killarney area to establish breeding territories elsewhere in Kerry and in counties that include Cork, Clare and Galway. Eagles have also been reported from Northern Ireland and at least one released bird has travelled to Scotland. The scarcity of eagles in the Grousemount area has been demonstrated by the surveys carried out for the project in winters 2014/15 and 2015/16.
- While the three collisions at nearby wind farms were highly regrettable, it is noted that there have been no further collisions between eagles and turbines anywhere in Ireland since these in 2011/12, a period during which installed wind energy generating capacity in Ireland grew by almost 50%. It is noted also that the relatively high number of collisions at the Smøla site in Norway (as referred to by NPWS) is not comparable with the situation at Grousemount, as Smøla Wind Farm

is within an area with a dense population of breeding eagles (c.60 nesting pairs). It is noted further that only one collision (again regrettable) has been reported to date from Scotland, where there is now a high population of breeding White-tailed Sea Eagles and where the situation of White-tailed Sea Eagles and wind farms is more similar to that in Ireland.

- Mitigation, which will be co-ordinated by a Project Ecologist, will be focused on minimising the potential for eagles to be attracted to the site by the regular search for, and removal of, carrion.
- The applicant is committed to bird monitoring in the post-construction period. Visual monitoring of any use of the site by White-tailed Sea Eagle will be supplemented and enhanced by a programme of remote monitoring using GSM/GPS tagging. In the event that an eagle(s) is recorded in the area of the wind farm, turbines can be switched off in accordance with the method agreed with NPWS and/or the White-tailed Sea Eagle Reintroduction Programme until the bird(s) passes on from the area.

Finally, it is acknowledged that the Department's consideration of the proposal on the basis of being a *de novo* development is the correct approach. However, it must also be acknowledged that, being a revision and amalgamation of two existing planning permissions on the site with an equal number and size of wind turbines, the proposal will not increase the overall number of consented wind turbines in the Roughty River valley. As such, an increased risk to White-tailed Sea Eagle, which is the basis of the Department's precautionary approach, cannot actually arise.

2.5 References Cited

BirdLife International (2015) Review and guidance on use of "shut-down-on-demand" for wind turbines to conserve migrating soaring birds in the Rift Valley/Red Sea Flyway. Regional Flyway Facility. Amman, Jordan.

Balmer, D.E. et al. (2013) Bird Atlas 2007-2011, the breeding and wintering birds of Britain and Ireland. BTO Thetford.

Dahl, E.J. et al. (2011) Reduced breeding success in white-tailed eagles at Smøla windfarm, western Norway, is caused by mortality and displacement. *Biological Conservation* 2011.

May, R. et al. (2010) Collision risk in white-tailed eagles. Modelling collision risk using vantage point observations in Smøla wind-power plant. NINA Report 639. 25 pp.

Mee, A. et al. (2014) Irish White-tailed Sea Eagle Reintroduction Programme Report 2014.

3 Temporary Bridge - Sullane River at Ballyvourney

This includes part of the grid connection route and Delivery Route Option 1 which requires a temporary bridge over the Sullane River at Ballyvourney and local road improvements.

Please provide further details in relation to potential impacts on habitats, protected species (including bats) and flooding as a result of the temporary bridge and road improvement works. The Flood Risk assessment should be undertaken in accordance with the Department of the Environment, Heritage and Local Government document titled "The Planning System and Flood Risk Management – Guidelines for Planning Authorities" (November 2009).

Response

3.1 Bridge Details

The temporary bridge with a span of a approximately 27 m will cross the Sullane River upstream of the existing bridge. The chosen location provides for the shortest required span of 9 m, thereby maximising the set back of the bridge abutments from the river bank to approximately 9 m on either side.

Temporary site entrances will be formed at the N22 and the L3400, and a 5 m wide unsurfaced access track will be constructed to the bridge location

The bridge will comprise a single span simply supported steel structure that entails no in-stream works. It will be leased from a specialist bridge supply company offering a full erection and dismantling service to ensure that it is built and taken down quickly, with all activities complying with applicable quality, health, safety and environmental standards.

It will be a pre-engineered modular steel bridge system designed for delivery by standard road-going vehicles. A number of bridge units will be delivered to the northern bank of the river and will be bolted together to form a single span bridge deck. Following assembly, will be lifted and placed into position using a mobile crane, once abutment construction is complete.

It is expected that deliveries of turbines to Grousemount Wind Farm will be completed over a period of approximately 9 months. When deliveries are completed, the specialist bridge supplier will return to site and the temporary bridge will be removed.

3.2 Description of Habitats

A Habitat Map is presented as Appendix B hereto.

Leading from the N22, the temporary track will require the removal of a section of the roadside bank along the south side of the road (see Figure 3.1). The bank drops steeply up to 4 m to the adjoining field. There is a treeline (WL2) of tall beech trees and one large ash tree on the bank. It is estimated that up to nine of the trees will need to be removed. The scrub or hedge layer along the bank is dominated by beech (maintained to hedge height) and holly.

A stone culvert runs beneath the road and flows into a narrow drainage channel (FW4) which runs east along the base of the bank (see Figure 3.2). A dipper was present just below the culvert – it is possible (though probably unlikely) that a nest site may exist in a crevice within stonework associated with the culvert.

The temporary road then runs south through a field of improved grassland (GA1). A disused mill race channel flows through the field (see Figure 3.3) and will be crossed by use of a culvert. The mill race can best be classified as a drainage ditch (FW4).

3.2.1 River Crossing

The bridge will cross the Sullane River at a natural bend with steep banks on both sides (see Figure 3.4).

- **North Bank of River:** At the proposed bridge crossing point, the river bank is marked by exposed bedrock and loose rocks and stones. There are several ash trees overhanging the river here and one or possibly two will need to be removed to accommodate the bridge. These are of low to moderate size (<10 m high). There is also some scrubby blackthorn at the location.
- **South Bank of River**: At the proposed bridge crossing point, the river bank is lined by ash, sycamore, alder and willow trees. It is estimated that one multi-stemmed ash tree (c.6 m high) and possibly one tall ash (>10 m) will need to be removed to accommodate the bridge.

  Note re. Trees along River: Much of the Sullane River between Ballyvourney and Coolea is lined by trees such as ash, willows, alder and sycamore. In places, the trees broaden into patches of woodland, which could be described as Riparian woodland (WN5). At the proposed temporary bridge crossing, there is a more or less continuous single line of trees along each side of the river. While these riparian strips can loosely be classified as riparian woodland (WN5), they are not strictly woodland because of absence of width, structure and layers.

  The track then runs in a southwest direction through a further field of improved grassland and merges with the local road (see Figure 3.5). A section of low hedge (WL1) on a bank will be removed to accommodate the works. The hedge comprises one small ash tree and some scrubby willow. The understorey and ground layer is dominated by brambles, bracken, ivy and some ferns.

3.2.2 Potential Impacts on Habitats

Trees and Hedging

The development will require the removal of part of the treeline along the N22, a section of hedge along the local road and some trees from the riparian strips along the banks of the river.

The sections of treeline and hedge will be replanted using the same species as currently present when the temporary access is decommissioned. On this basis, and taking into account that the tree species within the treeline is non-native beech (other than one ash), the ecological significance of this impact is negligible to minor.

Several trees along the river banks will be cut to base to facilitate the placement of the temporary bridge. The trees are ash and willow. It is proposed that the when the bridge is removed, an inspection will be carried out by an ecologist to determine the amount of replanting required along the banks, as it is expected that the willows will regenerate naturally. The ecological significance of this impact is rated as negligible to minor in the context of the river system.

Grassland

The access leading to and from the bridge will traverse fields of improved grassland. As this is a widespread habitat and not of conservation interest, the placement of the access here is not of significance.

River

There will be no direct impacts on the Sullane River channel by the placement of the temporary bridge. Of particular note is that there will be no instream works and that the river banks will not be interfered with (other than cutting of trees to base as already discussed). It is not expected that the presence of the bridge over the river channel for a period of approximately 9 months would have any adverse effects on the ecology of the river.

Drainage Channels

The drainage channel alongside the N22 and the Mill Race channel will need to be culverted to facilitate the road construction. These are minor ecological features and the loss of short sections is not considered an impact of significance.

3.3 Protected Species

Otter

The Sullane River provides optimum habitat for otter and the species is expected to be widespread along the river and its tributaries.

From survey in February 2016, there was no evidence of otter breeding sites (holts) or resting places at the location of the temporary bridge or for at least a 50 m distance upstream and downstream.

The presence of the temporary bridge will not restrict the movement of otters along the river channel or its banks. Disturbance to otters by vehicles passing over the bridge would not be significant as (i) vehicle usage will be infrequent, and (ii) otters readily pass below bridges on public roads.

Bats

Only one tree (a tall ash in treeline along N22) has good potential for roosting bats as this large tree has substantial ivy cover. The riparian strips along the river are mostly willows and ash of low to moderate height and would not be expected to support roosting bats.

As a precautionary measure, all of the mature trees to be felled within the treeline along the N22 will be surveyed for bat presence by a suitably experienced specialist. This will be done in the period April to October when bats are active. If bats are found, an application for a derogation licence will be made to the National Parks and Wildlife Service to allow its legal removal. Such trees should ideally be felled in the period late August to late-October, or early-November, in order to avoid disturbance of any roosting bats as per National Roads Authority guidelines (NRA 2006a and 2006b). Tree felling should be completed by mid-November at the latest as bats roosting in trees are very vulnerable to disturbance during their hibernation period (November – April). Trees with ivy *Hedera helix* cover, once felled, will be left intact on-site for 24 hours prior to disposal to allow any bats beneath foliage to escape overnight.

While bats will roost in stone culverts, Mr Conor Kelleher (bat expert) considered that as the culvert here is very low off the ground the chances of it being used by bats are minimal, as they would be prone to predation by rats, stoats etc. Nevertheless, the culvert will be checked for bat presence at the time when the survey for bat presence in trees is being carried out.

Birds

While the Sullane River has potential to support kingfisher (listed on Annex I of the Birds Directive), there were no sightings of this species during the various ecological surveys for the wind farm and grid connection route. From survey in February 2016, it is considered that the section of river at the location for the temporary bridge does not have suitable banks for nesting kingfisher.

Dipper, a further specialised riparian species, does occur along this section of the Sullane River. This species often nests beneath bridges or in crevices in river banks (such as among base of trees). There is some potential that nesting could occur along the river at the location of the temporary bridge. Additionally, as already noted, a bird was observed in February 2016 at the stone culvert beneath the N2 road. While it is possible that a nest site could occur within stonework associated with the culvert, this is probably unlikely and the bird observed was more likely just feeding or bathing in the spray from the pouring water. Should works be planned to commence at the river during the nesting season, a pre-construction survey will be carried out for signs of nesting dippers as well as grey wagtails (latter Red listed). Should either of these species be present, works will be delayed until nesting attempts are complete. The stonework at the culvert will also be checked for nesting dippers.

To protect breeding birds of treelines and hedgerows, removal of the treeline along the N22, the riparian strips along the river banks, and the section of hedge along the local road will take place outside of the nesting season (March-August).

Conclusion on Impacts on Protected Species

With the use of mitigation measures as necessary (as described and following pre-construction surveys), it can be concluded that the temporary bridge and associated access works will not have significant adverse impacts on protected species which may occur in the area of the works.

3.4 Flooding

A Flood Risk Assessment, in accordance with *"The Planning System and Flood Risk Management - Guidelines for Planning Authorities"* issued by the Department of Environment, Heritage and Local Government in November 2009, was prepared to assess flood risk from fluvial, surface water and ground water sources. The following Report is submitted separately:

- Report: Temporary Bridge at Ballyvourney, Flood Risk Assessment, March 2016.

This Flood Risk Assessment addresses the proposed installation of the temporary bridge traversing the Sullane River close to Ballyvourney village in Co. Cork. The bridge will comprise a single span structure of rapid build modular construction sitting on abutments of reinforced concrete at either end of the span. The access track either side of the bridge will be raised by approximately 2 m above existing ground level close to the bridge abutments before gradually returning to the existing ground level further away from the river. The bridge is to be located approximately 250 m upstream of Ballyvourney Town Bridge at the grid reference E519300 N577600 (ITM) and will require the creation of a temporary entrance from the N22 and from the L3400 (both to the west of Ballyvourney village).

The Conclusion of the Report is as follows:

Model results, which have been validated by hand calculations from first principles, indicate water levels and velocities in the vicinity of the study area will not be affected by the bridge and access road. The 1% AEP flood level is predicted to be more than 300 mm below the soffit level of the proposed temporary bridge placing it in Flood Zone B, in accordance with the Section 50 hydraulic design standard specified by the OPW and the Planning Guidelines. A section of the private access track is projected to be inundated, albeit to a low level (approximately 0.06 m), in the design flood event. It is reasoned that as the development is temporary and will have its use limited to transport vehicles engaged in delivery of wind turbines, such a risk to the site is acceptable if it reduces the potential impact on the existing hydraulic regime in the area.

It is therefore concluded that any risk to the proposed development will be minimal and restricted to a section of the access track which is at the existing ground level in the floodplain. The proposed development is predicted not to have any deleterious effects on the hydraulic characteristics of the river and adjoining floodplain.

Figure 3.1: View of section of N22 (looking west) from where the access will lead off. The treeline here is of tall beech and one ash (tree with ivy cover).

Figure 3.2: View of stone culvert in bank below N22. This will be covered by the proposed works.

Figure 3.3: View of mill race in field (looking west) where new access will pass. A section of the channel will be culverted.

Figure 3.4: View looking west at bend in river where temporary bridge will be placed. A small number of trees will be removed from each of the banks.

Figure 3.5: View (looking west). of the L3400 local road where the new access will join. A section of hedgerow will be removed. This is mainly willow with one small ash.

4 Kerry Slug

The EIS (p 9.6) concludes that a survey for this Annex II species along the cable route is not necessary and the NPWS is concerned that this conclusion was based on a broad habitat classification, rather than a microhabitat description. Suitable Kerry slug habitat may exist in lichen-covered rocks in heathland and grassland, and under the woodland canopy in the Cascade Wood area and along wooded road sides. It is not clear if the footprint of the works will involve some clearance of the road margin (a cut into roadside banks may be necessary, according to Screening for Appropriate Assessment report).

If this is the case please provide a detailed survey (undertaken during suitable weather conditions) to examine for:

i. Suitable microhabitats along the cable route, delivery route (both options) in the event that road widening is required, and internal access tracks.

ii. Kerry slugs within suitable habitats for this species.

The Kerry Slug survey (EIS Appendix F.5) reports the presence of this species within the windfarm site and that a derogation licence will be sought before works commence. The NPWS states that this licence should be obtained prior to a decision to grant planning permission.

Please comment in detail on this issue.

Response

The reference by the NPWS to the Screening for Appropriate Asssessment report is within the section describing impacts within the Mullaghanish to Musheramore Mountains SPA. The banks here are predominantly grassy and would have negligible potential for harbouring Kerry Slugs.

Within the section of the route which passes through the St. Gobnet's Wood SAC, the cable will be entirely within the public road. The single joint bay (no 18) here is within the road margin and does not extend into the adjoining woods (where Kerry Slug could be expected), although some marginal vegetation will need to be cleared.

To allay the concerns expressed by the Department, a further survey for Kerry Slug was undertaken at the locations of all the joint bays along the route of the UGC and at locations where road improvement works are proposed. The following Report is presented as Appendix C hereto:

- Grid Connection Route and Road Improvements, Kerry Slug Surveys, Wetland Surveys Ireland, March 2016

The Discussion and Recommendations of the Report are as follows:

> *Results from the current survey confirm the presence of Kerry Slug at two locations where road improvement works are proposed. The presence of suitable Kerry Slug habitat was confirmed directly adjacent to the roadside at five joint bay locations along the UGC route, although Kerry Slug were not confirmed at any of these locations following nocturnal searches.*
>
> *The development of the UGC and road improvements may potentially cause direct disturbance of small areas of Kerry Slug habitat as identified during the current*

survey. This habitat disturbance will be restricted to roadsides and will have a negligible effect on the overall distribution of Kerry Slug habitat in the area based on the extensive distribution of similar habitats throughout the wider study area. This potential impact is therefore is deemed to be negligible adverse impact. During construction, works could potentially result in the death of individual Kerry Slugs due to machinery movements and or excavations in areas of suitable habitat.

The following measures are recommended to minimise the above potential impacts on the local Kerry Slug population:

- *Immediately prior to undertaking works in areas of suitable habitat, the project ecologist will check for the presence of Kerry Slug. Should slugs be discovered then they will be transferred to suitable habitat in the surroundings.*
- *Due to the unavoidable disturbance to Kerry Slug habitat, a derogation license will be sought from the NPWS prior to the commencement of construction. Works will be carried out in compliance with any conditions set by such the license.*

While the applicant is of the opinion that seeking a a derogation licence is premature in the absence of a planning permission and knowledge of conditions applying to such a planning permission, an application to the Wildlife Licensing Unit, National Parks and Wildlife Service, Department of Arts, Heritage and the Gaeltacht for a licance was made by Wetland Surveys Ireland Ltd. on 14th March 2016 (see Appendix D hereto).

5 Roughty River pNHA & Endemic Hawkweeds

There is a considerable road network proposed for the wind farm. The potential effects of increased cumulative surface water runoff, and higher consequential hydrographic peaks on the winter flood zone habitat of the endemic Kerry hawkweed, Scully's hawkweed and Killarney hawkweed should be quantatively assessed, taking account of predicted increases in summer rainfall as a result of climate change.

It is not clear from the EIS (p. 9.37) whether;

a. *Shading from proposed bridges would affect the population (i.e. no semi-quantitative prediction of plants affected), and*

b. *Habitat management could increase potential sites for this species elsewhere on the river (as opposed to preservation in seed banks), given the likelihood that the plants recolonise sites as part of their metapopulation dynamics.*

Please comment in detail on this issue and provide the results of any other relevant peer reviewed scientific studies undertaken in relation to these species.

Response

Surface Water Run-off: A detailed assessment of changes in surface water run-off volumes was undertaken by Hydro-Environmental Services and was presented in the EIS (p. 15.13 & 15.14), where the following was stated:

> *The covering of the development footprint with impermeable materials, which is a worst case scenario that will not be the case in reality [as hardstanding will have some permeability] , could result in an increase in average total site surface water runoff of 3,638 m³/month for the month of highest average recorded rainfall (an increase of 0.14% over the baseline condition). This equates to an average increase of 117 m³/day (Table 15.11). This is a very small increase and results from a small area of the site being developed, the proposed development footprint being approximately 38ha, representing 2.6% of the total site area of 1,465 ha. The additional volume in all sub-catchments is low due to the fact that the runoff potential from the site is naturally high (95%). Additionally, the calculation conservatively assumes that all hardstanding areas will be impermeable (i.e. has 100% runoff). This in reality will not be the case, since almost all hardstanding areas will be permeable to some extent. Therefore, the actual increase in runoff will be negligible.*

Flow duration data for the Roughty River, which is derived from EPA Hydro Tool, is as follows:

%ile	Flow (m³/s)	Upper 95% Confidence Limit	Lower 95% Confidence Limit
5	10.750	14.073	8.226
10	7.392	9.314	5.867
20	4.156	5.136	3.362
30	2.550	3.178	2.047
40	1.601	2.013	1.274

%ile	Flow (m^3/s)	Upper 95% Confidence Limit	Lower 95% Confidence Limit
50	1.056	1.323	0.843
60	0.728	0.926	0.572
70	0.490	0.641	0.375
80	0.333	0.444	0.249
90	0.206	0.292	0.146
95	0.149	0.223	0.999

The estimated 5%ile flow would be considered to be a high flood flow, but is still likely to be less than a peak winter flood flow. Therefore, comparing the potential increase in site runoff to the 5%ile flow is considered to represent a conservative comparison.

The potential average increase in runoff from the site due to the development (117 m^3/day - 0.00135 m^3/s) is equivalent to only 0.012% of the Roughty River's 5%ile flow of 10.7 m^3/s. This increase is negligible. Even if the estimated increase in runoff was factored by ten, it would still be negligible (0.12%) relative to the 5%ile flow. The potential increase in site runoff would have negligible effects on the hydrographic peak of the winter floods.

The estimated increased site runoff rate of 117 m^3/day is for the wettest winter month. Assuming this runoff rate as a worst case scenario for summer (which would more than allow for increases due to climate change) and comparing it to the 95%ile flow of 0.149 m^3/s (which would be considered a low flow), it still only accounts for only 0.9% of the 95%ile low flow. Again, this is negligible.

The calculations, which take no account of the considerable attenuation within the wind farm drainage system at check dams, silt traps and settlement ponds, and of the fact that there will be no direct discharge to any watercourse (diffuse discharge to over ground vegetated areas is proposed), show quantatively that potentially increased runoff rates from the site will be negligible and that increases in winter or summer flood peaks will be imperceptible to none.

Hawkweed: As noted in the EIS (p. 9.12), two of the proposed new bridge structures (nos. 44 & 46) cross the Roughty River over stretches of river where the hawkweed (*Hieracium spp*.) species occur.

In the EIS, it is stated clerarly (p. 9.29) that the plants beneath the bridge decks (5 m wide) would be expected to be affected by shade. In respect of the number of plants potentially affected, it is estimated that at each bridge location not more than 10 individual plants would be present beneath the bridge deck. Of relevance is that the plants have a scattered distribution on bedrock and on large boulders in the river and do not occur at high densities in any one area (see Figures 5.1 & 5.2). It is noted that plants only partly shaded at the outer edges of the deck would probably survive.

The mitigation proposed in the EIS (p. 9.27), i.e. preservation in seed banks, is in line with the recommendation in Rich *et al*. (2008)[2]) (page 152), as follows:

> *"Additional ex situ collections of seeds or living plants would be valuable"*.

[2] Rich, TGC., Hodd, D.J., McCosh, EC, Mhic Daeid, A., McVeigh, J & M.B. Wyse Jackson. (2008) Conservation of Ireland's Biodiveristy: A survey and assessment of the current status of three Irish endemic Hawkweeds from Kerry, Hiercium argentatum, H. Scullyi & H Sparsifrons (Asteracea). *Biology and Environment: Proceedings of the Royal Irish Academy* 108B: 143-155.

The surveyor of the hawkweed sites in July 2015 (Dr. John Conaghan) considers as follows:

(i) There appears to be no shortage of suitable habitat for the plants along the Roughty River both in the vicinity of the wind farm and further downstream.

(ii) Habitat management within the river would be difficult as it would require the importation of large boulders to provide a substrate for the plants. Such boulders might cover substrate used by fish and may alter the flow of the river (again possibly affecting fish movements etc.).

On this basis, and considering the existing natural state of the river, it is considered that the introduction of management to this river would be undesirable.

Figures 5.1 & 5.2: Views showing typical locations for the Hawkweeds (Hieracium spp.) on bedrock outcrops and boulders in the Roughty River, September 2015. The plants occur sparsely, though widely, along several kilometres of the river.

6 Sillahertane Bog NHA

The EIS (p. 9.35) refers to the proposed cable works area being physically close to the NHA, and to some of the turbine access tracks being within c. 10m of the NHA.

Please clarify if either of these works, which may act as drainage conduits, will have any effects on the hydrology of the NHA bog upslope, by, for instance, tapping preferential groundwater flows which could lead to greater upslope water loss during droughts.

Response

Rather than referring to some access tracks as being within c. 10 m of Sillahertane Bog NHA, the referenced part of the EIS (p. 9.35) states that there will be no track construction within 100 m of the NHA boundary and that the nearest turbines will be at a distance of at least 200 m.

The potential for hydrological impacts on Sillahertane Bog NHA was dealt with in Section 15.2.10 of the EIS (p. 15.19) where the following is stated:

> *Sillahertane Bog NHA, which borders a small section of the proposed development, is located in a separate sub-catchment immediately to the northeast. No wind farm development infrastructure will be located either up-gradient or down-gradient of it and there will be no impacts on the surface water hydrology of the NHA. Additionally, being in a separate sub-catchment, there is no groundwater flow from the development areas towards the NHA. There will be no hydrological impacts from potential alteration of groundwater flow paths.*

With no groundwater or surface water flow from the development into the NHA or from the NHA to the development site, there is no potential for the wind farm infrastructural works to affect the hydrology of the bog by tapping into preferential groundwater flows which could lead to greater upslope water loss within the bog. Based on topography, the inferred groundwater direction within Sillahertane Bog is in a north-westerly direction towards the streams further downslope within the NHA.

The element of the development with the greatest potential to impact on the hydrology of the NHA is the closest borrow pit (located north of the turbine T5). The distance from the borrow pit where pumped induced drawdown could potentially arise was estimated using the Sichart (1928) equation, as follows:

$$R = 3000.Sw.\sqrt{k} = 3000 \times 15 \times 0.001 = 45 \text{ m}$$

Where: R = radius of drawdown influence (m); Sw = water level drawdown in excavation (depth of 15 m is assumed); k = permeability (conservative k value of 1×10^{-6} m/s for low permeability rock, classified as a Poor Aquifer by the GSI).

The distance between the borrow pit and the NHA boundary (> 100 m) is a multiple of the calculated potential radius of water level drawdown influence and there will be no potential to impact on the NHA. The calculation presents a very conservative approach that does not allow for groundwater recharge from rainfall, which would reduce the radius of influence. The distance calculated above would represent a dry summer scenario and is very conservative.

The operation of the temporary borrow pits or other elements of the development will have no potential to impact on groundwater levels or flows within Sillahertane Bog NHA.

7 Otters

The EIS reports Otter signs near Droichead an Cheapach (Bohill River).

Please clarify whether otter breeding sites or potential resting places were observed within 50m either side of the road crossings (by cable) or where bridge upgrade is required.

The EIS (p 14.25-14.26) records the potential for significant effects with regard to geotechnical stability at turbines T22 and T38, both upslope of the Roughty River.

Please assess the potential effects of sedimentation due to peat slip erosion on breeding otter in the vicinity.

Response

7.1 Otter Breeding Sites and Resting Places

As described in the baseline assessment, otter is considered widespread on the main rivers and streams within the wind farm site and along the corridor for the underground cable. In the baseline assessment carried out for the EIS, the proposed crossings of the main channels of the Garrane, Bohill, Sullane and Roughty rivers were walked upstream and downstream of the impact location for search of otter presence, especially holts. Recent otter activity (spraints) was located only on the Bohill River.

In February 2016, all rivers and streams considered to have fish possibly present (no. 15) or certainly present (no. 8) (as identified in Figures 11.1 – 11.3 of the EIS) were assessed for otter breeding sites and/or resting places. Streams classified as having ‘no fish life’ or ‘fish very unlikely’ are considered unsuitable to support otters on a regular basis due to the absence or near absence of fish and to their small size (see Figure 7.3 for example), although otters may use these as corridors when moving across country.

At each of the 23 survey locations assessed in February, stretches of approximately 50 m upstream and downstream of the road crossing or bridge upgrade points were searched for signs of otter activity, e.g. holts, slides, spraints. Most of these watercourses provide suitable habitat for otters (see Figures 7.1 & 7.2). although there was no evidence of breeding or resting sites in the search areas. Spraints were notably scarce probably as a result of high water levels during January and early February. However, spraints (see Figure 7.4) were recorded at four locations, namely on the Sullane (Lunnagh Beg & Reanabobul) and the Roughty (Sillaherdane & new access track over main channel).

From the assessments for the EIS and additional survey in February 2016, it is concluded that while the larger rivers and streams in the study area provide suitable habitat for otters (as shown in some cases by presence of spraints), there was no evidence of otter breeding sites or resting sites within 50 m either side of the road crossings (by cable) or where bridge upgrade is required.

Nevertheless, as recommended in the mitigation section of the EIS, further survey is necessary prior to construction at watercourses which have potential for breeding otters. This will allow for discovery of new holts, which could be established by the time of construction, and also for holts which possibly were missed in the surveys to date (due to high water, difficulty of access in places etc.). Should otter holts be found at any location, mitigation would be undertaken as necessary (in compliance with the Wildlife Acts 1976 and 2000).

7.2 Potential Effects of Sedimentation on Breeding Otters

Section 10 of the EIS (Aquatic Ecology – Wind Farm) provided a thorough assessment of the potential impact of the wind farm project on the Roughty River and it tributaries, and specified detailed mitigation measures to protect water quality from sedimentation and other potential pollutants in respect of protected fish and other aquatic life (including freshwater pearl mussel). As fish and other aquatic life would be more sensitive than otter to the impacts of sedimentation, it is considered that the measures proposed here and in Section 15 (Hydrology, Hydrogeology & Water Quality) to control water pollution will also ensure that there are no adverse impacts on the local otter population.

Rather than recording the *"potential for significant effects regarding geotechnical stability"* at turbines T22 and T38, the EIS presented a Risk Level of Significant at these turbines. As outlined (p. 14.7), the risk level was determined based on the result of a risk rating, which is calculated by multiplying a likelihood score by an impact score. The four risk level categorisations applied derive from the Scottish Guidelines – Peat Landslide Hazard and Risk Assessment and they are used to determine the level of site investigation required. It is to be noted that the score in the risk rating or the associated risk level does not indicate the probability of a peat slip occurring.

As indicated in the EIS (Table 14.4), the actions required for the Significant categorisation of risk level are as follows: Targeted site investigation. Design of specific mitigation measures. Part-time supervision during construction. Project activity to date has been fully commensurate with the above.

The EIS concluded as follows regarding peat stability:

> *"Taking mitigation measures into account, it is concluded that Grousemount Wind Farm can be constructed safely from a geotechnical perspective and that the proposed development will not result in significant long-term adverse environmental impacts."*

Effects of sedimentation due to peat slip erosion on breeding otter in the vicinity of turbines T22 and T38 or any other turbine will not arise.

Figure 7.1: View of Bohill River which provides optimum habitat for otters. Spraints were recorded at this location during the assessment for the EIS.

Figure 7.2: View of river at Reanabobul – otter presence was confirmed on this river by the presence of spraints in February 2016.

Figure 7.3: Many of the river and stream crossings along the underground cable route would not support breeding otters due to their small size, though otters may use these as corridors when moving across country. Example shown is at Coomnagre in the Mullaghanish Mountains.

Figure 7.4: View of otter spraint on rock in the river at Reanabobul, February 2016.

8 Red Grouse

The proposed windfarm would be located in a remote heathland area which provides a valuable habitat for Red grouse.

Please assess the effects of opening up this access to access by humans, dogs and foxes via turbine access routes with regard to disturbance displacement and increased predation.

Please assess the potential for increased hooded crow use of the area, and increased predation of Red grouse nests by crows.

Response

While it is not planned that the general public will have unrestricted access to the wind farm lands, which will remain in private ownership following completion of the development, the presence of wind farm access tracks might facilitate the entry of more people into the area than at present. However, it is considered that the numbers involved would not be at such a level as to cause disturbance to wildlife and to Red grouse in particular. In any case, most visitors would restrict their access to the tracks within the site and, generally, would not be expected to walk across wet bog and heath areas where the grouse could occur.

As recorded in the EIS (p. 9.19), foxes are already widespread in this area and it is not understood how the wind farm access tracks, or the wind farm itself, would lead to an increase in the number of foxes.

As with fox, hooded crows are already widespread in the area (EIS p. 9.21), with birds often roosting in large numbers in nearby conifer forests. Again, it is not understood how the wind farm development would lead to an increase in the number of hooded crows in the area. In fact, the removal of carcases to discourage eagles (as proposed) would also remove a primary food sources for crows and foxes, and hence, may help to reduce predation by these species on Red grouse nests.

9 Inland Fisheries Ireland

IFI raised concerns in relation to the following matters and the project and / or mitigation measures should be amended accordingly (as appropriate):

a. *An immediate response to pollution from episodic and / or chronic low level sediment discharges sediment; the sampling regime should provide real time information on water quality and a suspended solids / turbidity analyser should be introduced to provide real time comparative results that can be relayed to supervisory personnel for immediate remedial action.*

Response: Attention is drawn to the monitoring regime outlined in the EIS (p. 10.42), where it is proposed that continuous automated online monitoring of suspended solids will be carried out at key locations agreed with NPWS & IFI.

b. *Pollution control measures are required to prevent sediment laden runoff from a section of the delivery route (L3021) that runs through a recently felled forest and several small streams also run through this section of the route, and this should be addressed in the Surface Water Management Plan.*

c. *Forestry mound drains and firebreaks can act as conduits for surface water runoff and should be redirected to sediment control facilities.*

Response: Whereas it is correctly stated that the forestry site at this location was clear felled in the recent past, the following is noted:

- The area of felled forestry has revegetated well since felling was completed.
- Disturbance will be limited to the construction corridor in which the access track will be installed, which is very limited in comparison with the extent of the felled area.
- As shown in the Habitat Map (EIS Figure 9.2), there is Improved Agricultural Grassland habitat between the former forestry area and the crossing of the Roughty River. (see), which effectively acts as a Leave Strip between the felled area and the watercourse.

As elsewhere within the site, the drainage infrastructure will be installed here at the commencement of operations, i.e. in advance of construction of the access track. It is recognised (EIS p. 10.34) that the specific means by which suspended solids in discharges to streams will be prevented from exceeding limits set is a matter of detailed engineering design. The applicant invites a grant of planning permission being conditioned with a requirement that the Surface Water Management Plan be subject to written approval by IFI prior to commencement of the development.

d. *Avoid the use of sedimentary rocks in road construction (shale) to prevent pollution due to fines washing out into roadside drainage (this is a major source of chronic pollution and difficult to control).*

Response: Attention is drawn to Section 14.1.3 of the EIS (p. 14.4), where the results of testing of rock samples from the borrow pits are discussed. In summary, results indicated that mechanical breakdown and sedimentation issues are not expected.

e. *Any full culverts required on fish bearing waters should ensure upstream passage of fish at all times, the culvert gradient should be less than 1/200 and oversized 500 mm to allow for countersinking into the stream bed.*

f. *The NRA Water Crossings on national toad scheme guidelines should be adopted as minimum criterion.*

g. *Culverts for field drainage channels and non-ecologically sensitive drainage systems should be oversized, countersunk by 500mm, backwatered and rock protected to prevent down cutting / erosion.*

Response: The applicant accepts the above recommendations and invites a grant of planning permission being conditioned with a requirement that they be implemented in full.

Implications of the RFI for the EIS and AA Screening Report

The following is stated In relation to the RFI:

Please note that the EIA and AA screening Report may need to be amended as a result of new survey results.

Response

During the preparation of this response, additional surveys were undertaken in relation to birds (White-tailed Sea Eagle), Kerry Slug and otter.

Whilst the results of these surveys have increased the baseline information available, they have not in any way changed any of the conclusions or findings of either the EIS or the AA Screening report. In that regard it is not considered necessary to amend either of these documents.

Conclusions

Site Suitability

Exhaustive geotechnical investigations have been carried out at the site and a full peat stability risk assessment (PSRA) has been undertaken. Taking mitigation measures into account, it was concluded that the proposed development can be constructed safely from a geotechnical perspective and that it will not result in significant long-term adverse environmental impacts. Further to the above, an independent peer review of the PSRA by appropriately experienced specialists confirmed that the approach adopted had used best industry practice in line with the recommendations of the guidelines from the Scottish Executive.

White-tailed Sea Eagle

The applicant fully recognises and accepts the high conservation value of the White-tailed Sea Eagle, the importance of its Reintroduction Programme and the sensitivity of the species where breeding territories and wind turbines co-exist. However, the applicant considers that the proposed development at Grousemount would not pose a significant risk to eagles for reasons associated with the site's location, its unsuitability for breeding, roosting or feeding, the status of the Reintroduction Programme whereby no further releases of birds are planned in County Kerry and many birds have undertaken long-term dispersal from the Killarney area to establish breeding territories elsewhere in Kerry and in counties that include Cork, Clare and Galway. Notwithstanding the conclusions in relation to collision risk, mitigation measures involving the employment of a Project Ecologist, GSM/GPS tagging as part of the further development of the White-tailed Sea Eagle Programme and potential turbine shutdown are proposed. Further to all of the above, the proposed development is a revision and amalgamation of two existing planning permissions on the site with an equal number and size of wind turbines. Thus, no increased risk to White-tailed Sea Eagle, which is the basis of the Department's precautionary approach, will actually arise.

Temporary Bridge – Sullane River at Ballyvourney

While the development will require the removal of some hedging and trees, the habitats in the area of the proposed works are not of high conservation value. It is concluded that the temporary bridge and associated access works will not have significant adverse impacts on protected species which may occur in the area of the works. A Flood Risk Assessment concluded that any risk to the proposed development will be minimal and the proposed development is predicted not to have any deleterious effects on the hydraulic characteristics of the river and adjoining floodplain.

Kerry Slug

The presence of Kerry Slug was confirmed at two locations where road improvement works are proposed. While searches failed to confirm the presence of Kerry Slug, suitable habitat was found directly adjacent to the roadside at a small number of joint bay locations along the UGC route. Whereas the works may potentially cause direct disturbance of small areas of Kerry Slug habitat, this will have a negligible effect on the overall distribution of such habitat in the area based on its extensive distribution throughout the wider study area. The potential impact is therefore is deemed to be a negligible adverse impact. Should slugs be discovered during checking for their presence Immediately prior to undertaking the works, they will be transferred to suitable habitat in the surroundings.

Roughty River pNHA & Endemic Hawkweeds

Calculations, which were undertaken on a highly conservative basis that took no account of a variety of mitigating factors that would further reduce the results, show quantatively that potentially increased runoff rates from the site will be negligible and that increases in winter or summer flood peaks will be imperceptible to none. The hawkweed plants beneath the bridge decks, each being 5 m wide with a presence not more than 10 individual plants, would be expected to be affected by shade. The mitigation proposed is in line with recommendations and, considering the existing natural state of the river, it is considered that the introduction of management to this river would be undesirable.

Sillahertane Bog NHA

There will be no track construction within 100 m of the NHA boundary and that the nearest turbines will be at a distance of at least 200 m. With no groundwater or surface water flow from the development into the NHA or from the NHA to the development site, there is no potential for the hydrology of the bog to be affected by the proposed development. The element of the proposal with the greatest potential for such impact is the closest borrow pit. However, its distance to the NHA boundary is a multiple of the calculated potential radius of water level drawdown influence of the borrow pit. The operation of the temporary borrow pits or other elements of the development will have no potential to impact on groundwater levels or flows within Sillahertane Bog NHA

Otters

Otter is considered widespread on the main rivers and streams within the wind farm site and along the corridor for the UGC. From the assessments undertaken, it is concluded that there was no evidence of otter breeding sites or resting sites within 50 m either side of the road crossings (by cable) or where bridge upgrade is required. Further survey is necessary prior to construction at watercourses having potential for breeding otters, to allow for discovery of new holts, which could be established by the time of construction, and for holts that possibly were missed in the surveys to date. Should otter holts be found at any location, mitigation would be undertaken as necessary. Further to this, it is considered that the measures proposed to control water pollution will ensure that there are no adverse impacts on the local otter population. Effects of sedimentation due to peat slip erosion on breeding otter in the vicinity of any other turbine will not arise.

Red Grouse

Iit is considered that the extent of any additional public access to the site that may arise following completion of the development would not be such as to cause disturbance to wildlife and to Red grouse in particular. Foxes and hooded crows are already widespread in this area and there is no basis for believing that the wind farm access tracks, or the wind farm itself, would lead to an increase in their numbers.

Inland Fisheries Ireland

Where the comments by IFI are not already addressed in the EIS, the applicant accepts the recommendations made and invites a grant of planning permission being conditioned with a requirement that they be implemented in full.

APPENDIX A

Planning Submission from Golden Eagle Trust - Barnastooka Wind Farm (Ref. 10/0197)

Submission by the Golden Eagle Trust in relation to the proposed Barnastooka Wind Farm

The Golden Eagle Trust has been monitoring the released White-tailed Sea Eagles released in Kerry since August 2007, using radio and satellite telemetry. We are building a database of habitat and range use by immature birds. Over the coming years we will identify core foraging areas used consistently by immature White-tailed Sea Eagles

The proposed wind farm site at Barnastooka has been used by immature White-tailed Sea Eagles recently. This wind farm lies eight kilometres south-east of the boundary of, what appears to be, a key foraging area for immature White-tailed Sea Eagles (Golden Eagle Trust unpubl. data). Observations and radio-tracking have shown use of a foraging site in the vicinity of the proposed wind farm, just recently.

Immature White-tailed Sea Eagles have used upland areas throughout the Iveragh Peninsula and the Killarney-Mangerton Mountain areas since releases began in 2007. Eagles have consistently used the Mangerton area from October 2008 where they have found good foraging areas and suitable overnight roost sites (Golden Eagle Trust unpubl. data). The Golden Eagles Trust believes that the White-tailed Sea Eagles only began to use the Barnastooka upland area initially due to the concentration of dead livestock at one location on a regular basis. We believe that if the concentration of dead livestock ceased, there would be no other dietary attraction to entice White-tailed Sea Eagles onto the proposed wind farm site. As a result the source of this recent attraction would cease.

Because some White-tailed Sea Eagles have been foraging nearby in an area of grassland and heather during the day, they have tended to settle, perch and roost at night time at two particular areas, within three and seven kilometres respectively, of the proposed wind farm. The proposed wind farm itself does not hold any potential sites for birds to perch on (either on mature trees or cliff ledges) and roost overnight (A. Mee pers. obs). The roost sites of immature, non-breeding White-tailed Sea Eagles is closely linked to local food availability and availability of undisturbed roosting sites.

We do not believe that the proposed wind farm site, in this application, will be a future breeding area for White-tailed Sea Eagles and therefore requiring pertinent studies and consultation with statutory bodies. Adult White-tailed Sea Eagles nest within five kilometres of large waterbodies with a good source of fish, which makes up 80-90% of the diet of Sea Eagle nestlings (Halley et al. 2006; Helander & Stjernberg 2003).

However, in order to minimize any potential risk to immature White-tailed Sea Eagles that may use the wind farm site post-construction, we recommend the following:

1. Regular fortnightly checks for fallen livestock within the wind farm site.
2. Removal of any dead livestock from within the wind farm site.
3. Any fallen livestock seen outside but neighbouring the site will be notified to the relevant herd owner.
4. All older sheep suffering with "broken mouth" will be removed from the sheep flocks grazed within the wind farm site each autumn.
5. The landowners, Kerry Wind Power, and the Golden Eagle Trust will lease regularly throughout the operation of the wind farm.

Submitted 2 February 2010

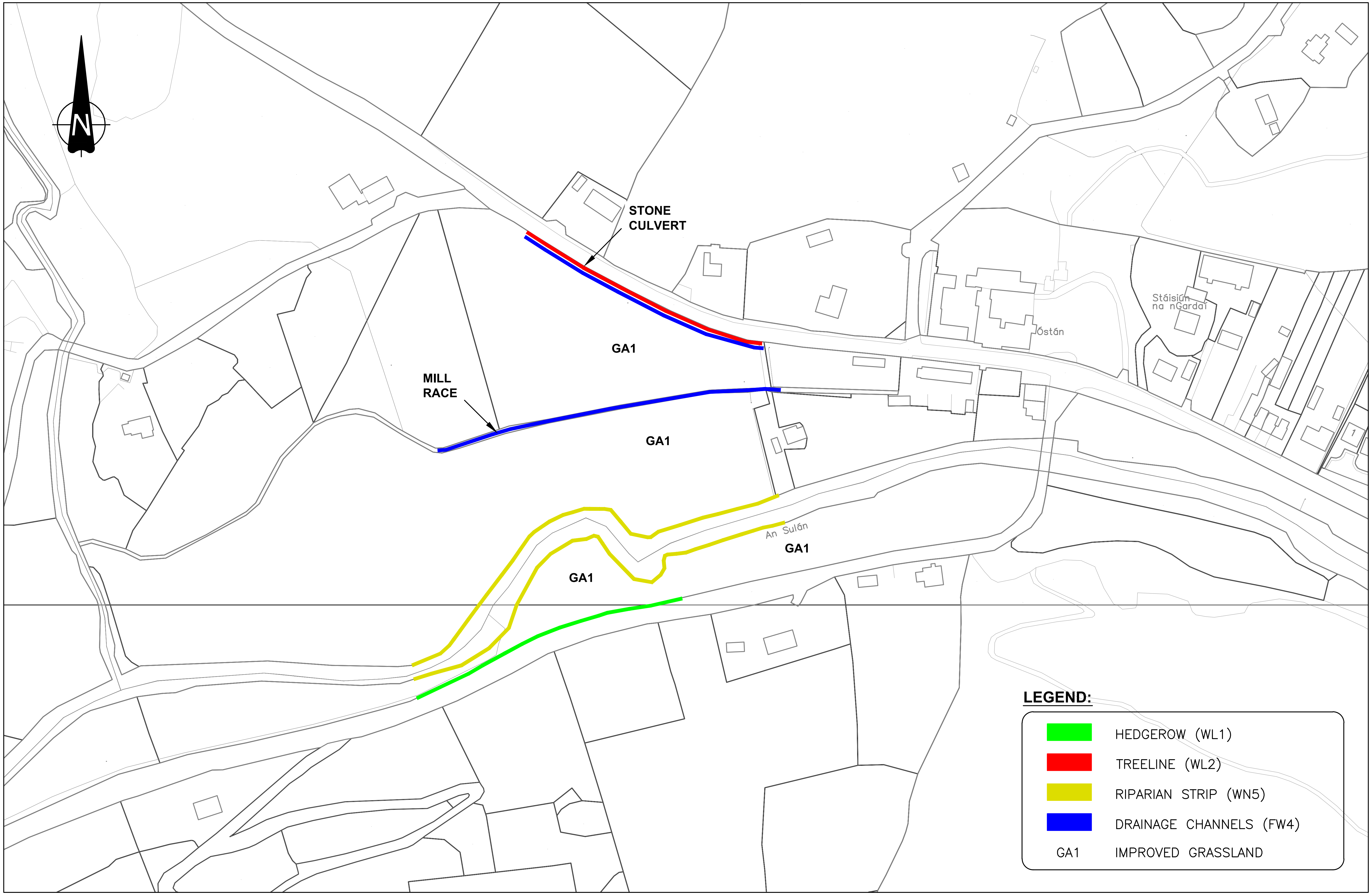
References

Halley, D. J., T. Nygård, and A. O. Folkestad. 2006. An evaulation of the proposed sea eagle *Haliaeetus albicilla* reintroduction area in Ireland. Unpubl. report to the Irish White-tailed Eagle steering group.

Helander, B. and Stjernberg. 2003. Action plan for the conservation of white-tailed sea eagle (*Haliaeetus albicilla*). BirdLife International Sweden & Council of Europe, Strasbourg.

APPENDIX B

Habitat Map: Ballyvourney



BALLYVOURNEY HABITAT MAP

APPENDIX C

Grousemount Wind Farm, Grid Connection Route and Road Improvements, Kerry Slug Surveys

Grousemount Wind Farm, County Kerry

Kerry Slug Survey and Assessment

Prepared for

ESBI

September 2015

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Document Control Sheet

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Revision	Status	Author	Review	Approved	Date
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1 INTRODUCTION

Wetland Surveys Ireland Ltd were commissioned by ESBI to undertake a survey for Kerry Slug (*Geomalacus maculosus*) within a proposed wind farm site at Grousemount, County Kerry. The aim of the survey is to determine whether Kerry slug is present within the wind farm site and to gain an understanding of its abundance and distribution throughout the site. The results of the survey will inform the assessment of potential ecological impacts of the proposed wind farm and devise appropriate mitigation as may be required.

The occurrence of the wind farm within the known range of Kerry Slug (*Geomalacus maculosus*) together with the presence of suitable habitat throughout the site suggests the likely presence of the species.

1.1 KERRY SLUG - CONSERVATION STATUS AND DISTRIBUTION

The Kerry slug (*Geomalacus maculosus*) is protected by the Wildlife (Amendment) Act 2000. It is listed under Annex II of the Habitats Directive and seven Special Areas of Conservation (SACs) have been designated for the species with a combined total area of approximately 95,337 hectares. The Kerry slug is also listed in Annex IV of the Habitats Directive and as such is strictly protected from injury, or disturbance / damage to their breeding or resting place wherever it occurs.

Historically, the Kerry Slug has been considered to be restricted to Devonian Old Red Sandstone areas of Kerry and West Cork where it occurs most commonly in either of three distinct habitats:

- deciduous woodlands in particular those with rocky outcrops or boulders;
- rock outcrops associated with heath or blanket bog; and
- lake shores

Within these habitats, the species tends to only be present if there is outcropping Devonian Old Red Sandstone, humid conditions and lichen, liverwort and / or mosses in which the species shelters and feeds (Platts and Speight 1988).

However, the species has also been recently discovered on both granite outcrops within blanket bog and from a Conifer plantation in County Galway (Kearney 2010). Further records of the species from Conifer Plantations suggest that this may also be a suitable habitat for the species (McDonnell *et al.* 2013). A possible explanation put forward to explain the recent discovery of the species in County Galway is an inadvertent introduction (during forestry operations) (McDonnell *et al.* 2013). However this has not yet been determined (Reich *et al.* 2012).

The overall conservation status of the species has been reported as favourable and it is not currently considered threatened within its range[1].

A review of data held by the National Biodiversity Data Centre (August 2015) confirms that the species has previously been reported from all four 10km squares that the site intersects (W07; W17; W06; W16). However, none of the records held by the NBDC relate to the wind farm site itself. The wind farm is not located within any site designated for nature conservation. The nearest site designate for the protection of Kerry Slug is the Killarney National Park, Macgillycuddy's Reeks and Caragh River Catchment SAC (NPWS Site Code: 0365).

Based on the habitats recorded during the ecological assessment of the wind farm, the following potentially suitable habitats have been identified:

- wet heath and rock outcrop habitat present throughout much of the site.

2 METHODOLOGY

2.1 DESKTOP REVIEW

A desktop assessment including a review of previous records of Kerry Slug within and surrounding the study area was undertaken, the results of which are presented in Section 1.1 above.

2.2 FIELD SURVEYS

There are three main survey approaches that are used to survey for Kerry Slug. These include hand searching techniques (diurnal or nocturnal) and live refuge trapping (metric traps). The method used during the current survey is live refuge trapping as recommended for use by McDonnell *et al.* (2013). This method is favoured over other techniques because it enables quantitative sampling (McDonnell and Gormley 2011a,b). In addition, it removes the requirement of undertaking searches during wet weather (in the case of diurnal searches), and the health and safety risks associated with nocturnal searches in remote locations. The metric trap method involves the following:

- Metric traps. This is a refuge trap technique. The metric traps (0.25 m^2), manufactured by De Sangosse (Pont du Casse, France), are made up of absorbent material covered with a reflective upper surface and a black perforated plastic on the underside. They are wetted in advance of being laid out and are baited with Carrot. Traps are secured to rock outcrops (outcrop metric traps) or on surface vegetation (in the case of heath) using stones, tent pegs, or nails as appropriate. They can also be wrapped around tree trunks (banded metric traps) when undertaking surveys at wooded sites (not relevant to

[1]*NPWS (2013). The status of EU protected habitats and species in Ireland. Overview Volume 1. Unpublished Report, National Parks and Wildlife Service.*

current survey). Traps are checked weekly for a period of up to six weeks. If required, traps are re-wetted during site visits using a watering can.

In all, 31 metric traps were set out amongst potentially suitable habitat within the wind farm site during early August 2015 (see Figure 1; Plate 1; Plate 2). In addition to checking the metric traps, incidental observations of Kerry Slug were recorded during each site visit. A targeted nocturnal hand searching survey was also undertaken within two areas of the site to compliment the metric trap survey. A summary of the dates, methods, and weather conditions of each site visit undertaken to date are presented in Table 1 while summary details of each trap are presented in Table 2.

Table 1: Details of site visits undertaken as part of the Kerry Slug surveys to date.

Date	Methods	Weather
04/08/2015	Setting of metric traps Incidental observations during site visit	Frequent showers; Light south-westerly wind; Mild; Complete cloud cover
05/08/2015	Setting of metric traps Incidental observations during site visit	Constant drizzle with intermittent heavy showers; Light south-westerly wind; Mild; Complete cloud cover
13/08/2015	Checking of metric traps Incidental observations during site visit	Dry with sunny spells; Warm Light southerly breeze; 20% Cloud cover
19/08/2015	Checking of metric traps Incidental observations during site visit	Early morning fog, lifted after 10 am Warm Light South-westerly breeze 60% cloud cover
26/08/2015	Checking of metric traps Incidental observations during site visit	Early morning fog, lifted after 10am Heavy showers in the late morning, lighter showers in the afternoon Mild; Complete cloud cover
01/09/2015	Checking of metric traps Incidental observations during site visit	Dry with sunny spells; Light North-westerly breeze; Mild; 60% cloud cover
15/09/2015	Checking of metric traps Incidental observations during site visit Nocturnal hand searching survey in proximity to two clusters of metric traps (Area around Trap 17-18 and area around Trap 20-31). Collecting of metric traps	Nocturnal survey Dry Mild Light South-westerly breeze 33% cloud cover

Table 2: Summary details of metric traps set during the study.

Trap Number	Easting (IG)	Northing (IG)	Date trap set	Type	Habitat
1	109410	71169	04/08/2015	Outcrop metric traps	ER1 Exposed siliceous rock
2	109399	71176	04/08/2015	Metric traps on vegetation	HH3 Wet heath
3	109457	71186	04/08/2015	Outcrop metric traps	ER1 Exposed siliceous rock
4	109460	71215	04/08/2015	Metric traps on vegetation	HH3 Wet heath
5	109424	71208	04/08/2015	Metric traps on vegetation	HH3 Wet heath
6	109398	71213	04/08/2015	Outcrop metric traps	ER1 Exposed siliceous rock
7	109400	71224	04/08/2015	Metric traps on vegetation	HH3 Wet heath
8	109420	71248	04/08/2015	Metric traps on vegetation	HH1 Dry siliceous heath
9	109385	71267	04/08/2015	Outcrop metric traps	ER1 Exposed siliceous rock
10	109385	71266	04/08/2015	Metric traps on vegetation	HH1 Dry siliceous heath
11	109877	70381	05/08/2015	Metric traps on vegetation	HH3 Wet heath
12	109936	70190	05/08/2015	Metric traps on vegetation	HH3 Wet heath
13	109966	70181	05/08/2015	Metric traps on vegetation	HH3 Wet heath
14	109013	70207	05/08/2015	Outcrop metric traps	ER1 Exposed siliceous rock
15	109014	70211	05/08/2015	Outcrop metric traps	ER1 Exposed siliceous rock
16	109912	70391	05/08/2015	Outcrop metric traps	ER1 Exposed siliceous rock
17	109047	70958	05/08/2015	Outcrop metric traps	ER1 Exposed siliceous rock
18	109058	70965	05/08/2015	Outcrop metric traps	ER1 Exposed siliceous rock
19	109063	70960	05/08/2015	Outcrop metric traps	ER1 Exposed siliceous rock
20	107520	71438	05/08/2015	Metric traps on vegetation	HH3 Wet heath
21	107527	71422	05/08/2015	Metric traps on vegetation	HH3 Wet heath
22	107155	71465	05/08/2015	Metric traps on vegetation	HH3 Wet heath
23	107167	71475	05/08/2015	Outcrop metric traps	ER1 Exposed siliceous rock
24	107113	71479	05/08/2015	Outcrop metric traps	ER1 Exposed siliceous rock
25	107023	71490	05/08/2015	Outcrop metric traps	ER1 Exposed siliceous rock
26	107022	71484	05/08/2015	Outcrop metric traps	ER1 Exposed siliceous rock
27	106967	71475	05/08/2015	Metric traps on vegetation	HH3 Wet heath / GS4 Wet grassland
28	106959	71492	05/08/2015	Outcrop metric traps	ER1 Exposed siliceous rock
29	106959	71497	05/08/2015	Metric traps on vegetation	GS4 Wet grassland / ER1 Exposed siliceous rock
30	106804	71488	13/08/2015	Outcrop metric traps	ER1 Exposed siliceous rock
31	106791	71480	13/08/2015	Metric traps on vegetation	GS4 Wet grassland / HH3 Wet heath

Plate 1: Outcrop metric trap at Grousemount Wind Farm site.

Plate 2: Metric trap laid on wet heath habitat in proximity to exposed outcropping rock at Grousemount Wind Farm.

3 RESULTS

Results of the metric trap survey are presented in Table 3 below. In all, traps were checked on five occasions during the period August - September 2015.

Details of incidental observations of Kerry Slug recorded during site visits are presented in Table 4 below together with the outcome of nocturnal hand searches undertaken in two areas within the site.

In summary, a total of 41 individual Kerry Slugs were recorded in metric traps during the site visits (see Table 3). All records were from traps laid on outcropping rock (as illustrated in Plate 3).

A further 10 individuals were recorded from outcropping rock and wet heath (single individual) elsewhere on the site during diurnal site visits (see Table 4; Figure 1).

Results of the nocturnal hand searching are also presented in Table 4 below. In all, 46 individuals were recorded from outcropping rock (and boulders) or from heath in close proximity to bare rock surfaces. A notable finding of the nocturnal searches was the confirmed presence of Kerry Slug in areas where metric traps had failed to record the species (area surrounding Traps 17-19).

Other slug species that were observed during the survey are listed in Table 5. All of these species are listed as being of least concern in the NPWS red data list of non-marine molluscs and are all considered common with a widespread distribution.

Table 3: Results of metric trap survey for Kerry Slug at Grousemount wind farm, showing number of individual Kerry Slugs recorded at each trap on survey dates.

Trap Number	Principal Habitat	13/08/2015[2]	19/08/2015	26/08/2015	01/09/2015	15/09/2015
1	ER1 Exposed siliceous rock			1		
2	HH3 Wet heath					
3	ER1 Exposed siliceous rock			1		
4	HH3 Wet heath					
5	HH3 Wet heath					
6	ER1 Exposed siliceous rock	1	1	1		1
7	HH3 Wet heath					1
8	HH1 Dry siliceous heath					
9	ER1 Exposed siliceous rock	2	3	3		
10	HH1 Dry siliceous heath					
11	HH3 Wet heath					
12	HH3 Wet heath					
13	HH3 Wet heath					
14	ER1 Exposed siliceous rock					
15	ER1 Exposed siliceous rock					
16	ER1 Exposed siliceous rock					
17	ER1 Exposed siliceous rock					
18	ER1 Exposed siliceous rock					
19	ER1 Exposed siliceous rock					
20	HH3 Wet heath					
21	HH3 Wet heath					
22	HH3 Wet heath					
23	ER1 Exposed siliceous rock	2	5	4	4	1
24	ER1 Exposed siliceous rock				1	
25	ER1 Exposed siliceous rock					
26	ER1 Exposed siliceous rock					
27	HH3 Wet heath / GS4 Wet grassland					
28	ER1 Exposed siliceous rock	2	1	2		1
29	GS4 Wet grassland / ER1 Exposed siliceous rock					
30	ER1 Exposed siliceous rock	NA	1	1	1	
31	GS4 Wet grassland / HH3 Wet heath	NA				
	Total records	**7**	**11**	**13**	**6**	**4**

[2] Weather conditions were dry and warm. Many outcrop metric traps were dried out and subsequently re-wetted during site visit.

Table 4: Incidental observations (including nocturnal hand searching on 15/09/2015) of Kerry Slug recorded during the course of site visits to Grousemount wind farm.

Record No	Date	Easting (IG)	Northing (IG)	No Individuals	Comment
1	04/08/2015	109449	71184	1	Recorded on sheltered east facing rock outcrop.
2	04/08/2015	109467	71001	1	Recorded on south facing rock outcrop.
3	05/08/2015	107023	71490	2	Recorded on large boulders with good lichen cover (south facing), surrounded by wet heath.
4	05/08/2015	107022	71484	1	Recorded on south facing boulder, good lichen cover. Individual was recorded within a crevice on the boulder.
5	19/08/2015	109340	71219	1	Recorded on wet heath. Individual was recorded on Molinia caerulea with no rock outcrop in the immediate surroundings.
6	26/08/2015	109426	71009	1	Recorded on rock outcrop, surrounded by wet heath.
7	26/08/2015	109438	71014	3	Recorded on large rock/boulder
8	15/09/2015	109070	70974	2	Nocturnal survey. On vertical rock outcrop, north facing.
9	15/09/2015	109079	70974	2	Nocturnal survey. On vertical rock outcrop, north facing.
10	15/09/2015	109079	70957	3	Nocturnal survey. On vertical rock outcrop, north facing.
11	15/09/2015	109062	70972	4	Nocturnal survey. On sod and stone wall with grass cover.
12	15/09/2015	107554	71434	4	Nocturnal survey. On stone wall that occurs parallel to the access track.
13	15/09/2015	107550	71433	5	Nocturnal survey. On stone wall that runs parallel to the access track.
14	15/09/2015	107588	71434	13	Nocturnal survey. Recorded along stone wall comprising small boulders, parallel to farm access track.
15	15/09/2015	106960	71492	1	Nocturnal survey. On rock outcrop in close proximity to Trap 28.
16	15/09/2015	107030	71495	7	Nocturnal survey. On the dry stone wall immediately adjacent to stream.
17	15/09/2015	107154	71485	2	Nocturnal survey. Recorded on large boulder.
18	15/09/2015	106958	71493	3	Nocturnal survey. On rock outcrop in close proximity to Trap 28.

Plate 3: Four Kerry Slugs recorded on a large flat boulder in close proximity to a stream (Trap No. 23 on 26/08/2015).

Table 5: Other slug species recorded from metric traps during the current study.

Common name	Scientific name	Total number	Habitat	Conservation Interest*
Black Slug	*Arion (arion) ater*	2	Rock outcrop within wet heath	Least Concern
Dusky Slug	*Arion (Mesarion) subfuscus*	1	Rock outcrop within wet heath / wet grassland.	Least Concern
Hedgehog Slug	*Arion (kobeltia) intermedius*	1	Rock outcrop within wet heath	Least Concern
Marsh Slug	*Deroceras (Deroceras) laeve*	2	Rock outcrop within wet grassland	Least Concern
Tree Slug	*Lehmannia marginata*	9	Rock outcrop within wet heath / wet grassland.	Least Concern

*Non-marine Molluscan Red Data List (Byrne *et al.* 2009)

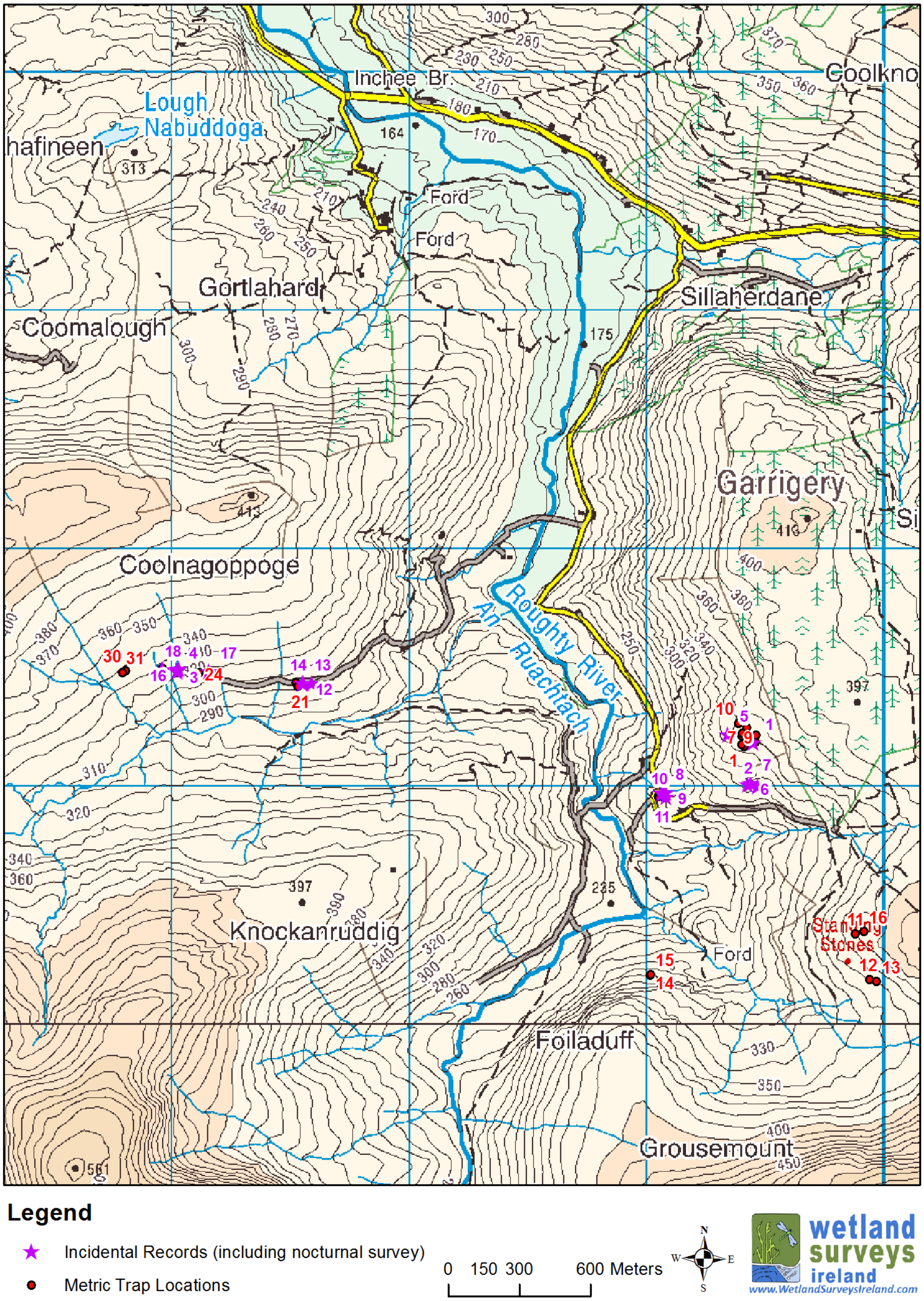

Figure 1: Map showing the location of metric traps (labeled according to number). Incidental Kerry Slug records are also indicated.

4 DISCUSSION AND RECOMMENDATIONS

Results from the current survey confirm the presence of Kerry Slug within the wind farm site. These results also suggest a notable preference for exposed siliceous rock. This is in line with previous surveys undertaken amongst similar habitat complexes (McDonnell and Gormley 2011a). The species is thought to be widespread throughout suitable habitat within its known range (NPWS 2013).

The development of the wind farm could potentially impact on the local population of Kerry Slug due to loss and disturbance of suitable habitat. Based on the likely extent of habitat loss throughout the wind farm site, this impact is likely to be minor and localised as only a very small proportion of suitable Kerry Slug habitat within the site will be impacted. During construction, works could also result in the death of low numbers of Kerry Slug due to machinery movements in areas of suitable habitat.

The following measures are recommended to minimise the above potential impacts on the local Kerry Slug population:

- Areas of suitable habitat that occur outside of the footprint of the development should be avoided during the course of construction thereby minimising the loss and disturbance of Kerry Slug habitat.
- Immediately prior to undertaking works in areas of suitable habitat, the project ecologist will check for the presence of Kerry Slug. Should slugs be discovered then they will be transferred to suitable habitat in the surroundings. Similar on-going monitoring of suitable habitat within works areas should continue throughout the construction phase. Such monitoring should be undertaken during periods of wet weather when slugs are most active and feeding on the surface and therefore at greater risk of impacts by movement of machinery.
- Due to the unavoidable disturbance to Kerry Slug habitat, a derogation license will be sought from the NPWS prior to the commencement of construction. Works will be carried out in compliance with any conditions set by such the license.

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APPENDIX D

Application for Derogation Licence to Disturb Kerry Slug

Wetland Surveys Ireland Ltd
Ecological Consultants

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Sinéad Harrington
Wildlife Licensing Unit,
National Parks and Wildlife Service,
Department of Arts, Heritage and the Gaeltacht,
7 Ely Place,
Dublin 2.

14 March 2016

RE: Application for Derogation Licence to Disturb Kerry Slug, or their Breeding or Resting Places

Dear Sinéad,

I wish to make an application for a derogation licence for potential disturbance to Kerry Slug (EU Habitats Directive Annex IV species) as provided for by Article 16 of the Habitats Directive on behalf of ESB International.

The works relate to the proposed development of a wind farm at Grousemount, County Kerry. The proposed development is currently the subject of a planning Application lodged with An Bord Pleanála. In line with Circular Letter NPWS 02/07 issued by your Department, I wish to apply for the derogation license in advance of a planning decision being made.

I attach two reports in support of this application which present the results of surveys undertaken for Kerry Slug at the wind farm site itself and at areas where works are proposed along the proposed grid connection route and turbine transport route. An assessment of potential impacts is presented together with recommended mitigation measures aimed at minimising impacts on Kerry Slug during the course of development.

Please let me know should you require any further information. Look forward to hearing from you in due course.

Yours sincerely,

Patrick Crushell

Dr Patrick Crushell, MCIEEM
Ecologist

Temporary Bridge at Ballyvourney

Flood Risk Assessment

ESB Wind Development

Document No.:

Date: 15/03/2016

ESB International, Stephen Court, 18/21 St Stephen's Green, Dublin 2, Ireland.

Phone +353 (0)1 703 8000

www.esbi.ie

File Reference:		
Client / Recipient:	ESB Wind Development Limited	
Project Title:	Grousemount Wind Farm	
Report Title:	Temporary Bridge at Ballyvourney – Flood Risk Assessment	
Report No.:	n/a	
Volume:	000	
Prepared by:	Harry Griffin	Date: March 2016
Title:	Graduate Civil Engineer	
Verified by:	Jim Fitzpatrick	Date: March 2016
Title:	Senior Consultant	
Approved by:	Roisin O'Donovan	Date: March 2016
Title:	Senior Consultant	

Change History of Report

Date	New Revision	Author	Summary of Change

Executive Summary

This report covers the identification of, and the measures taken to address, the potential flood risk to the proposed construction of a temporary bridge in Ballyvourney, Co. Cork. The single span structure will span 27 m with abutments placed outside the river banks. The access road to the bridge will adhere to the existing ground level as much as possible but embankments will be required close to the bridge. It is envisaged that the bridge structure will be in place for up to 1 year.

This report considers the flood risk of the proposed development in relation to all three stages of the staged approach outlined in the Planning Guidelines in relation to Flood Risk Management. To address the potential flood risk arising from the proposed development it was necessary to develop a hydraulic model of the river and the adjoining floodplain.

In accordance with the requirements of the Planning Guidelines and Section 50 of Arterial Drainage Act 1945 the bridge was designed to convey the 1% AEP (Annual Exceedance Probability) flood event while maintaining a freeboard of at least 300 mm. Any flood risk to the proposed development will be minimal and restricted to a section of the access track which is at the existing ground level in the floodplain. This risk is considered acceptable due to the exclusive access the development shall have to wind turbine transport vehicles. The bridge and access track will not significantly alter the hydraulic characteristics of the watercourse and therefore dwellings in the vicinity will not be adversely affected in the design flood event.

Contents

1 Introduction

This Flood Risk Assessment addresses the proposed installation of a temporary bridge traversing the Sullane River close to Ballyvourney village in Co. Cork. The bridge will comprise a single span structure of rapid build modular construction sitting on abutments of reinforced concrete at either end of the span. The access track either side of the bridge will be raised by approximately 2 m above the existing ground level close to the bridge abutments before gradually returning to the existing ground level further away from the river. The bridge is to be located approximately 250 m upstream of Ballyvourney Town Bridge at the grid reference 519300 E; 577600 N (Irish Transverse Mercator). The bridge will require the creation of a temporary entrance from the N22 and from the L3400 (both to the west of Ballyvourney village) along with public road improvements at identified locations along the L3400 towards the site. The development will facilitate the delivery of wind turbine components, primarily the turbine blades, to the Grousemount Wind Farm site in Co. Kerry. The wind farm shall comprise of 38 no. wind turbines and all associated foundations and hard standing areas.

The Flood Risk Assessment was prepared in accordance with ‘The Planning System and Flood Risk Management - Guidelines for Planning Authorities’ issued by the Department of Environment, Heritage and Local Government in November 2009. Flood risk from fluvial, surface water and ground water sources has been assessed based on existing available information.

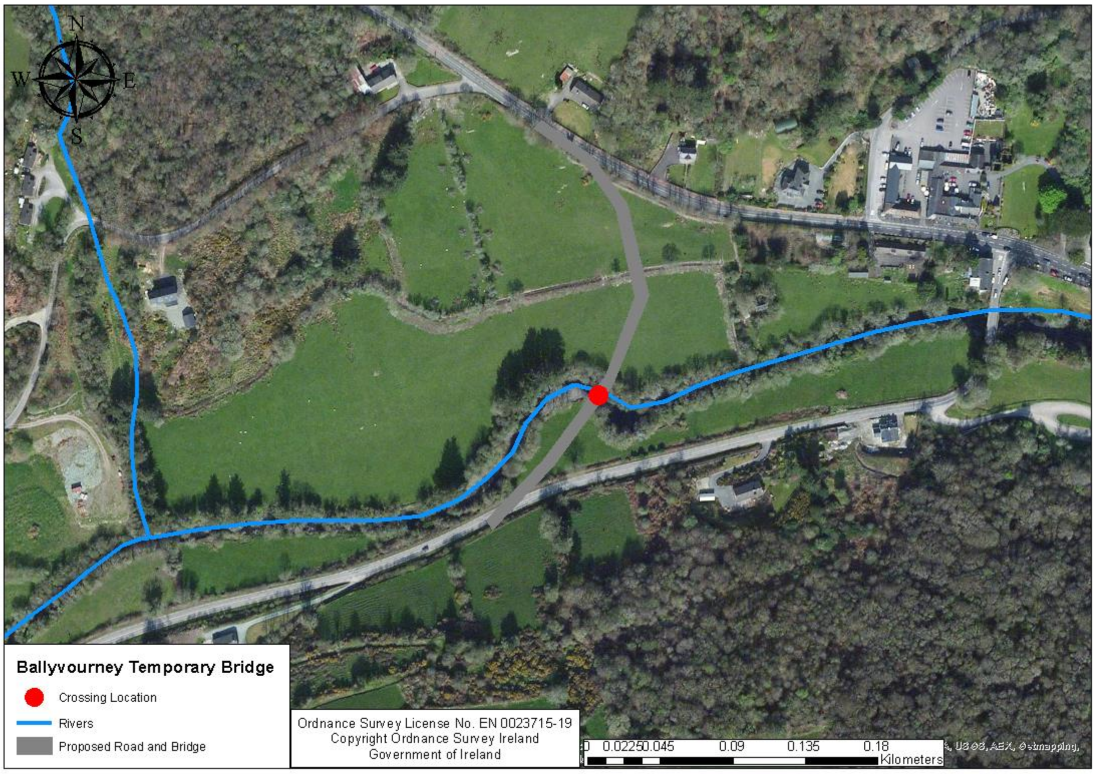


Figure 1 Proposed location of temporary bridge and entrance road in Ballyvourney

In the Lee Catchment Flood Risk Assessment and Management (CFRAM) Study Final Report (Halcrow, 2014), Ballyvourney and Ballymakeery were identified as being at significant economic risk of flooding (Figure 2). Hydraulic modelling carried out as part of the CFRAM Study found that some of the most significant flooding in the Upper Lee catchment occurs in these two villages, where out of bank flows from the Sullane River result in significant risk to a number of properties along the N22. A small number of properties in the area are at risk from events as frequent as the 50% Annual Exceedance Probability (AEP) event but most properties are not at risk until at least the 2% AEP event.

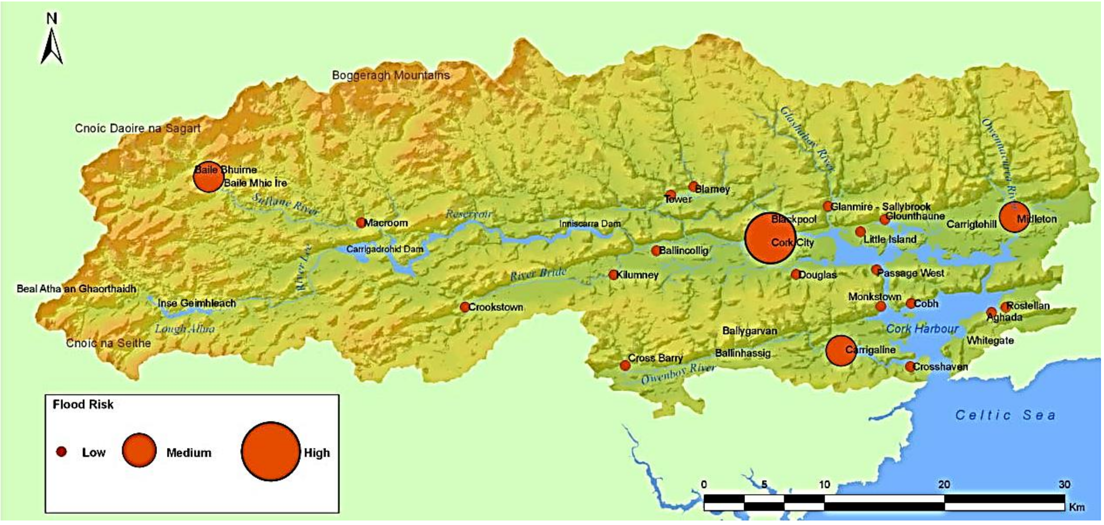


Figure 2 Graphical representation of economic risk areas in the Lee Catchment (Halcrow, 2014)

1.1 Scope

This assessment considers the following:

- The Department of Environment, Heritage and Local Government guideline document to Planning Authorities in relation to Flood Risk Management.
- Review of data on recorded historic floods.
- Impact of the presence of the proposed development on the existing flood risk regime at the subject site.
- Risk of flooding due to direct rainfall.
- Risk of flooding from groundwater.

2 Planning Guidelines

In November 2009 the Department of Environment, Heritage and Local Government issued a guideline document to Planning Authorities in relation to Flood Risk Management.

These guidelines set out the policy on development and flood risk in Ireland and provide a framework for the integration of flood risk assessment into the planning process. The objective is to ensure that flood risk is taken into account at all stages in the planning process and as a result to:

- Avoid inappropriate development in areas at risk of flooding,
- Avoid new developments increasing flood risk elsewhere,
- Ensure effective management of residual risks for development permitted in floodplains.

The Guidelines set out a staged approach for the consideration of flood risk in relation to developments as follows:-

Stage 1: Flood risk identification – to identify whether there may be any flooding or surface water management issues related to either the area of regional planning guidelines, development plans and LAP's or a proposed development site that may warrant further investigation at the appropriate lower level plan or planning application levels;

Stage 2: Initial flood risk assessment – to confirm sources of flooding that may affect a plan area or proposed development site, to appraise the adequacy of existing information and to scope the extent of the risk of flooding which may involve preparing indicative flood zone maps. Where hydraulic models exist the potential impact of a development on flooding elsewhere and of the scope of possible mitigation measures can be assessed. In addition, the requirements of the detailed assessment should be scoped; and

Stage 3: Detailed flood risk assessment – to assess flood risk issues in sufficient detail and to provide a quantitative appraisal of potential flood risk to a proposed or existing development or land to be zoned, of its potential impact on flood risk elsewhere and of the effectiveness of any proposed mitigation measures.

The Guidelines classify developments into three vulnerability classes based on the effects of flooding

i) Highly vulnerable development,

ii) Less vulnerable development and

iii) Water Compatible development.

The Guidelines classify land areas within three flood zones based on the probability of flooding. Flood zones are defined as follows in the Guidelines:

Zone A is at highest risk. In any one year, Zone A has a 1 in 100 year (1%) chance of flooding from rivers and a 1 in 200 year (0.5%) chance of flooding from the sea.

Zone B is at moderate risk. The outer limit of Zone B is defined by the 1 in 1,000 year (or 0.1%) flood from rivers and the sea.

Zone C is at low risk. In any one year, Zone C has less than 1 in 1,000 year (<0.1%) chance of flooding from rivers, estuaries or the sea.

In the identification of flood zones, no account should be taken of any flood relief walls or embankments.

	Flood Zone A	Flood Zone B	Flood Zone C
Highly vulnerable development (including essential infrastructure)	Justification Test	Justification Test	Appropriate
Less vulnerable development	Justification Test	Appropriate	Appropriate
Water-compatible development	Appropriate	Appropriate	Appropriate

Table 1 Matrix of vulnerability versus flood zone to illustrate appropriate development and that required to meet the Justification Test (reproduced from Table 3.2 of Planning Guidelines)

Table 1, which is reproduced from the guideline document to Planning Authorities in relation to Flood Risk Management states that less vulnerable developments should be located within Flood Zone B or C. Section 4.3.1 of this Flood Risk Assessment document will consider the Flood Zone assignment for the proposed site.

Table 1 refers to the use of a Justification Test under certain circumstances. In cases where there are insufficient sites available to locate a development in the appropriate low flood risk zone, the guideline documents allows for consideration of sites within flood risk zones. A Justification Test is then required to assess such proposals in the light of proper planning and sustainable development objectives.

This report considers the flood risk of the proposed development in relation to all three stages of the staged approach outlined above.

3 Ballyvourney Temporary Bridge Site

The site of the proposed temporary bridge is upstream of Ballyvourney village. It can be accessed via the N22 to the north and the L3400 the south (Figure 3). Local area character is that of a typical upland river valley consisting of a mixture of trees and grassland maintained for pastoral farming. In the Ballyvourney-Ballymakeery area five separate mountain streams converge draining approximately 65 km^2 of the Derrynasaggart mountains on the Cork/Kerry border.

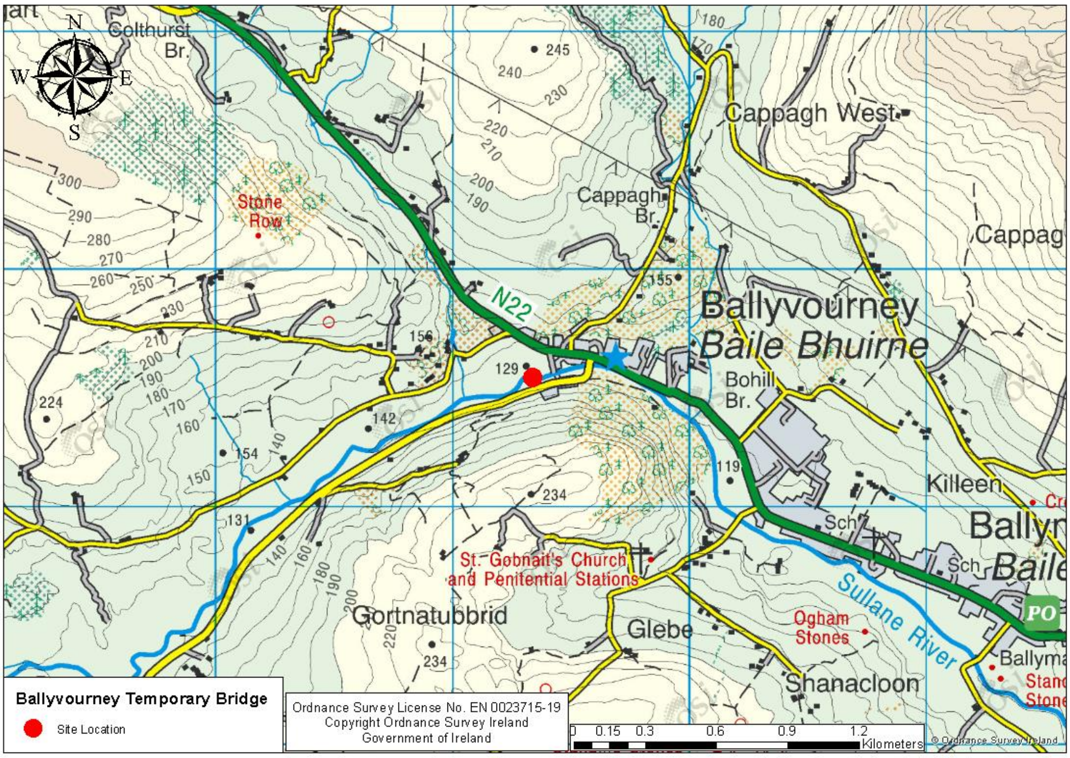


Figure 3 General Location of Temporary Bridge

There are a number of developments comprising one-off houses in the area, particularly along the N22 to the north, as well as a few houses along the L3400 to the south (Figure 4). These developments are elevated with respect to the Sullane and lie outside the known floodplain according to the Lee CFRAM Study (Figure 5, Figure 6 and Figure 7). However, two dwellings, one 100 m downstream of the proposed bridge location and the other 230 m downstream at Ballyvourney Town Bridge are located on the edge of the known floodplain (Figure 8 and Figure 9). The river reach of concern is flanked on both sides by high trees and short grass. The river is 15 – 20 m wide and gently sloping in the vicinity of the modelled reach.

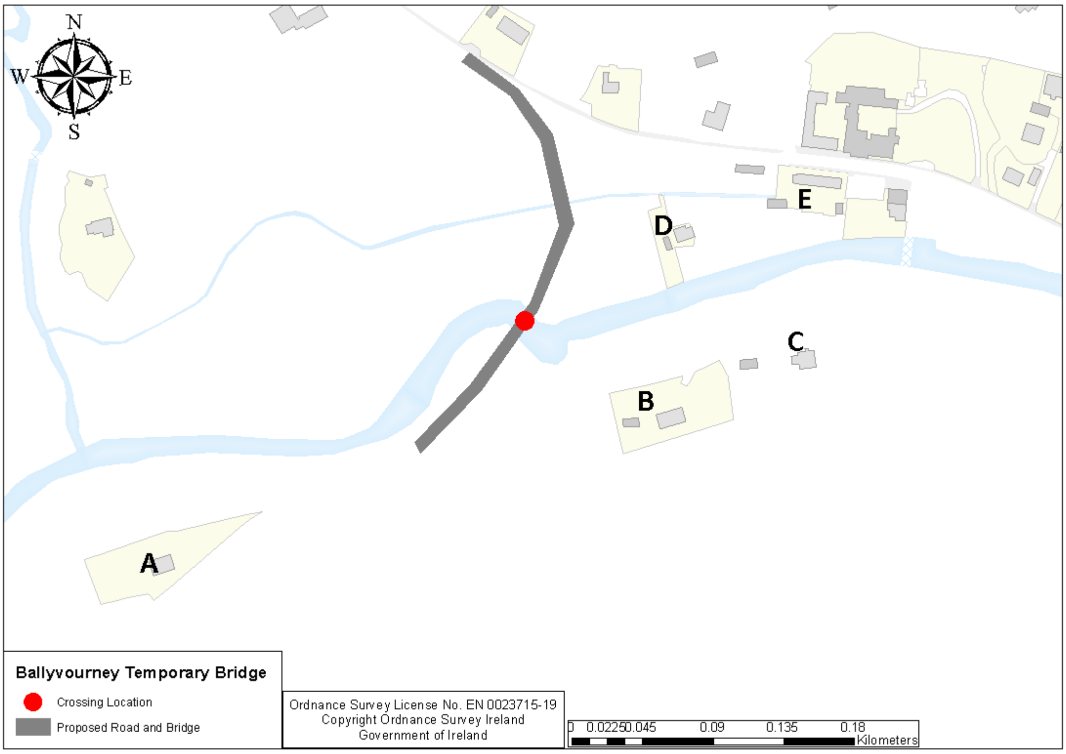


Figure 4 Developments in the vicinity of the proposed temporary bridge and access road

Figure 5 House at location A as indicated in Figure 4

Figure 6 House at location B as indicated in Figure 4

Figure 7 House at location C as indicated in Figure 4

Figure 8 House at location D as indicated in Figure 4

Figure 9 House at location E as indicated in Figure 4

4 Flooding Risk

Flood Risk to the site of the new works is considered in relation to the following criteria:

- History of Flooding
- Available Predictive Flood Risk Mapping
- Fluvial Risk: Inundation from flow from neighbouring watercourses
- Pluvial Risk: Flooding due to direct rainfall
- Groundwater Flood Risk
- Impact of presence of the proposed development on the existing flood risk regime at its proposed site.

4.1 Historic floods

The review of historic flooding was undertaken using the Office of Public Works (OPW) website www.floodmaps.ie. This web site forms a record of all available flood records held by the OPW, all local authorities and other relevant state organisations such as the EPA and the Department of Environment Heritage and Local Government. This website represents the current definitive database of historic flood information in this country.

The website has a record of flooding affecting the village of Ballyvourney in August 1986 which was the most severe experienced for many years (Figure 10). Damage to roads and bridges in the Lee catchment was concentrated on the upper reaches due to the narrow and steep gradients at this stage. In a 5 km stretch of the River Sullane near Ballyvourney four bridges were extensively damaged.

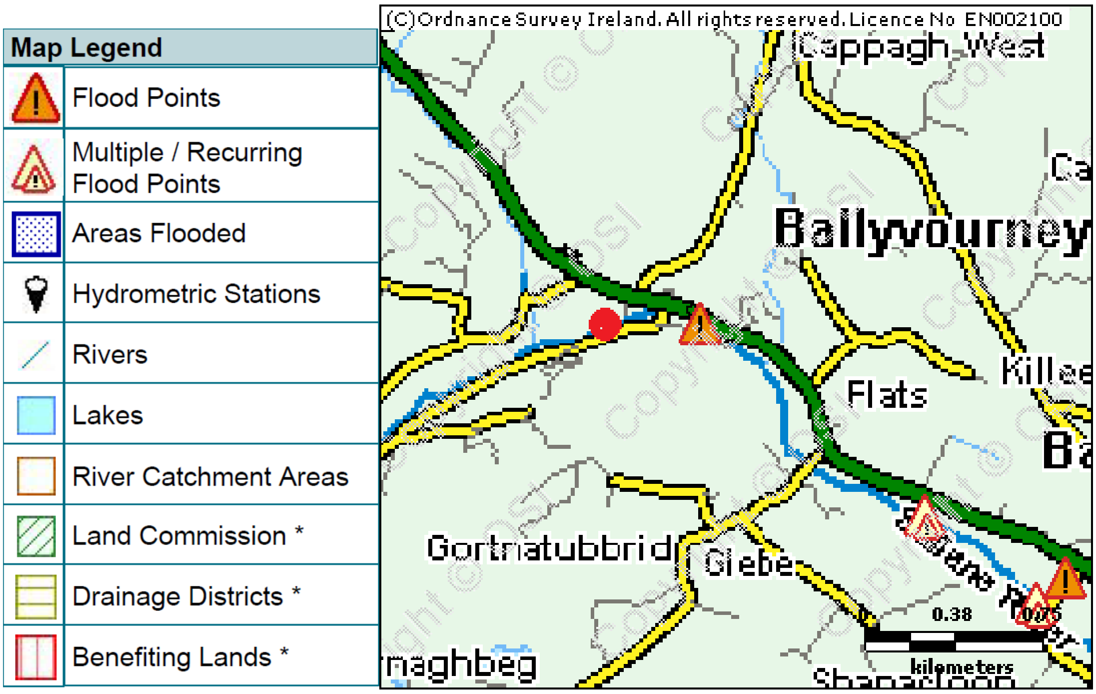


Figure 10 Flood Report downloaded from www.floodmaps.ie (site outline denoted by red circle)

The detailed flood risk assessment carried out by the OPW (2013) identified that upstream of each existing bridge in the villages of Ballymakeery-Ballyvourney, the rising of floodwater due to the restriction imposed by each given structure lead to increased flood levels. In the 1986 flood, regarded as the worst in living memory, a significant section of the upstream right bank wall collapsed alongside Ballyvourney Town Bridge resulting in a short-term surge of floodwaters before receding. Two properties flooded upstream of the bridge but have not flooded since. Subsequent damaging flood events in the villages have not had a recorded impact in the vicinity of the proposed temporary bridge.

4.2 Review of OPW Flood Risk Mapping

As part of Ireland's obligations under the EU "Floods" Directive, the OPW is currently engaged in the generation of new mapping which will provide predictive estimates of the extent of floodplains as part of its Catchment Flood Risk Assessment Management Studies (CFRAMS). This programme is being undertaken on a River Basin District basis.

The temporary bridge site is located within the Lee River Basin District. The Lee CFRAM Study was the primary pilot project for this new national approach to flood risk management. The OPW in partnership with Cork City Council and Cork County Council commissioned the study in 2006. The final report was substantially produced prior to the flooding of November 2009 and re-assessment of the extents and severe impacts of the flooding was required to address its significance at some locations before the publication of the final report in 2014 (Halcrow, 2014).

A subsequent review of the Lee CFRAM study report concluded that a standalone detailed flood risk assessment study of Ballymakeery-Ballyvourney was required. The assessment led to a revision of the hydrology, hydraulics and the preferred flood relief scheme options, likely to be viable on technical, economic, social and environmental grounds. (OPW, 2013).

Flood extent maps and flood depth maps for Ballymakeery-Ballyvourney for existing conditions prepared for these studies are shown in Appendix A. Flood extent maps for projected future scenarios can be viewed at the following link: http://www.opw.ie/en/leecframs/floodmaps/maps/bailemhicire-bailebhuirne/. Flood depth maps illustrate the estimated flood depths for areas inundated by a flood event of a given probability of occurrence, i.e. 10%, 1% and 0.1% AEP.

4.3 Fluvial Flood Risk

The site is located in the Upper Lee catchment on the River Sullane. The Sullane is part of the Lee River Basin and joins the River Lee approximately 20 km downstream of the site at Carrigadrohid Reservoir.

The proposed crossing is located at an elevation of approximately 125 m OD Malin. The temporary bridge deck and new access road will be at an elevation of 127.4 mOD.

The river has an upstream catchment of 55 km^2 at the crossing point. Figure 11 illustrates the site location in respect to the upstream catchment.

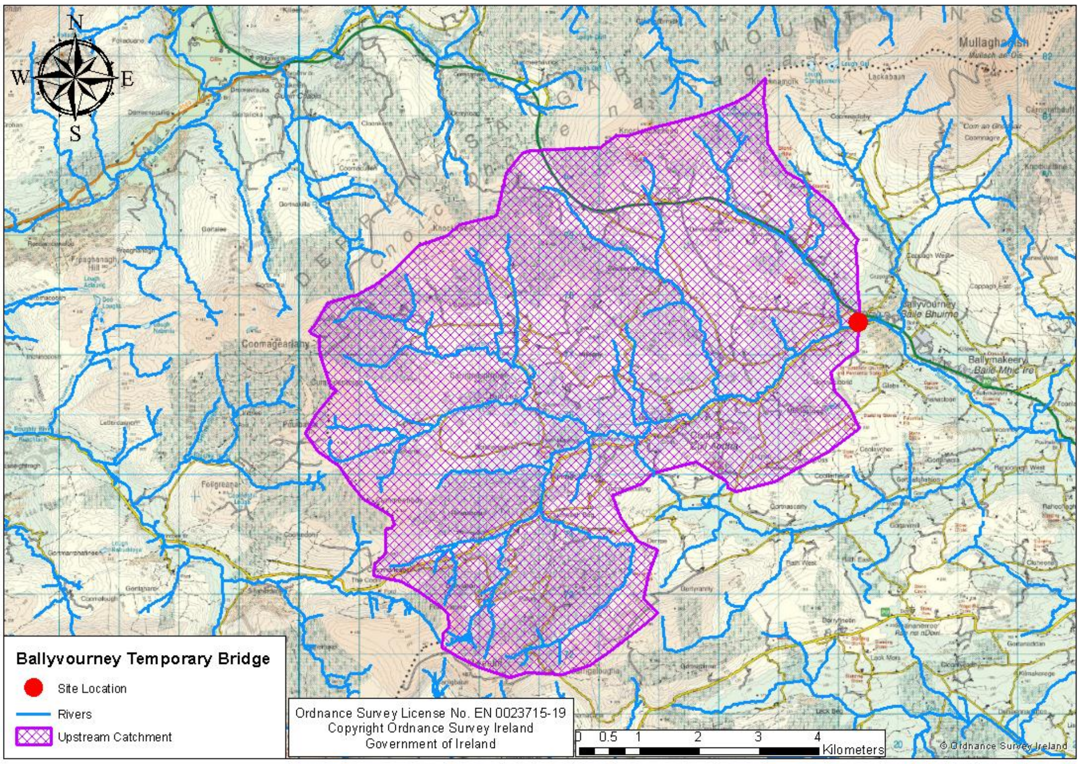


Figure 11 Plan of upstream catchment for proposed bridge crossing

Fluvial flood extent maps published as part of the Lee CFRAM Study programme indicate that in the event of severe flood conditions flood waters from the Sullane will likely encroach on a large area during the 10% AEP flood event (Figure 12).

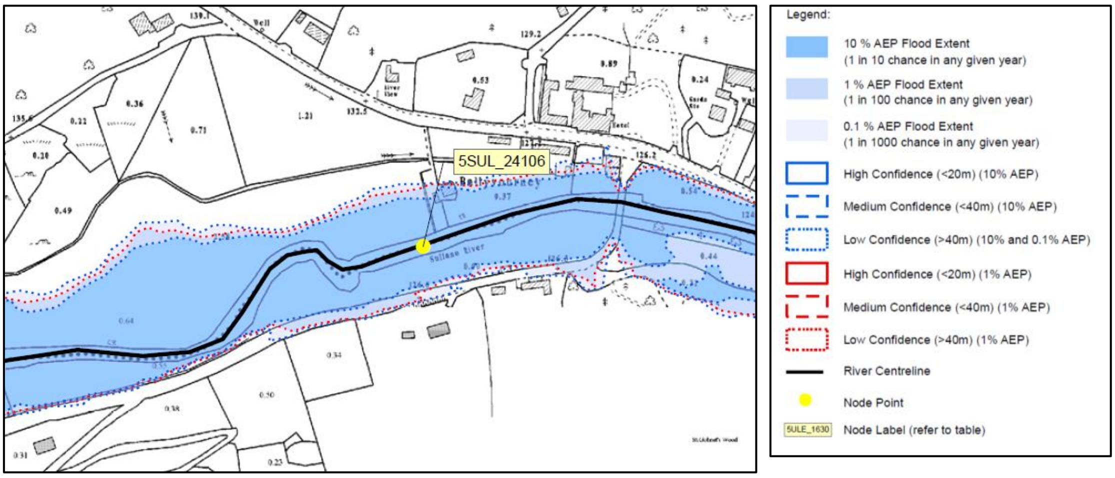


Figure 12 Extract from Lee CFRAMS Flood Extent Map for Ballyvourney (Appendix A)

To address the potential flood risk arising from the proposed development it was necessary to develop a hydraulic model of the river and the adjoining floodplain. The accuracy and reliability of the river water level calculations depend to a large extent on the availability and quality of data used to represent that which is being modelled. A description of the work done to build the model is described in this section.

4.3.1 Topographical Survey

For this report, a topographical survey was undertaken of the area extending from a the tributary 300 m upstream of the new bridge to the existing bridge 250 m downstream incorporating the expected extent of the floodplain The six surveyed cross-sections (S1 to S6) captured the river bed, banks and the floodplain (Figure 13). Interpolation was used to model intermediate sections between S1 and S2, S2 and S3, and S5 and S6.

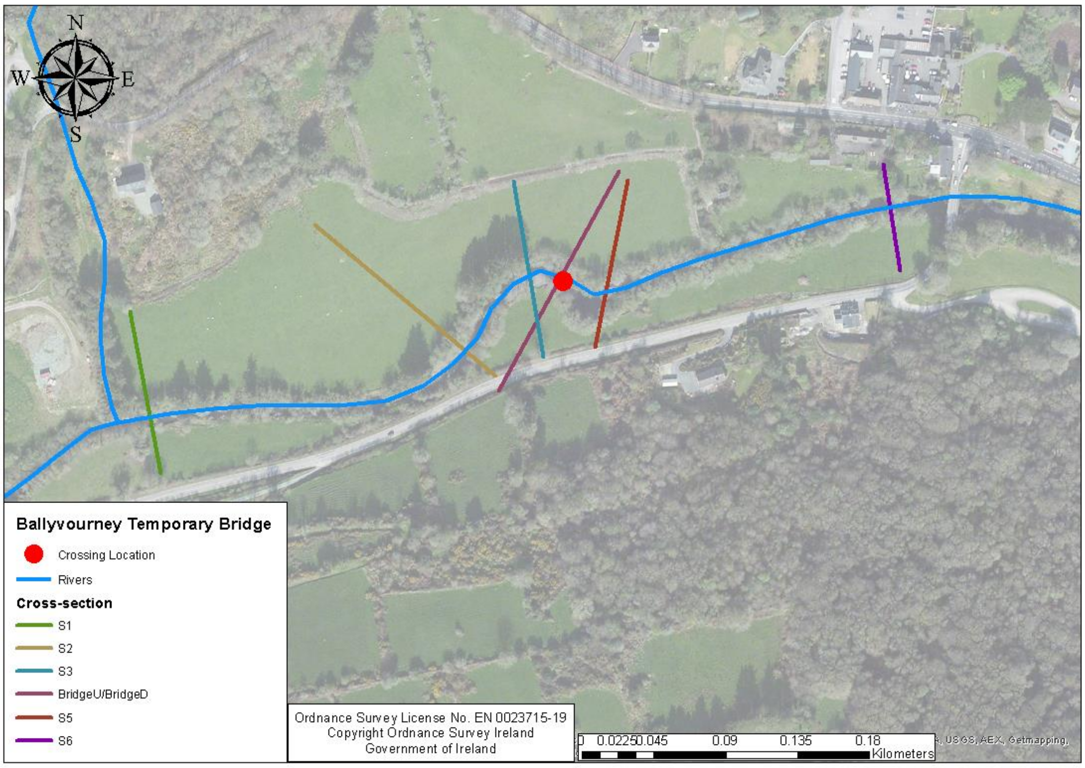


Figure 13 Cross-sections surveyed for input to ISIS model

4.3.2 Design Discharge Magnitude

The flood zone assignment for the bridge and associated access road is that of a less vulnerable development. Therefore, to meet the Planning Guidelines, it was decided that the design standard for the bridge should place it outside Flood Zone A. To satisfy this standard, the bridge soffit shall be above the 1% AEP river level. In order to satisfy the hydraulic design standards under Section 50 of the Arterial Drainage Act 1945 the bridge shall maintain a freeboard of at least 300 mm when passing this design flow. The proposed private access road to the bridge shall match the existing ground levels of the floodplain in as much as possible. Embankments either side of the bridge have been incorporated in the hydraulic model described in Section 4.3.3.

The OPW Flood Studies Update (FSU) portal was used to calculate the magnitude of the 100 year flood (Q100) in the catchment. As the catchment to the proposed temporary bridge is greater than 25 km^2 hand calculation techniques such as the rational method or the IH124 method were not required for estimating design peak flow for the catchment.

The FSU methodologies are now recommended by the OPW as being the preferred method for extreme rainfall and flood estimation in Ireland. The FSU model estimates QMED (the 1 in 2 year event, usually the bank-full condition) at ungauged sites using the following seven variable equation:

$QMED = 1.237 \times 10^{-5}\ AREA^{0.937}\ BFISOIL^{-0.922}\ SAAR^{1.306}\ FARL^{2.217}\ DRAIND^{0.341}\ S1085^{-0.185}(1+ARTDRAIN2)^{0.408}$

QMED is the index flood used in the FSU methodologies. The index flood is a reference flood that can be relatively reliably estimated from gauged data which for FSU methodologies is the median of floods in the annual maximum (A-max) series for a given location. QMED is said to have a return period of two years on the annual maximum scale of frequency.

QMED is estimated from seven catchment descriptors:

AREA = drainage area (km^2)
BFISOIL = catchment soil and geology index
SAAR = average annual rainfall (mm)
FARL = an index of flood attenuation by reservoirs and lakes
DRAIND = an index of drainage density
S1085 = the mainstream slope (m/km)
ARTDRAIN2 = length of upstream network included in OPW scheme channels (km).

Approximate 68% and 95% confidence intervals for QMED are given as;

68% confidence interval = (QMED/FSE, QMED*FSE)
95% confidence interval = ($QMED/FSE^2$, $QMED*FSE^2$)

FSE is the factorial standard error, which for the FSU method has a value of 1.37.

The nearest downstream ungauged catchment node on the Flood frequencies module in the FSU portal, subject site 19_946_2, is located approximately 175 m downstream of the proposed crossing was used to estimate the design discharge magnitude. The results of the FSU analysis for this subject catchment were conservatively assumed to reflect the discharge at the proposed crossing.

The outputs and procedures utilised to calculate the design discharge using the FSU are shown in Table 2. The more conservative 95% confidence Q100 value was used as the design flow to reflect the high risk nature of the area.

The 2009 Planning Guidelines recommend that climate change be factored into consideration for flood risk assessments although there is no national guideline on how to account for the additional risk. Climate change along with other future changes (e.g. urbanisation, forestation, etc.) are being taken into account in the Lee CFRAM study with two scenarios in particular being considered –

- Mid-Range Future Scenario (MRFS) – typical values of 20% for flood flow and 500 mm for Mean Sea Level rise will be considered;
- High-End Future Scenario (HEFS) – typical values of 30% for flood flow and 1000 mm for Mean Sea Level rise will be considered.

As the bridge will only be in place for a short period (less than a year) before removal it was decided not to factor in the possibility of future changes that would increase the design flow such as those mentioned above.

OPW FSU Estimate (http://opw.hydronet.com)		
Catchment area (km2)	55.82	km^2
Standard Average Annual Rainfall (SAAR)	2029.1	mm
BFISOIL	0.5602	
QMED	58.48	m^3/s
Growth Factor	2.18	
Q100	127.49	m^3/s
Factorial Error	1.37	
Q100 (68% Confidence)	174.66	m^3/s
Q100 (95% Confidence)	239.28	m^3/s

Table 2 Q100 estimation for catchment to temporary bridge location using FSU methodologies

4.3.3 Hydraulic model using ISIS software

The internationally recognised 1-D ISIS hydraulic modelling package was used to simulate hydraulic conditions along the river upstream and downstream of the proposed temporary bridge and to estimate flood levels in the floodplain under design storm flow conditions. The ISIS 1-D river network model allows the flow characteristics of both the river and the proposed bridge to be defined separately and the overbank floodplain conveyance also to be defined. The 1-D model includes the attenuation effect of the adjoining flood plain area on the incoming flood waves. A description of the ISIS modelling package is given in Appendix B of this report.

The downstream control used in the modelling is a normal depth boundary. A downstream level control was automatically calculated using bed levels and the slope upstream of the control.

The impact of the proposed bridge on flood levels has been determined by modelling the river with the existing conditions and with the proposed bridge for the same river reach. The modelling results show that the proposed bridge and access road will not impact significantly on the hydraulic regime in the modelled reach.

An illustration of the ISIS model set-up used to compute the results is provided in Figure 14 which shows how the proposed bridge has been modelled relative to the existing channel.

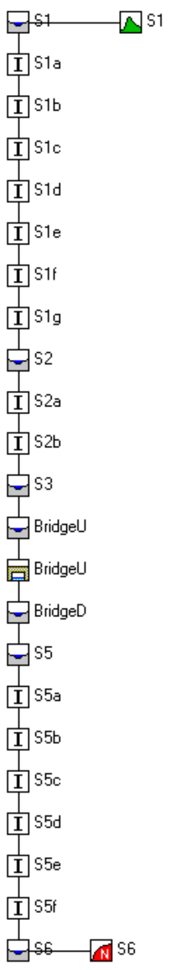


Figure 14 Set-up of ISIS 1D model for proposed river conditions

A backwater calculation based on the methods of the CIRIA Culvert Design and Operation Guide was also performed in order to validate the outputs from the ISIS suite. These calculations are presented in Appendix F.

4.3.4 River Channel

Figure 15 shows the longitudinal profile of the river bed. As surveyed, cross sections upstream and downstream of the bridge location are also included in Appendix D.

Using guidance from Chow (1959) Manning coefficients were estimated in the river and floodplain. A Manning roughness coefficient of 0.04 has been using to represent the channel bed in the modelled reaches as the river is clean and winding with rocks and stones. The floodplain is composed almost entirely of short grass with a Manning value of 0.03 used to represent it (Figure 16 and Figure 17).

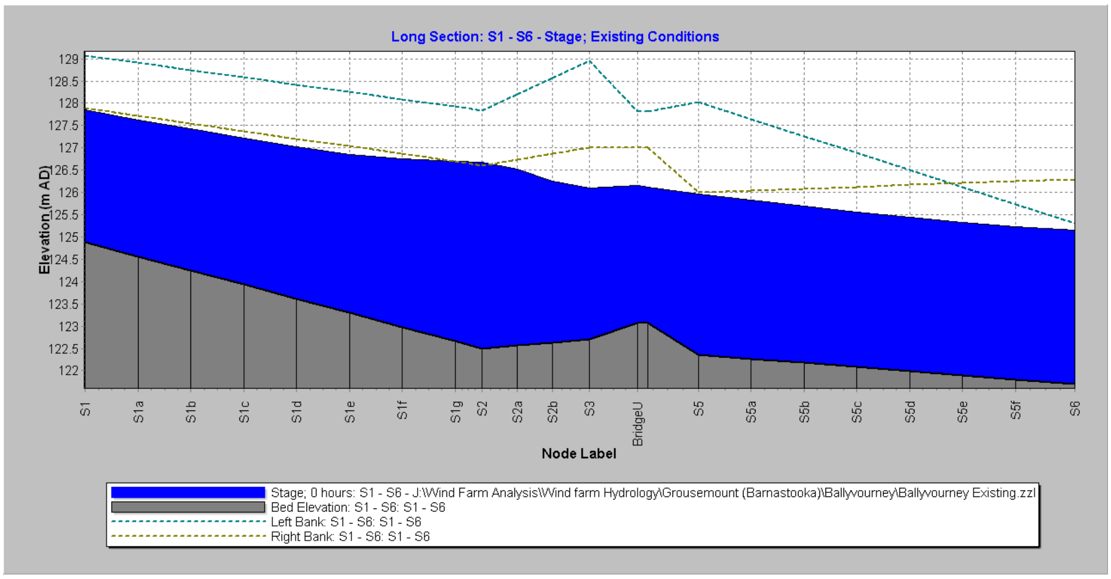


Figure 15 Longitudinal profile of modelled river reach

Figure 16 Catchment conditions on floodplain south of bridge location

Figure 17 Catchment conditions on floodplain north of bridge location

4.4 Head Loss through Channel

This section examines the head loss through the existing channel and the proposed bridge in the Sullane river over the reach of concern. The proposed crossing location is shown in Figure 18. The results of the overall ISIS outputs are shown in Table 3 and Appendix D. The proposed works will involve the installation of a single span structure of rapid modular construction spanning 27 m between abutments with a length of 6 m between upstream and downstream ends.

Figure 18 View of proposed bridge location looking east

4.4.1 Existing Conditions

Table 3 presents the estimated water levels, velocities and Froude number for the design 100 year event in the existing subject channel. The channel gradient on the River Sullane leads to subcritical conditions occurring throughout with the exception of section S3 with velocities ranging from 2 m/s to 3.4 m/s.

ISIS computes averaged velocities at each nodal point. The existing channel has a limited conveyance capacity. Once flood plain flow is excluded, this would imply that velocities would in reality be greater within the confines of the channel than indicated in Table 3.

Node Label	Chainage m	Bed Level mOD	Flow m^3/s	Water Level mOD	Froude	Velocity m/s		Bed Level mOD	Flow m^3/s	Water Level mOD	Froude	Velocity m/s
		Existing Channel Conditions						**Proposed Channel Conditions**				
S1	0	124.88	239.28	127.859	0.989	2.886		124.88	239.28	127.859	0.989	2.886
S1a	30	124.563	239.28	127.633	0.958	2.892		124.563	239.28	127.633	0.958	2.892
S1b	60	124.246	239.28	127.422	0.953	2.888		124.246	239.28	127.422	0.953	2.888
S1c	90	123.93	239.28	127.222	0.949	2.87		123.93	239.28	127.222	0.949	2.87
S1d	120	123.613	239.28	127.032	0.939	2.84		123.613	239.28	127.032	0.939	2.84
S1e	150	123.296	239.28	126.858	0.918	2.773		123.296	239.28	126.858	0.918	2.773
S1f	180	122.979	239.28	126.749	0.826	2.532		122.979	239.28	126.749	0.826	2.532
S1g	210	122.663	239.28	126.701	0.684	2.175		122.663	239.28	126.701	0.684	2.176
S2	225.4	122.5	239.28	126.686	0.61	1.997		122.5	239.28	126.686	0.61	1.997
S2a	245.4	122.565	239.28	126.519	0.748	2.418		122.565	239.28	126.519	0.748	2.418
S2b	265.4	122.631	239.28	126.249	0.961	3.095		122.631	239.28	126.249	0.961	3.096
S3	286.5	122.7	239.28	126.093	1.02	3.401		122.7	239.28	126.093	1.02	3.402
Bridge U	313.5	123.07	239.28	126.158	0.717	2.312		123.07	239.28	126.159	0.717	2.311
Bridge D	319.5	123.07	239.28	126.114	0.757	2.403		123.07	239.28	126.114	0.757	2.403
S5	358	122.36	239.28	125.973	0.775	2.546		122.36	239.28	125.973	0.775	2.546
S5a	378	122.267	239.28	125.832	0.777	2.584		122.267	239.28	125.832	0.777	2.584
S5b	408	122.175	239.28	125.694	0.776	2.613		122.175	239.28	125.694	0.776	2.613

Node Label	Chainage m	Bed Level mOD	Flow m^3/s	Water Level mOD	Froude	Velocity m/s		Bed Level mOD	Flow m^3/s	Water Level mOD	Froude	Velocity m/s
		Existing Channel Conditions						**Proposed Channel Conditions**				
S5c	438	122.082	239.28	125.562	0.767	2.624		122.082	239.28	125.562	0.767	2.624
S5d	468	121.99	239.28	125.44	0.748	2.611		121.99	239.28	125.44	0.748	2.611
S5e	498	121.897	239.28	125.332	0.72	2.57		121.897	239.28	125.332	0.72	2.57
S5f	528	121.804	239.28	125.24	0.682	2.501		121.804	239.28	125.24	0.682	2.501
S6	561.8	121.7	239.28	125.154	0.632	2.401		121.7	239.28	125.154	0.632	2.401

Table 3 ISIS outputs for proposed and existing channel conditions during the 100 year flood

4.4.2 Impact of Development on Current Flood Regime in the Area

The proposed bridge will span 27 m, be 6 m in width and will have a soffit level of 126.5 mOD giving an effective conveyance capacity area of 80 m2. The inlet parameters chosen for the bridge as a result are shown in Appendix C.

Table 3 compares the results from the ISIS computed Q100 model for the proposed and existing channel conditions. It is clear from the results shown in Table 3 that the proposed bridge will have no discernible impact on the hydraulic regime in the analysed reach. These results are discussed below.

The indications are that the new bridge design will result in negligible increase in water level. This arises as the new bridge deck will be high enough and the access track low enough to the existing ground level to not cause a change in conveyance conditions in the design event. However, in a section where the access track is located at the level of the floodplain is projected to be inundated to a height of 0.06 m in the design event.

The proposed bridge will have a freeboard of 0.341 m at its entrance and 0.386 m at its exit for the 100 year design flood. A cross section of the bridge section is exhibited in Figure 19. Velocity through the proposed bridge will be approximately the same as that for existing conditions and the Froude number, Fr, in the vicinity of the proposed bridge will also mirror existing conditions. It is clear from Table 3 that the new bridge will not exacerbate existing flood risk in the river reach with conditions remaining the same as before. A summary of the ISIS computed results are provided in Appendix D.

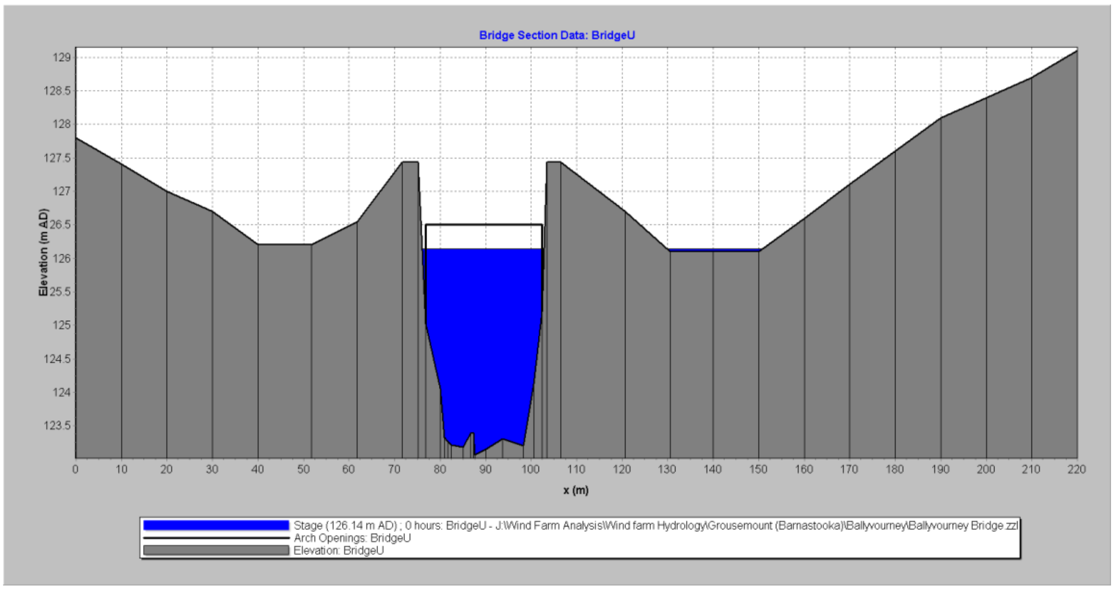


Figure 19 Cross-section of proposed bridge section during 100 year flood (exaggerated y-axis)

A manual analysis using a backwater calculation was carried out to verify the outputs from the ISIS model. The results from this analysis are provided in Table 4 and in addition a more detailed description of the calculations is provided in Appendix F. The outputs from the backwater calculation correspond closely with those computed by ISIS and are within allowable margins of error.

	Backwater calculation water level – 100 year flood (mOD)	ISIS Water Level – 100 year flood (mOD)
Bridge entrance	126.184	126.159
Bridge exit	126.184	126.114

Table 4 Comparison between ISIS results and calculations from first principles

The approximate extent of the floodplain either side of the river in the design flood event as projected by the ISIS model is illustrated in Figure 20.

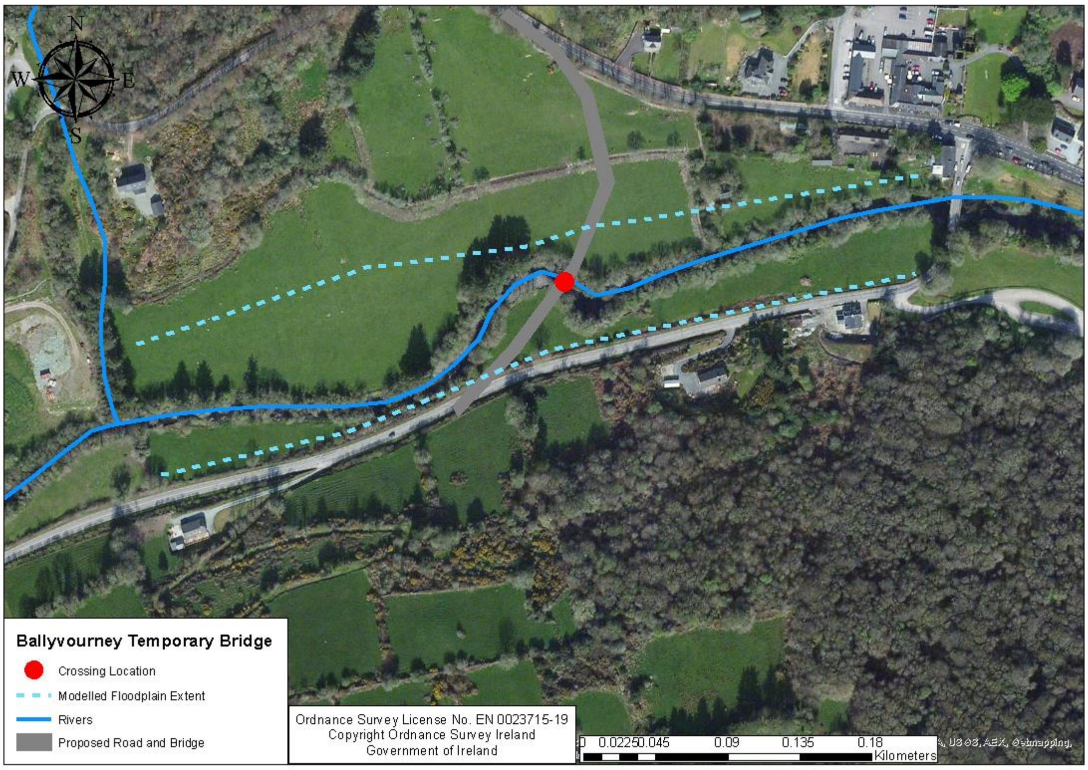


Figure 20 Extent of floodplain in 1% AEP flood event as modelled in ISIS

4.5 Pluvial Flood Risk

Although the annual average rainfall in the Ballyvourney area is high, due to the nature of the site a pluvial modelling assessment has not been undertaken as part of this study. Suitable drainage measures will be installed to manage surface water arising on the bridge and access road and to prevent water run-off from the works areas directly entering the river.

4.6 Groundwater Flood Risk

The Geological Survey of Ireland (GSI) mapping indicates that the site is underlain by alluvium and till derived chiefly from Devonian sandstones. This bedrock is indicated to be a locally important aquifer with bedrock which is moderately productive only in local zones. The GSI indicates that the groundwater is of high to extreme vulnerability to surface contamination as the soil thickness is indicated to be less than 10 m deep.

The ground conditions described indicate that site works are unlikely to encounter groundwater and were groundwater encountered it is likely to be a limited perched groundwater body. Groundwater does not represent a discernible risk for flooding at this site.

5 Conclusions

Model results, which have been validated by hand calculations from first principles, indicate water levels and velocities in the vicinity of the study area will not be affected by the bridge and access road. The 1% AEP flood level is predicted to be more than 300 mm below the soffit level of the proposed temporary bridge placing it in Flood Zone B, in accordance with the Section 50 hydraulic design standard specified by the OPW and the Planning Guidelines. A section of the private access track is projected to be inundated, albeit to a low level (approximately 0.06 m), in the design flood event. It is reasoned that as the development is temporary and will have its use limited to transport vehicles engaged in delivery of wind turbines, such a risk to the site is acceptable if it reduces the potential impact on the existing hydraulic regime in the area.

It is therefore concluded that any risk to the proposed development will be minimal and restricted to a section of the access track which is at the existing ground level in the floodplain. The proposed development is predicted not to have any deleterious effects on the hydraulic characteristics of the river and adjoining floodplain.

6 References

Chow V.T., (1959) Open channel hydraulics, McGraw Hill, New York.

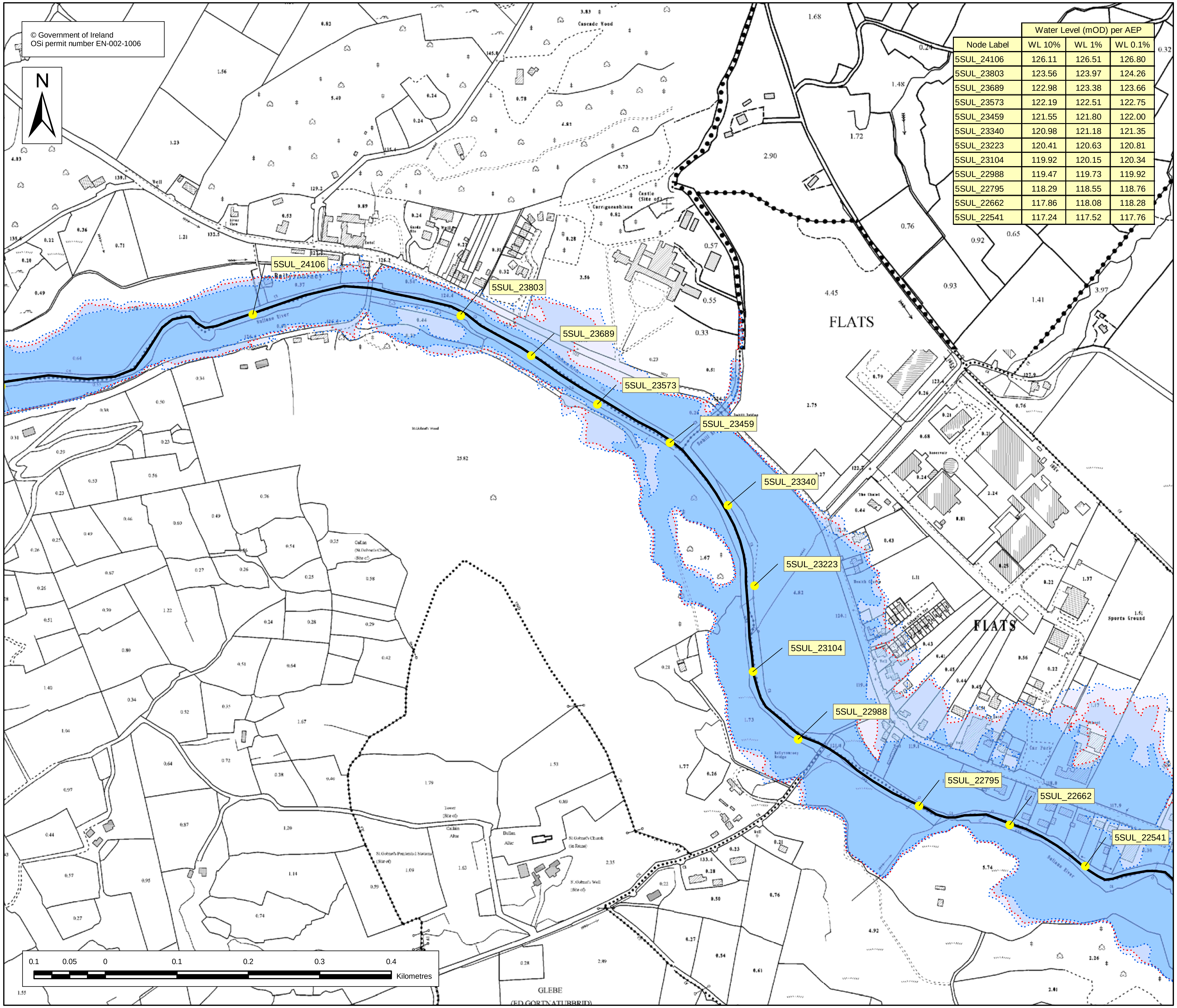
Department of Environment, Heritage and Local Government (2009) The Planning System and Flood Risk Management - Guidelines for Planning Authorities.

Halcrow Group Ireland Ltd. (2014) Lee Catchment Flood Risk Assessment and Management Study – Final Report.

Murphy C., (2009) Flood estimation in ungauged catchments. Work Package 2.3. Flood studies update.

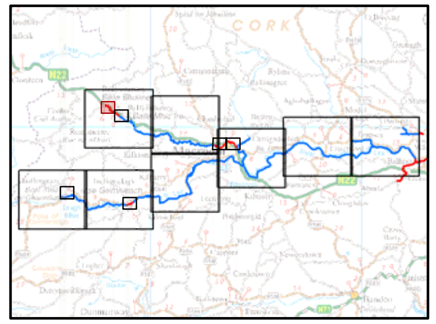
Office of Public Works (2013) Baile Mhic Ire Flood Relief Study Engineering Report

Appendix A: Lee CFRAM Study Ballyvourney-Ballymakeery Flood Maps



	Water Level (mOD) per AEP		
Node Label	WL 10%	WL 1%	WL 0.1%
5SUL_24106	126.11	126.51	126.80
5SUL_23803	123.56	123.97	124.26
5SUL_23689	122.98	123.38	123.66
5SUL_23573	122.19	122.51	122.75
5SUL_23459	121.55	121.80	122.00
5SUL_23340	120.98	121.18	121.35
5SUL_23223	120.41	120.63	120.81
5SUL_23104	119.92	120.15	120.34
5SUL_22988	119.47	119.73	119.92
5SUL_22795	118.29	118.55	118.76
5SUL_22662	117.86	118.08	118.28
5SUL_22541	117.24	117.52	117.76

Location Plan :



EXTENT MAP

Legend:

- 10 % AEP Flood Extent (1 in 10 chance in any given year)
- 1 % AEP Flood Extent (1 in 100 chance in any given year)
- 0.1 % AEP Flood Extent (1 in 1000 chance in any given year)
- High Confidence (<20m) (10% AEP)
- Medium Confidence (<40m) (10% AEP)
- Low Confidence (>40m) (10% and 0.1% AEP)
- High Confidence (<20m) (1% AEP)
- Medium Confidence (<40m) (1% AEP)
- Low Confidence (>40m) (1% AEP)
- River Centreline
- Node Point
- 5ULE_1630 Node Label (refer to table)

USER NOTE :

USERS OF THESE MAPS SHOULD REFER TO THE DETAILED DESCRIPTION OF THEIR DERIVATION, LIMITATIONS IN ACCURACY AND GUIDANCE AND CONDITIONS OF USE PROVIDED AT THE FRONT OF THIS BOUND VOLUME. IF THIS MAP DOES NOT FORM PART OF A BOUND VOLUME, IT SHOULD NOT BE USED FOR ANY PURPOSE.

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OPW
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Dublin 2
Ireland

Project :
LEE CATCHMENT FLOOD RISK ASSESSMENT AND MANAGEMENT STUDY

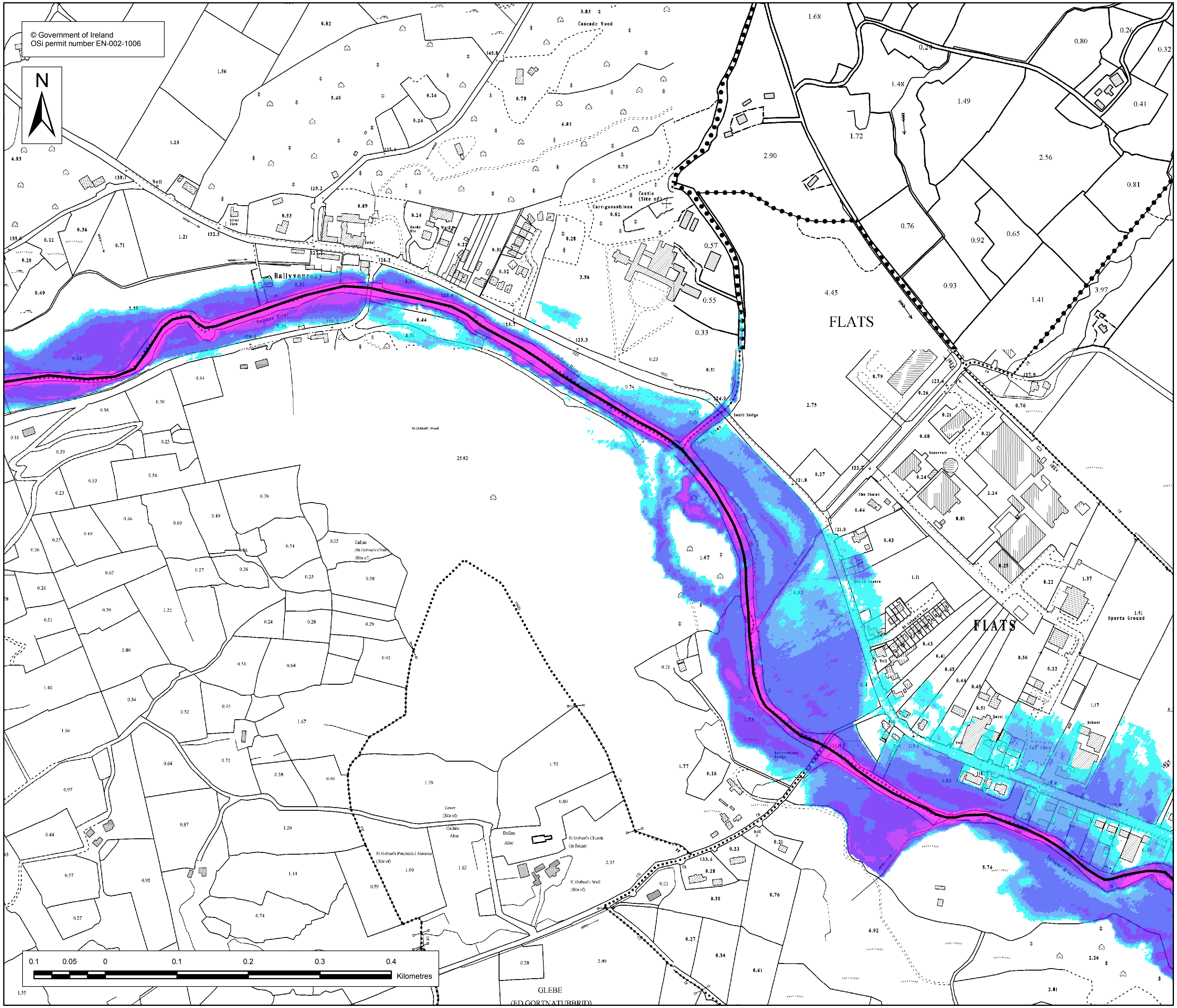
Map :
BAILE BHUIRNE / BAILE MHIC ÍRE

Map Type : FLOOD EXTENT
Source : FLUVIAL FLOODING
Map area : URBAN AREA
Scenario : MID RANGE FUTURE SCENARIO

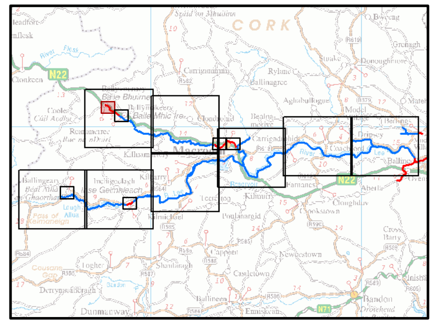
Figure By : Valeria Medina Date : 22 June 2012
Checked By : Paul Dunne Date : 22 June 2012
Approved By : Clare Dewar Date : 22 June 2012

Figure No. : M5/UA/EXT/MRFS/003 Revision 1

Drawing Scale : 1:5,000 Plot Scale : 1:1 @ A3



Location Plan :



DEPTH MAP 1% AEP

Legend Depth Grid:

- 0 - 0.25 m
- 0.25 - 0.50 m
- 0.50 - 1.00 m
- 1.00 - 1.50 m
- 1.50 - 2.00 m
- > 2.00 m
- River Centreline

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Ireland

Project :
LEE CATCHMENT FLOOD RISK ASSESSMENT AND MANAGEMENT STUDY

Map :
BAILE BHUIRNE / BAILE MHIC ÍRE

Map Type :	DEPTH
Return Period :	1% AEP EVENT
Source :	FLUVIAL FLOODING
Map area :	URBAN AREA
Scenario :	CURRENT

Figure By :	Valeria Medina	Date :	03 May 2012
Checked By :	Paul Dunne	Date :	03 May 2012
Approved By :	Clare Dewar	Date :	03 May 2012

Figure No. : M5/UA/DEP/100/003
Revision 1

Drawing Scale : 1:5,000
Plot Scale : 1:1 @ A3

Appendix B: ISIS Software package

ISIS software is a computer program developed and maintained by Halcrow in the U.K. It has been used by ESB International on various river model studies.

ISIS Professional is a full, one-dimensional (1D) hydrodynamic simulator for modelling water flows and levels in open channels and estuaries. It is built on an open file system enabling users to quickly and conveniently see and alter model data files and integrate custom modelling tools. It has user friendly productivity tools, including a model health checker and results extractor and analysis.

ISIS Professional allows users to carry out fast and accurate modelling of the key elements of river and channel systems.

Full interactive views of data and results are available long section and cross section, together with model build checking, advanced results reporting and analysis using tables and graphs.

ISIS Professional can be used to build or view models up to 1000 nodes. An extra add-on to the ISIS Professional of unlimited nodes allows larger models to be built within a 1D environment.

The equations for free surface flow are based on the Saint-Venant equations for flow in open channels. These are used in conjunction with the governing hydraulic equations for each unit. These equations are inevitably a combination of empirical and theoretical equations, many of them nonlinear. The non-linear equations are first linearised and the solution to the linear form of the problem is then found. In order to carry out unsteady simulations an estimate of the initial conditions (flow and stage) are required at every model node. This is most often obtained by carrying out a steady state run at the proposed start time.

ISIS allows the inclusion of structures with automatic operation to be incorporated by means of logical control rules.

Appendix C: Cross sections and bridge details used in ISIS models

Cross-section S1		
x (m)	y (mOD)	Manning's n
0	129.07	0.03
10.5	128.62	0.03
13.6	128.49	0.03
23.1	127.72	0.03
36.7	127.21	0.03
54.4	127.16	0.03
60.5	127.11	0.03
61.7	127.11	0.03
61.8	127.56	0.03
62.6	127.64	0.03
62.9	127.23	0.03
65.3	126.21	0.03
66	125.66	0.03
67.5	125.13	0.04
70.1	125.1	0.04
73	124.88	0.04
74.9	124.91	0.04
76.9	125.23	0.04
77.2	126.62	0.03
78.3	126.57	0.03
79.1	126.44	0.03
82.1	126.85	0.03
90.3	126.74	0.03
95.8	127.15	0.03
110.5	127.9	0.03
Distance to next section		30 m

Cross-section S1a (interpolate)	
Distance to next section	30 m

Cross-section S1b (interpolate)	
Distance to next section	30 m

Cross-section S1c (interpolate)	
Distance to next section	30 m

Cross-section S1d (interpolate)	
Distance to next section	30 m

Cross-section S1e (interpolate)	
Distance to next section	30 m

Cross-section S1f (interpolate)	
Distance to next section	30 m

Cross-section S1g (interpolate)	
Distance to next section	15.4 m

Cross-section S2		
x (m)	y (mOD)	Manning's n
0	127.84	0.03
15.9	127.54	0.03
41.8	126.49	0.03
47.1	126.28	0.03
57.5	125.96	0.03
75.1	125.55	0.03
87.1	125.62	0.03
91.8	125.54	0.03
95.3	125.49	0.03
102.4	125.61	0.03
103.6	125.65	0.03
105.5	125.27	0.03
106.1	124.93	0.03
108.1	124.82	0.03
110.6	125.31	0.03
115.2	125.39	0.03
116.2	124.44	0.03
118	124.07	0.03
119.1	123.89	0.03
119.8	123.32	0.04
120.6	122.92	0.04
124.9	122.5	0.04
125	122.66	0.04
125.3	123.52	0.04
126.3	123.58	0.04
126.4	125.66	0.03
126.9	125.67	0.03
127.1	125.46	0.03
129	125.73	0.03
138.2	126.27	0.03

141.8	126.49	0.03
143	126.6	0.03
Distance to next section		20 m
Cross-section S2a (interpolate)		
Distance to next section		20 m
Cross-section S2b (interpolate)		
Distance to next section		21.1 m
Cross-section S3		
x (m)	y (mOD)	Manning's n
0	128.95	0.03
11.2	128.83	0.03
19.6	128.74	0.03
27.3	128.11	0.03
40.7	126.57	0.03
47.5	126.25	0.03
50.8	124.98	0.03
51.5	124.75	0.03
51.9	123.13	0.04
55.4	122.7	0.04
56.8	122.98	0.04
59.4	123.26	0.04
60.5	123.81	0.03
61.2	123.86	0.03
63.4	124.04	0.03
68.7	124.4	0.03
70.3	125.12	0.03
72.5	125.53	0.03
82.9	125.25	0.03
86.5	125.52	0.03
98.2	125.38	0.03
104.7	125.82	0.03
109	127	0.03
Distance to next section		27 m
Cross-section BridgeU		
x (m)	y (mOD)	Manning's n
0	127.81	0.03
31.7	126.92	0.03
32.1	126.91	0.03
52.7	125.51	0.03
67.8	125.47	0.03
72.2	125.88	0.03

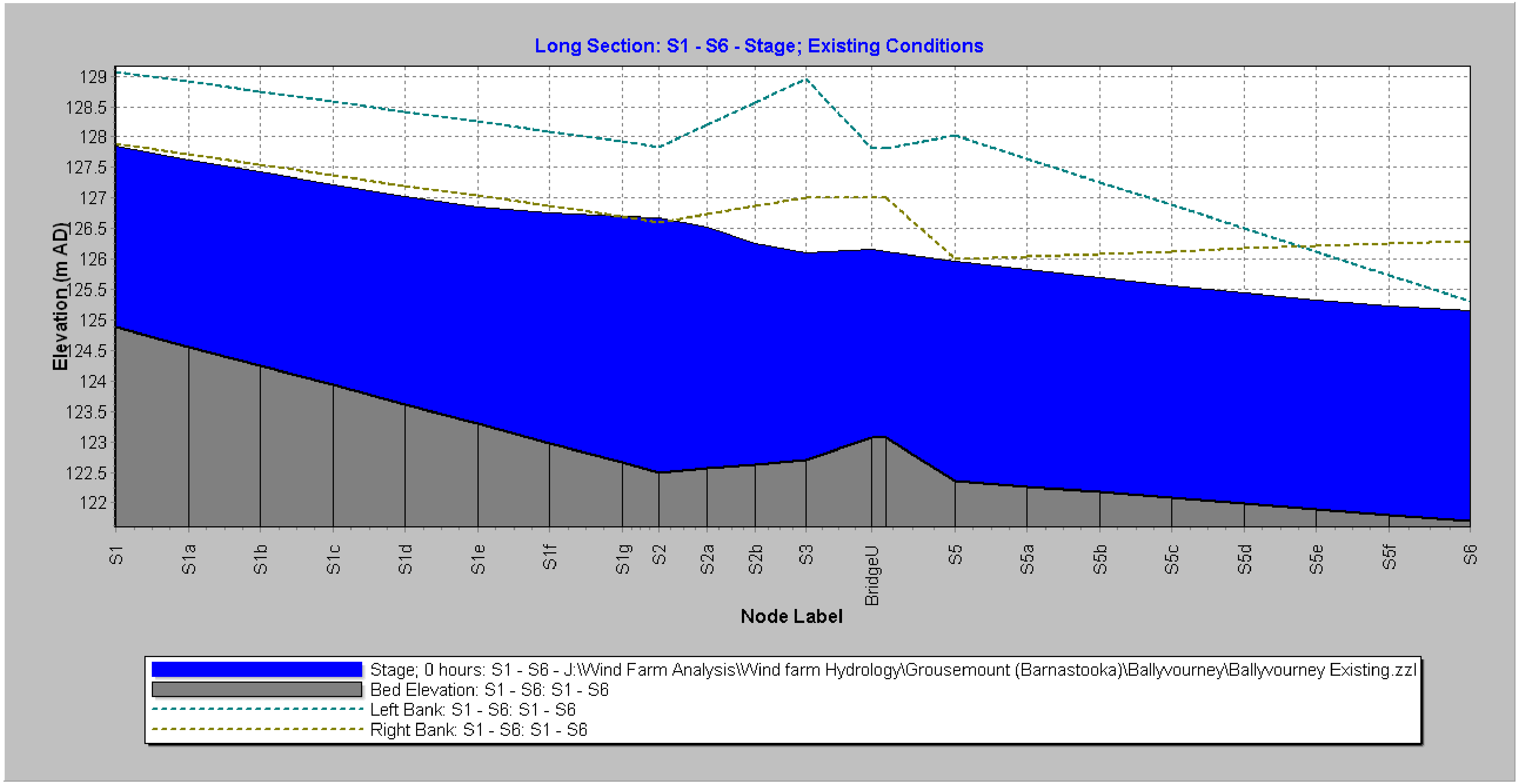
75.1	125.98	0.03
76.1	125.03	0.03
80.1	124.06	0.03
81	123.33	0.04
81.7	123.27	0.04
82.5	123.21	0.04
85	123.18	0.04
86.7	123.39	0.04
87.3	123.4	0.04
87.7	123.07	0.04
90.1	123.15	0.04
93.7	123.31	0.04
98.3	123.2	0.04
100.5	124.12	0.03
102.4	125.2	0.03
111.8	125.33	0.03
119.6	125.53	0.03
130	125.87	0.03
138	127	0.03
Distance to next section		6 m
Bridge USBPR1978: BridgeU		
Bridge Width (m)		27
Dual Distance (m)		6
Soffit Shape		FLAT
Calibration Coefficient		1
Skew Angle		0
Abutment Type		3
x (m)	y (mOD)	Manning's n
0	127.8	0.03
10	127.4	0.03
20	127	0.03
30	126.7	0.03
40	126.2	0.03
51.7	126.2	0.03
61.7	126.55	0.03
71.7	127.435	0.03
75.4	125.03	0.03
76.9	125.03	0.03
80.1	124.06	0.04
81	123.33	0.04
81.7	123.27	0.04
82.5	123.21	0.04
85	123.18	0.04
86.7	123.39	0.04

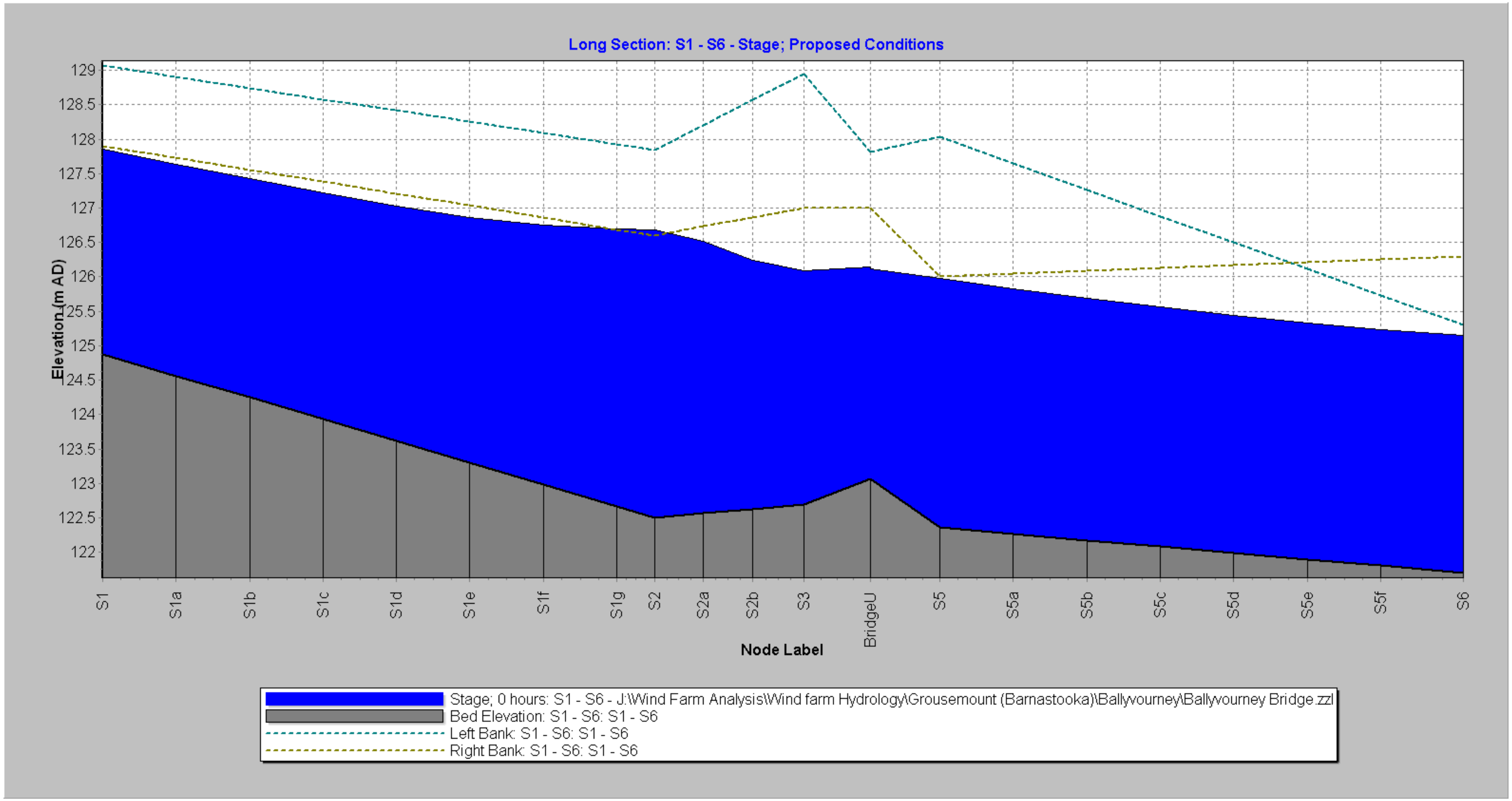
87.3	123.4	0.04
87.7	123.07	0.04
90.1	123.15	0.04
93.7	123.31	0.04
98.3	123.2	0.04
100.5	124.12	0.04
102.4	125.2	0.03
103.4	127.435	0.03
106.551	127.435	0.03
120.6	126.7	0.03
130.6	126.1	0.03
140	126.1	0.03
150	126.1	0.03
160	126.6	0.03
170	127.1	0.03
180	127.6	0.03
190	128.1	0.03
200	128.4	0.03
210	128.7	0.03
220	129.1	0.03
Start (m)		75.4
Finish (m)		102.4
Springing Level (mOD)		126.5
Soffit Level (mOD)		126.5
Cross-section BridgeD		
x (m)	x (m)	x (m)
0	0	0
31.7	31.7	31.7
32.1	32.1	32.1
52.7	52.7	52.7
67.8	67.8	67.8
72.2	72.2	72.2
75.1	75.1	75.1
76.1	76.1	76.1
80.1	80.1	80.1
81	81	81
81.7	81.7	81.7
82.5	82.5	82.5
85	85	85
86.7	86.7	86.7
87.3	87.3	87.3
87.7	87.7	87.7
90.1	90.1	90.1
93.7	93.7	93.7

98.3	123.2	0.04
100.5	124.12	0.03
102.4	125.2	0.03
111.8	125.33	0.03
119.6	125.53	0.03
130	125.87	0.03
138	127	0.03
Distance to next section		28.5 m
Cross-section S5		
x (m)	y (mOD)	Manning's n
0	128.03	0.03
9	127.97	0.03
10.4	127.88	0.03
25.4	126.95	0.03
43.6	125.5	0.03
60.4	125.35	0.03
62.6	125.33	0.03
71.3	124.9	0.03
72.2	124.23	0.03
73	123.6	0.03
77.7	122.92	0.04
80.5	122.7	0.04
82.9	122.36	0.04
84.8	122.36	0.04
85.7	122.56	0.04
87.2	123.61	0.03
89.9	123.45	0.03
91.5	123.85	0.03
94	124.18	0.03
94.9	124.57	0.03
97	124.7	0.03
97.3	125.35	0.03
107.9	125.6	0.03
110.4	125.54	0.03
117	126	0.03
Distance to next section		30 m
Cross-section S5a (interpolate)		
Distance to next section		30 m
Cross-section S5b (interpolate)		
Distance to next section		30 m
Cross-section S5c (interpolate)		

Distance to next section		30 m
Cross-section S5d (interpolate)		
Distance to next section		30 m
Cross-section S5e (interpolate)		
Distance to next section		30 m
Cross-section S5f (interpolate)		
Distance to next section		33.8 m
Cross-section S6		
x (m)	y (mOD)	Manning's n
0	125.3	0.03
6.2	124.63	0.03
8.7	124.43	0.03
11.3	124.24	0.03
16.7	124.06	0.03
16.9	124.36	0.03
17.4	124.48	0.03
18.9	122.47	0.04
19.2	122.55	0.04
20.2	122.02	0.04
21.2	121.7	0.04
24.8	121.72	0.04
29.5	122.08	0.04
32.5	122.32	0.04
33.6	122.65	0.04
33.9	123.14	0.03
36.9	123.46	0.03
44	123.58	0.03
46.6	123.77	0.03
58.7	124.16	0.03
74.7	126.3	0.03
Distance to next section	0 m	

Appendix D: Plots of ISIS Results




Long Section: S1 - S6 - Stage; Proposed Conditions
Elevation (m AD)
129
128.5
128
127.5
127
126.5
126
125.5
125
124.5
124
123.5
123
122.5
122
S1
S1a
S1b
S1c
S1d
S1e
S1f
S1g
S2
S2a
S2b
S3
BridgeU
S5
S5a
S5b
S5c
S5d
S5e
S5f
S6
Node Label
Stage; 0 hours: S1 - S6 - J:\Wind Farm Analysis\Wind farm Hydrology\Grousemount (Barnastooka)\Ballyvourney\Ballyvourney Bridge.zzl
Bed Elevation: S1 - S6: S1 - S6
Left Bank: S1 - S6: S1 - S6
Right Bank: S1 - S6: S1 - S6

Appendix E: FSU Web Portal Output

Flood Estimation Report #3645 (Ballyvourney Bridge)

Generated 26-02-2016 10:45

Subject site

Attributes

Name	Unit	Value
Coordinate [X]		119506.002492912
Coordinate [Y]		77581.9966559816
Distance	km	207.908889639589
Station Number		19_946_2
Location		
Water Body		
Catchment		
Hydrometric Area		
Organisation		
FSU Rating Classification		
Drainage works	year	
Contributing Catchment Area	km^2	55.82
Center Northing	m	76660
Center Easting	m	114830
Northing	m	77582
Easting	m	119506
A-Max series gap in years	year	
A-Max series number of years	year	
A-Max series number of usable years	year	
A-Max series end year	year	
A-Max series start year	year	
FARL		0.997
ALLUV		0.0297
PEAT		0.4163
FOREST		0.3195
PASTURE		0.3161
S1085	m/km	13.87479
MSL	km	13.142
DRAIND	km/km^2	1.35
ALTBAR		266
NETLEN	km	75.337
T4		
T3		

SAAPE	mm	499.66
T2		
ARTDRAIN2		0
ARTDRAIN		0
TAYSLO		1.37645
STMFRQ		105
BFISOIL		0.560236455
SAAR	mm	2029.1
RWSEG_CD		19_946
TOP_RWSEG		
Bankfull		
HGF	m^3/s	
MAF	m^3/s	
FAI		0.0881
FLATWET		0.67
URBEXT		0
HGF/QMED		
centroidx3857		-1028434.6306774
centroidy3857		6788617.05722837
x3857		-1020946.74534826
y3857		6790196.23650278

Pivotal site

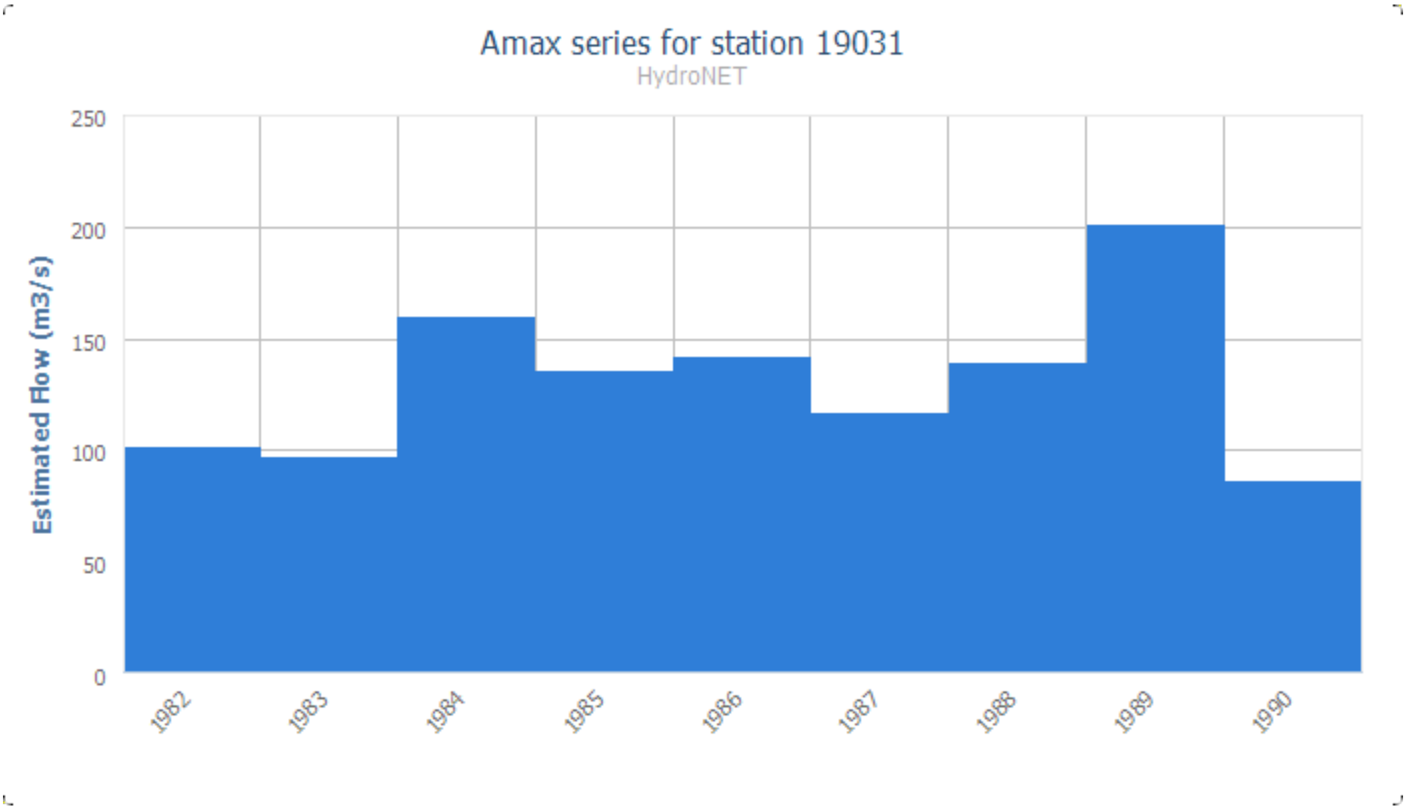
Attributes

Name	Unit	Value
Coordinate [X]		133578.998997881
Coordinate [Y]		72718.99910484
Station Number		19031
Location		MACROOM
Water Body		SULLANE
Catchment		Lee
Hydrometric Area		19
Organisation		ESB
FSU Rating Classification		ESB stn
Drainage works	year	0
Contributing Catchment Area	km^2	216.1121
Center Northing	m	78370
Center Easting	m	122556
Northing	m	72719
Easting	m	133579
A-Max series gap in years	year	0
A-Max series number of years	year	9
A-Max series number of usable years	year	9
A-Max series end year	year	1990
A-Max series start year	year	1982
FARL		0.999
ALLUV		0.0423
PEAT		0.2092
FOREST		0.1899
PASTURE		0
S1085	m/km	4.73156
MSL	km	31.864
DRAIND	km/km^2	1.101
ALTBAR		0
NETLEN	km	237.903
T4		0.17671680966309
T3		0.16379321395835
SAAPE	mm	501.59
T2		0.16912521705409
ARTDRAIN2		0
ARTDRAIN		0
TAYSLO		0.337827
STMFRQ		282
BFISOIL		0.558
SAAR	mm	1775.09
RWSEG_CD		19_892
TOP_RWSEG		19_1397
Bankfull		2.4
HGF	m^3/s	118.71
MAF	m^3/s	0
FAI		0.1
FLATWET		0.66
URBEXT		0.0067
HGF/QMED		0.87350993377483
x3857		-998063.738597367
y3857		6782643.6449761

centroidx3857		-1015701.89408503
centroidy3857		6789550.33462853
Distance	km	12.7668942126178

Map

Amax Series Chart



QMED Estimates

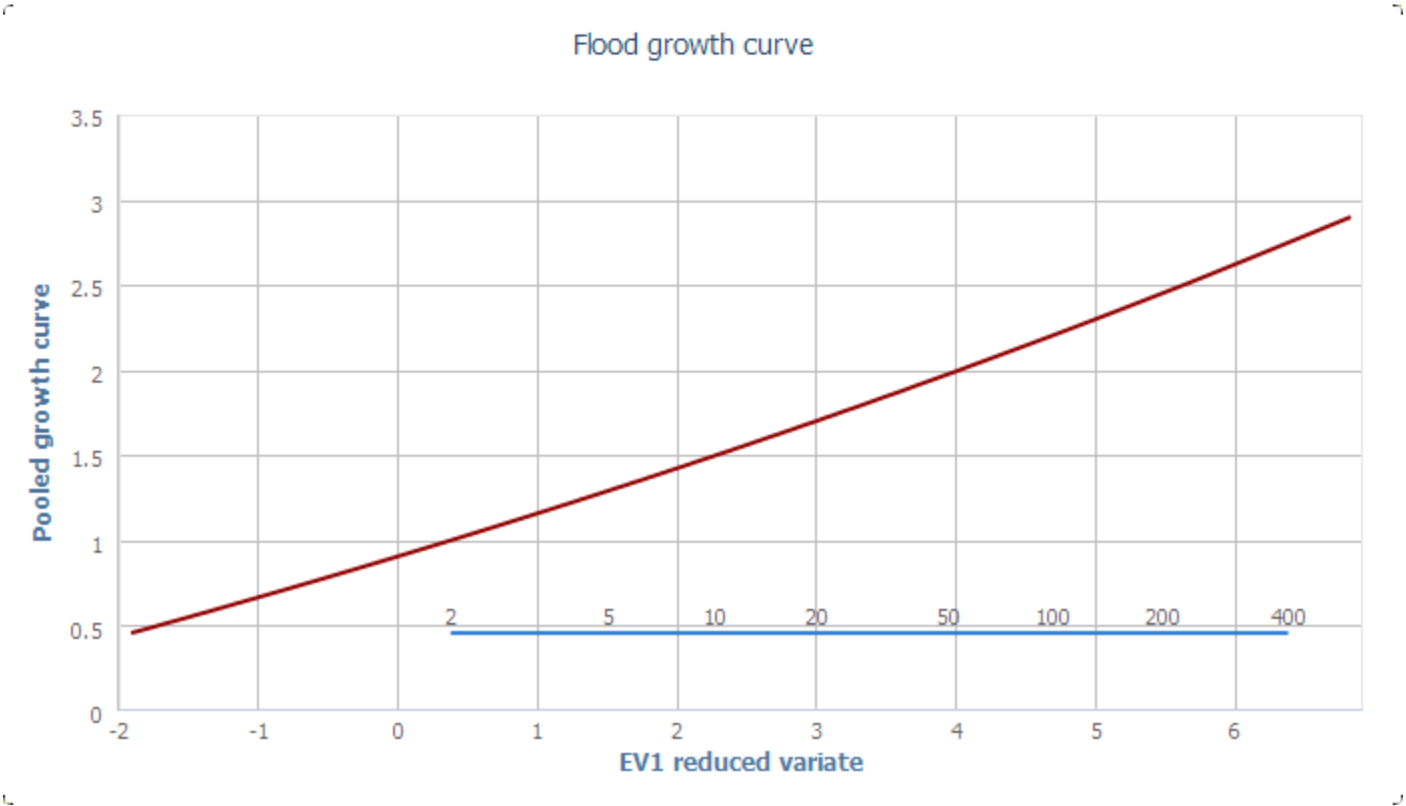
Subject rural QMED	34.14
Subject urban QMED	34.14
Pivotal gauged QMED	135.9
Pivotal adjustment factor QMED	1.71
Subject adjusted QMED	**58.48**

Pooling Group

Station	**Amax years**
21001 CUMMERAGH	25
32012 NEWPORT WEIR	24
19031 MACROOM	9
31072 DERRYCLARE	26
39008 GARTAN BRIDGE	33
30001 CARTRONBOWER	18
19014 DROMCARRA	45
10004 LARAGH	14
31002 CASHLA	26
27070 BAUNKYLE	29

01055 MOURNE BEG WEIR	9
34018 TURLOUGH	27
27003 CORROFIN	47
16013 FOURMILEWATER	33
22035 LAUNE BR.	14
22071 TOMIES PIER	31
20002 CURRANURE	31
10002 RATHDRUM	46
20006 CLONAKILTY W.W.	25

Selected Flood Growth Curve



Pooled growth curve	EV1 reduced variate
0.46	-1.92
0.49	-1.76
0.51	-1.67
0.53	-1.6
0.54	-1.55
0.55	-1.51
0.56	-1.47
0.57	-1.44
0.57	-1.41
0.58	-1.38
0.59	-1.36
0.59	-1.33
0.6	-1.31
0.6	-1.29
0.61	-1.27
0.61	-1.25
0.61	-1.23
0.62	-1.22
0.62	-1.2
0.63	-1.18
0.63	-1.17
0.63	-1.15
0.64	-1.14
0.64	-1.12
0.64	-1.11
0.65	-1.1
0.65	-1.08
0.65	-1.07
0.65	-1.06

0.66	-1.05
0.66	-1.04
0.66	-1.02
0.67	-1.01
0.67	-1
0.67	-0.99
0.67	-0.98
0.68	-0.97
0.68	-0.96
0.68	-0.95
0.68	-0.94
0.68	-0.93
0.69	-0.92
0.69	-0.91
0.69	-0.9
0.69	-0.89
0.7	-0.88
0.7	-0.87
0.7	-0.87
0.7	-0.86
0.7	-0.85
0.71	-0.84
0.71	-0.83
0.71	-0.82
0.71	-0.81
0.71	-0.81
0.72	-0.8
0.72	-0.79
0.72	-0.78
0.72	-0.77
0.72	-0.77
0.73	-0.76
0.73	-0.75
0.73	-0.74
0.73	-0.74
0.73	-0.73
0.73	-0.72
0.74	-0.71
0.74	-0.71
0.74	-0.7
0.74	-0.69
0.74	-0.68
0.74	-0.68
0.75	-0.67
0.75	-0.66
0.75	-0.66
0.75	-0.65
0.75	-0.64
0.75	-0.64
0.76	-0.63
0.76	-0.62
0.76	-0.61
0.76	-0.61
0.76	-0.6
0.76	-0.59
0.77	-0.59
0.77	-0.58

0.77	-0.58
0.77	-0.57
0.77	-0.56
0.77	-0.56
0.78	-0.55
0.78	-0.54
0.78	-0.54
0.78	-0.53
0.78	-0.52
0.78	-0.52
0.78	-0.51
0.79	-0.51
0.79	-0.5
0.79	-0.49
0.79	-0.49
0.79	-0.48
0.79	-0.48
0.79	-0.47
0.8	-0.46
0.8	-0.46
0.8	-0.45
0.8	-0.45
0.8	-0.44
0.8	-0.43
0.8	-0.43
0.81	-0.42
0.81	-0.42
0.81	-0.41
0.81	-0.4
0.81	-0.4
0.81	-0.39
0.81	-0.39
0.82	-0.38
0.82	-0.37
0.82	-0.37
0.82	-0.36
0.82	-0.36
0.82	-0.35
0.82	-0.35
0.83	-0.34
0.83	-0.33
0.83	-0.33
0.83	-0.32
0.83	-0.32
0.83	-0.31
0.83	-0.31
0.84	-0.3
0.84	-0.3
0.84	-0.29
0.84	-0.28
0.84	-0.28
0.84	-0.27
0.84	-0.27
0.84	-0.26
0.85	-0.26
0.85	-0.25
0.85	-0.25

0.85	-0.24
0.85	-0.23
0.85	-0.23
0.85	-0.22
0.86	-0.22
0.86	-0.21
0.86	-0.21
0.86	-0.2
0.86	-0.2
0.86	-0.19
0.86	-0.19
0.86	-0.18
0.87	-0.18
0.87	-0.17
0.87	-0.16
0.87	-0.16
0.87	-0.15
0.87	-0.15
0.87	-0.14
0.88	-0.14
0.88	-0.13
0.88	-0.13
0.88	-0.12
0.88	-0.12
0.88	-0.11
0.88	-0.11
0.88	-0.1
0.89	-0.09
0.89	-0.09
0.89	-0.08
0.89	-0.08
0.89	-0.07
0.89	-0.07
0.89	-0.06
0.89	-0.06
0.9	-0.05
0.9	-0.05
0.9	-0.04
0.9	-0.04
0.9	-0.03
0.9	-0.03
0.9	-0.02
0.91	-0.02
0.91	-0.01
0.91	0
0.91	0
0.91	0.01
0.91	0.01
0.91	0.02
0.91	0.02
0.92	0.03
0.92	0.03
0.92	0.04
0.92	0.04
0.92	0.05
0.92	0.05
0.92	0.06

0.92	0.06
0.93	0.07
0.93	0.08
0.93	0.08
0.93	0.09
0.93	0.09
0.93	0.1
0.93	0.1
0.94	0.11
0.94	0.11
0.94	0.12
0.94	0.12
0.94	0.13
0.94	0.13
0.94	0.14
0.94	0.14
0.95	0.15
0.95	0.16
0.95	0.16
0.95	0.17
0.95	0.17
0.95	0.18
0.95	0.18
0.96	0.19
0.96	0.19
0.96	0.2
0.96	0.2
0.96	0.21
0.96	0.21
0.96	0.22
0.96	0.23
0.97	0.23
0.97	0.24
0.97	0.24
0.97	0.25
0.97	0.25
0.97	0.26
0.97	0.26
0.98	0.27
0.98	0.27
0.98	0.28
0.98	0.29
0.98	0.29
0.98	0.3
0.98	0.3
0.99	0.31
0.99	0.31
0.99	0.32
0.99	0.32
0.99	0.33
0.99	0.34
0.99	0.34
1	0.35
1	0.35
1	0.36
1	0.36
1	0.37

1	0.37
1	0.38
1	0.39
1.01	0.39
1.01	0.4
1.01	0.4
1.01	0.41
1.01	0.41
1.01	0.42
1.02	0.43
1.02	0.43
1.02	0.44
1.02	0.44
1.02	0.45
1.02	0.46
1.02	0.46
1.03	0.47
1.03	0.47
1.03	0.48
1.03	0.48
1.03	0.49
1.03	0.5
1.03	0.5
1.04	0.51
1.04	0.51
1.04	0.52
1.04	0.53
1.04	0.53
1.04	0.54
1.04	0.54
1.05	0.55
1.05	0.56
1.05	0.56
1.05	0.57
1.05	0.57
1.05	0.58
1.06	0.59
1.06	0.59
1.06	0.6
1.06	0.6
1.06	0.61
1.06	0.62
1.06	0.62
1.07	0.63
1.07	0.64
1.07	0.64
1.07	0.65
1.07	0.65
1.07	0.66
1.08	0.67
1.08	0.67
1.08	0.68
1.08	0.69
1.08	0.69
1.08	0.7
1.09	0.71
1.09	0.71

1.09	0.72
1.09	0.73
1.09	0.73
1.09	0.74
1.1	0.74
1.1	0.75
1.1	0.76
1.1	0.76
1.1	0.77
1.1	0.78
1.11	0.79
1.11	0.79
1.11	0.8
1.11	0.81
1.11	0.81
1.11	0.82
1.12	0.83
1.12	0.83
1.12	0.84
1.12	0.85
1.12	0.85
1.13	0.86
1.13	0.87
1.13	0.88
1.13	0.88
1.13	0.89
1.13	0.9
1.14	0.9
1.14	0.91
1.14	0.92
1.14	0.93
1.14	0.93
1.15	0.94
1.15	0.95
1.15	0.96
1.15	0.96
1.15	0.97
1.16	0.98
1.16	0.99
1.16	0.99
1.16	1
1.16	1.01
1.17	1.02
1.17	1.02
1.17	1.03
1.17	1.04
1.17	1.05
1.18	1.06
1.18	1.06
1.18	1.07
1.18	1.08
1.18	1.09
1.19	1.1
1.19	1.1
1.19	1.11
1.19	1.12
1.19	1.13

1.2	1.14
1.2	1.15
1.2	1.15
1.2	1.16
1.21	1.17
1.21	1.18
1.21	1.19
1.21	1.2
1.21	1.21
1.22	1.21
1.22	1.22
1.22	1.23
1.22	1.24
1.23	1.25
1.23	1.26
1.23	1.27
1.23	1.28
1.24	1.29
1.24	1.3
1.24	1.31
1.24	1.32
1.25	1.32
1.25	1.33
1.25	1.34
1.25	1.35
1.26	1.36
1.26	1.37
1.26	1.38
1.26	1.39
1.27	1.4
1.27	1.41
1.27	1.42
1.27	1.43
1.28	1.44
1.28	1.46
1.28	1.47
1.29	1.48
1.29	1.49
1.29	1.5
1.29	1.51
1.3	1.52
1.3	1.53
1.3	1.54
1.31	1.55
1.31	1.57
1.31	1.58
1.32	1.59
1.32	1.6
1.32	1.61
1.33	1.62
1.33	1.64
1.33	1.65
1.34	1.66
1.34	1.67
1.34	1.69
1.35	1.7
1.35	1.71

1.35	1.73
1.36	1.74
1.36	1.75
1.36	1.77
1.37	1.78
1.37	1.79
1.37	1.81
1.38	1.82
1.38	1.83
1.39	1.85
1.39	1.86
1.39	1.88
1.4	1.89
1.4	1.91
1.41	1.92
1.41	1.94
1.41	1.96
1.42	1.97
1.42	1.99
1.43	2
1.43	2.02
1.44	2.04
1.44	2.06
1.45	2.07
1.45	2.09
1.46	2.11
1.46	2.13
1.47	2.15
1.47	2.16
1.48	2.18
1.48	2.2
1.49	2.22
1.49	2.24
1.5	2.26
1.5	2.28
1.51	2.31
1.52	2.33
1.52	2.35
1.53	2.37
1.53	2.4
1.54	2.42
1.55	2.44
1.56	2.47
1.56	2.49
1.57	2.52
1.58	2.55
1.58	2.57
1.59	2.6
1.6	2.63
1.61	2.66
1.62	2.69
1.63	2.72
1.64	2.76
1.64	2.79
1.65	2.82
1.66	2.86
1.67	2.89

1.69	2.93
1.7	2.97
1.71	3.01
1.72	3.06
1.73	3.1
1.75	3.15
1.76	3.19
1.77	3.25
1.79	3.3
1.81	3.36
1.82	3.42
1.84	3.48
1.86	3.55
1.88	3.62
1.91	3.7
1.93	3.78
1.96	3.87
1.99	3.97
2.02	4.08
2.06	4.21
2.1	4.35
2.15	4.52
2.21	4.72
2.29	4.97
2.4	5.3
2.56	5.79
2.9	6.82

Adopted Growth Factors

Return Period	Growth Factor	Design Peak Flow (m^3/s)
1.3	0.82	47.96
2	1	58.48
5	1.29	75.44
10	1.49	87.14
20	1.7	99.42
30	1.81	105.85
50	1.97	115.21
100	2.18	127.49
200	2.4	140.36
500	2.69	157.32
1000	2.93	171.35

Hydrograph Width Estimation Summary

Hydrograph summary is not available for this report because the hydrograph was not transferred to the subject site.

Hydrograph Plots

Hydrographs are not available for this report because module 3 was not finished.

IBIDEM Plots and Tables

No IBIDEM plots were saved by the user.

Audit Trail Report #3645 (Ballyvourney Bridge)

The Office of Public Works
Oifig na nOibreacha Poiblí

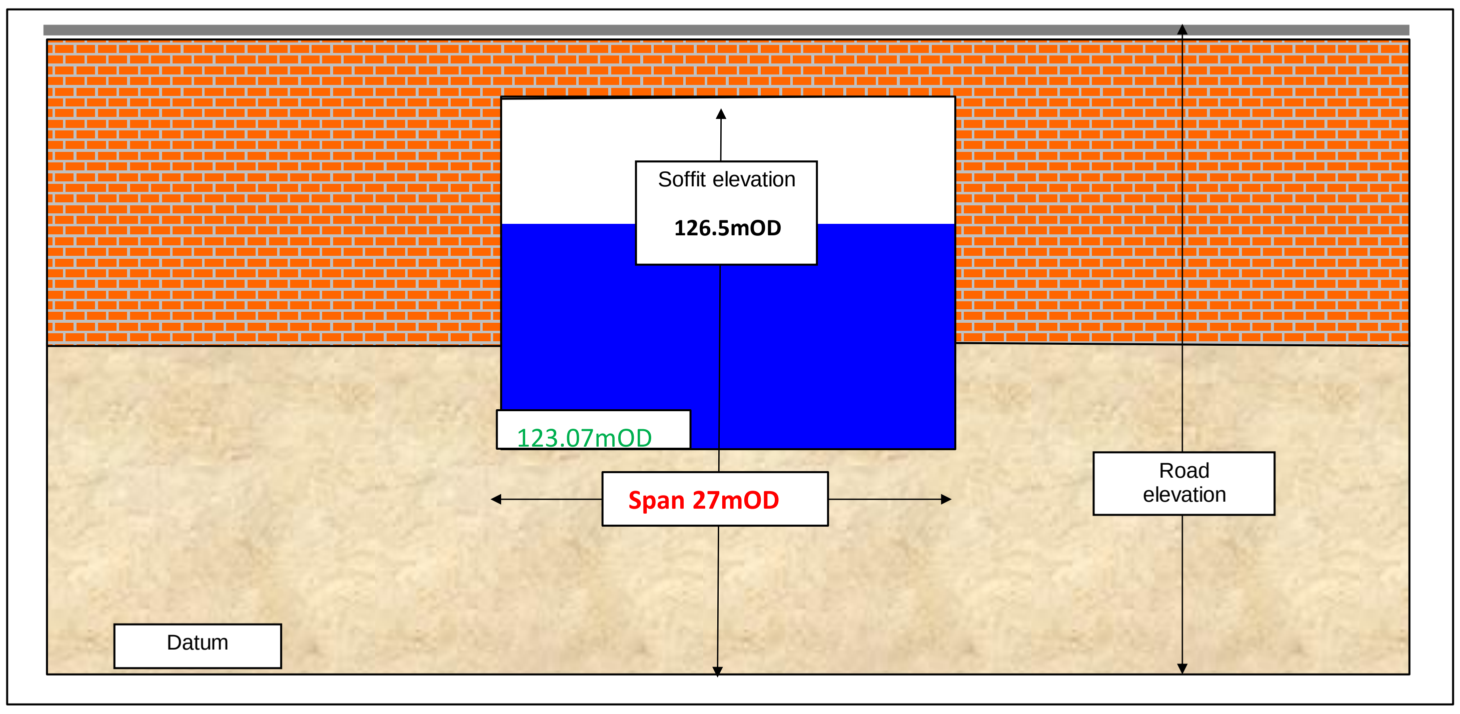
User ID:	harry.griffin@esbi.ie
Name:	Griffin, Harry
Company:	
Address:	
Report date & time:	26-02-2016 10:45
Start of Calculation:	11-01-2016 11:55

Decisions made by the user:

Decision	User comment	System information	Date

Appendix F: Backwater Calculations from first principles

PROJECT	CONTRACT	Calculation No.	
Grousemount Wind Farm	Main Works Contract	1	
CALCULATION TITLE		Calc. Sheet No.	1
Ballyvourney Proposed temporary bridge		of	1
	Calculated by H. Griffin	Date 04/03/2016	



Establish hydraulic performance requirements

Effective bridge height	3.43 m		
Effective bridge span	27.0 m		
Carriageway width	6.00 m		
Elevation of bed at inlet	123.070 mOD	Elevation of soffit at inlet	126.50 mOD
Elevation of bed at outlet	123.070 mOD	Elevation of soffit at outlet	126.50 mOD
Manning n of channel & floodplain	0.0370		

Calculate tailwater level

The bridge discharges to channel with no hydraulic structures likely to affect the water level at the downstream end.

Design discharge, Q	=	239.28 m³/s
Width of invert	=	27 m
Roughness coefficient, n	=	0.0370
Bed slope, S_o	=	0.0069

Calculation

Because there are no hydraulic structures we can assume channel control (rather than structure control) and use the Manning's equation to estimate water depth for the design discharge.

Calculate normal depth

For initial guess of water depth **y = 3.1136m**

The area and wetted perimeter of the relevant cross section are calculated as shown in the graph in the following section.

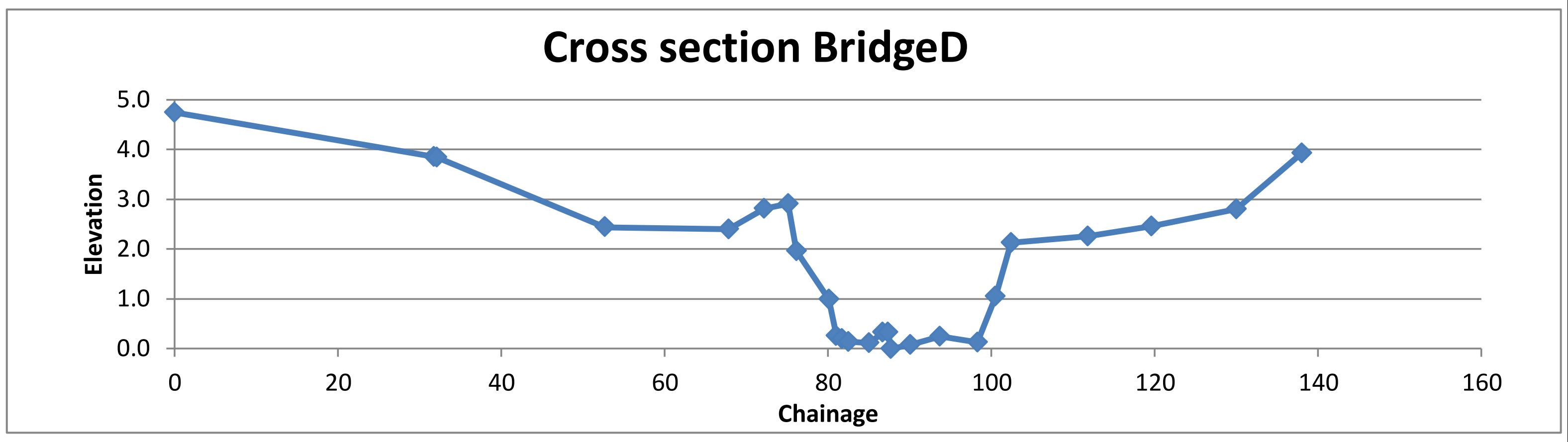
Try water depth=

3.1136 m

Normal depth
3.1136 m

Cross section BridgeD (as modelled in ISIS) (representative cross section downstream of proposed bridge

x (m)	y (m)	width (m)	area (m²)
0	4.74	0.0000	0.0000
31.7	3.85	0.0000	0.0000
32.1	3.84	9.9111	3.3379
52.7	2.44	15.1000	10.4729
67.8	2.4	4.4000	2.2377
72.2	2.81	2.9000	0.7354
75.1	2.91	1.0000	0.6786
76.1	1.96	4.0000	6.5543
80.1	0.99	0.9000	2.2397
81	0.26	0.7000	2.0185
81.7	0.2	0.8000	2.3549
82.5	0.14	2.5000	7.4714
85	0.11	1.7000	4.9276
86.7	0.32	0.6000	1.6731
87.3	0.33	0.4000	1.1794
87.7	0	2.4000	7.3766
90.1	0.08	3.6000	10.6329
93.7	0.24	4.6000	13.4714
98.3	0.13	2.2000	5.5519
100.5	1.05	1.9000	2.8948
102.4	2.13	9.4000	8.6346
111.8	2.26	7.8000	5.8779
119.6	2.46	10.4000	5.0292
130	2.8	2.2200	0.3481
138	3.93		
		51.2200	79.4421
		Total Perimeter	Total Area



Calculate normal depth

A=Calculated from cross section BridgeD = 79.4421 m²

P=Calculated from cross section BridgeD = 51.2200 m

R=A/P = 1.5510 m

$$Q = \left(\frac{1}{n} A R^{2/3}\right) S_o^{1/2}$$

(1/0.037x 79.4421 x 1.551^0.67) x 0.0069 ^1/2 = 239.2793 m³/s

Qdesign 239.28m³/s~ Q calculated 239.2793m³/s

Calculate tailwater elevation

V_{dc}=Q/A= 239.2800 / 79.4421 = 3.0120 m/s

H_t=Z_{bo}+y_{dc}+v_{dc}^2/2g= 123.0700 + 3.1136 + 3.4881^2/2g = Tailwater head 126.6460 mOD

WL_t=Z_{bo}+y_{dc}= 123.0700 + 3.1136 = Tailwater level 126.1836 mOD

Access likely flow type

The tailwater level (WLt=126.1836mOD) is lower than the soffit levels at the bridge outlet (Zso=126.5mOD) and inlet (Zsi=126.5mOD), indicating an unsubmerged outlet and free flow conditions in the bridge barrel.

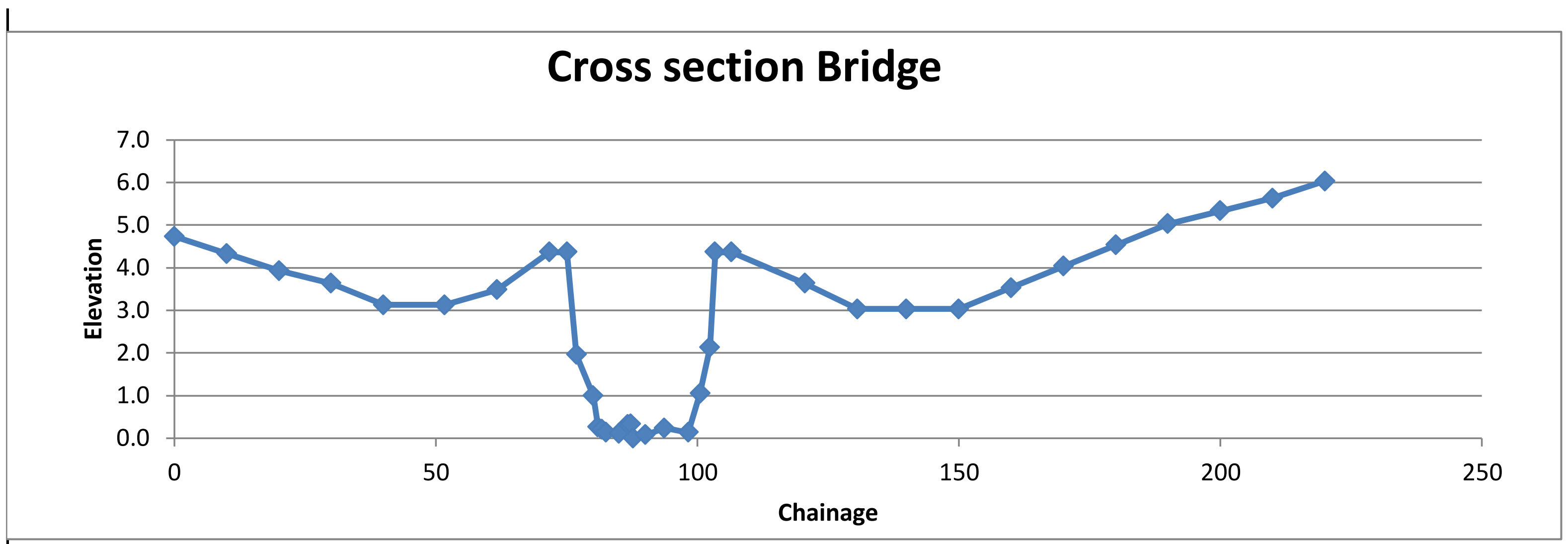
Although the allowable water depth in the bridge barrel y is 3.13 m soffit level - (300 mm freeboard + 123.07m)] we know that the tailwater depth ydc is 3.1136m. Because the depth of flow is likely to be governed by the tailwater depth, we shall assume that tailwater depth applies throughout the culvert.

Cross section Bridge (as modelled in ISIS) (representative cross section

Try water depth=

2.7858 m

x (m)	y (m)	width (m)	area (m)
0.000	4.73	0.0000	0.0000
10.000	4.33	0.0000	0.0000
20.000	3.93	0.0000	0.0000
30.000	3.63	0.0000	0.0000
40.000	3.13	0.0000	0.0000
51.700	3.13	0.0000	0.0000
61.700	3.48	0.0000	0.0000
71.700	4.365	0.0000	0.0000
75.100	4.365	0.6181	0.2552
76.900	1.96	3.2000	4.1947
80.100	0.99	0.9000	1.9448
81.000	0.26	0.7000	1.7891
81.700	0.2	0.8000	2.0927
82.500	0.14	2.5000	6.6521
85.000	0.11	1.7000	4.3704
86.700	0.32	0.6000	1.4765
87.300	0.33	0.4000	1.0483
87.700	0	2.4000	6.5900
90.100	0.0800	3.6000	9.4530
93.700	0.2400	4.6000	11.9639
98.300	0.1300	2.2000	4.8309
100.500	1.0500	1.9000	2.2721
102.400	2.1300	0.2934	0.0962
103.400	4.3650	0.0000	0.0000
106.551	4.3650	0.0000	0.0000
120.600	3.6300	0.0000	0.0000
130.600	3.0300	0.0000	0.0000
140.000	3.0300	0.0000	0.0000
150.000	3.0300	0.0000	0.0000
160.000	3.5300	0.0000	0.0000
170.000	4.0300	0.0000	0.0000
180.000	4.5300	0.0000	0.0000
190.000	5.0300	0.0000	0.0000
200.000	5.33	0.0000	0.0000
210.000	5.63	0.0000	0.0000
220.000	6.03		
		26.4115	59.0300
		Total Perimeter	Total Area



Backwater Calculation								
Proposed conditions						*Existing conditions*		
Depth	3.1136	2.7385	2.7858	3.1136		3.1136		3.1416
Chainage from start point, x=	0.0000	0.0000	6.0000	6.0000		0.0000		8.0000
Bed elevation, z=	123.0700	123.0700	123.0700	123.0700		123.0700		123.0700
Estimate trial water and channel properties								
Cross section area	79.4421	59.0300	59.0300	79.4421		79.4421		79.4421
Cross section perimeter	51.2200	26.4115	26.4115	51.2200		51.2200		51.2200
Hydraulic radius, R=A/P	1.5510	2.2350	2.2350	1.5510		1.5510		1.5510
Compound roughness, n	0.0370	0.0400	0.0400	0.0370		0.0370		0.0370
Conveyance, K=(1/n)AR^0.67	2881.1023	2529.4711	2529.4711	2881.1023		2881.1023		2881.1023
Calculate total head loss for the new point								
Flow velocity, V=Q/A	3.0120	4.0535	4.0535	3.0120		3.0120		3.0120
Velocity head, V^2/2g	0.4624	0.8375	0.8375	0.4624		0.4624		0.4624
Total head, H1=z+y+v^2/2g	126.6460	126.6460	126.6933	126.6460		126.6460		126.6740
Estimate head due to friction								
Friction slope Sf=(Q/K)^2	0.0069	0.0089	0.0089	0.0069		0.0069		0.0069
Mean friction slope, Sfmean=(Sf+Sfprev)/2		0.0079	0.0079	0.0069				0.0034
Δx=xi-xi-1		0.0000	6.0000	0.0000				8.0000
Head loss due to friction, hf=SfmeanΔx		0.0000	0.0475	0.0000				0.0276
Total head, H=Hf		126.6460	126.6935	126.6460				126.6736
Estimated water depth	126.1836	125.8085	125.8558	126.1836		126.1836		126.2116
	Properties based on cross section BridgeD	Bridge	Bridge	Properties based on cross section BridgeU		Properties based on cross section BridgeD		Properties based on cross section

Peat Stability Risk Assessment

ESB Wind Development Ltd.

Grousemount Wind Farm

Document No.: W78035-F105-018-R-0001

Date: August 2015

ESB International, Stephen Court, 18/21 St Stephen's Green, Dublin 2, Ireland.
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File Reference:	W78035	
Client / Recipient:	ESB Wind Development	
Project Title:	Grousemount Wind Farm	
Report Title:	Peat Stability Risk Assessment	
Report No.:	W78035-F105-018-R-0001	
Volume:	1 of 1	
Prepared by:	Susan Stack	Date: 26/08/2015
Title:	Civil Engineer	
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Title:	Consultant Geotechnical Engineer	
Approved by:	Paul Moran	Date: 26/08/2015
Title:	Consultant	

Template Used: T-020-007-ESBI Report Template

Change History of Report

Date	New Revision	Author	Summary of Change
26/08/2015	0	SS	First Issue

Executive Summary

The proposed Grousemount Wind Farm is located on private land approximately 8 km south-east of the village of Kilgarvan in County Kerry. It is proposed to construct 38 wind turbines and associated infrastructure on the site. ESBI were engaged to carry out a Peat Stability Risk Assessment (PSRA) for the wind farm.

The ground conditions across the Grousemount Wind Farm site generally consist of peat overlying glacial till over sandstone and siltstone bedrock. Peat depths are generally less than 1.0 m with only a few locations with peat depths of greater than 2.0 m and a maximum peat depth of 2.5 m.

A peat stability risk assessment was carried out based on the Natural Scotland Scottish Executive "Peat Landslide Hazard and Risk Assessment: Best Practice Guide for Proposed Electricity Generation Developments" (2006) which has also been recommended in the Irish Wind Energy Association (IWEA) "Best Practice Guidelines for the Irish Wind Energy Industry" (2008), and is supplemented by the experiences of ESBI on previously developed sites. Information on the ground conditions, topography, hydrology, ecology, land use and other factors were used to determine the likelihood of peat failure at each location analysed. The impact of a potential peat slide was also considered. The likelihood and impact of a peat failure at different areas of the site were combined to form the risk.

The results of the PSRA show that prior to risk mitigation measures being applied there is an insignificant[1] to substantial[1] peat stability risk rating on Grousemount Wind Farm.

Preliminary design stage, detailed design stage and construction stage mitigation measures have been specified for the project. All peat excavated on the site will be securely stored in excavated borrow pits and peat repositories with engineered rock berm containment that act as a shear key. A portion of the excess peat will be sidecast at suitable locations on the site which will be identified at detailed design stage.

The peat risk has been minimised by optimising the design of the wind farm and will be further mitigated by choosing a safe and controlled construction methodology; having a rigorous documentation and quality control system during construction and by controlling construction activities carefully.

It has been demonstrated within this report that after mitigation measures are applied at the preliminary, detailed design stage and construction stage that the risk rating range will reduce to insignificant[1] or significant[1].

[1] terminology from Scottish Executive Guidelines

Contents

Table of figures

1 Introduction

1.1 Grousemount Wind Farm Project

Grousemount Wind Farm is a proposed 115 megawatts (MW) wind farm on private land approximately 8 km south-east of Kilgarvan village in Co. Kerry. The project is being developed by ESB Wind Development. The proposed development is for 38 no. turbines, the construction of 28 km of new access track, one electrical substation, underground electrical cables linking the turbines with the control buildings, underground electrical cables linking the new substation to the existing substation at Ballyvouskill, Co. Cork, underground communication cables, four meteorological masts, and all related site works and ancillary development including borrow pits and repositories.

1.2 Scope of work

ESB International (ESBI) were engaged by ESB Wind Development to undertake a Peat Stability Risk Assessment (PSRA) for Grousemount Wind Farm. The purpose of this report is to present the results of the PSRA and the mitigation measures adopted to reduce the risk ratings for each element of the wind farm development.

The PSRA is based on a desk top study of the site, a site walkover by ESBI, peat probes taken by ESBI on site, and trial pits and coreholes excavated across the site by IGSL.

2 Desktop Study

2.1 Site Location

The proposed Grousemount Wind Farm site is located approximately 8 km south-east from Kilgarvan in Co. Kerry on the border with Co. Cork (Figure 2-1).

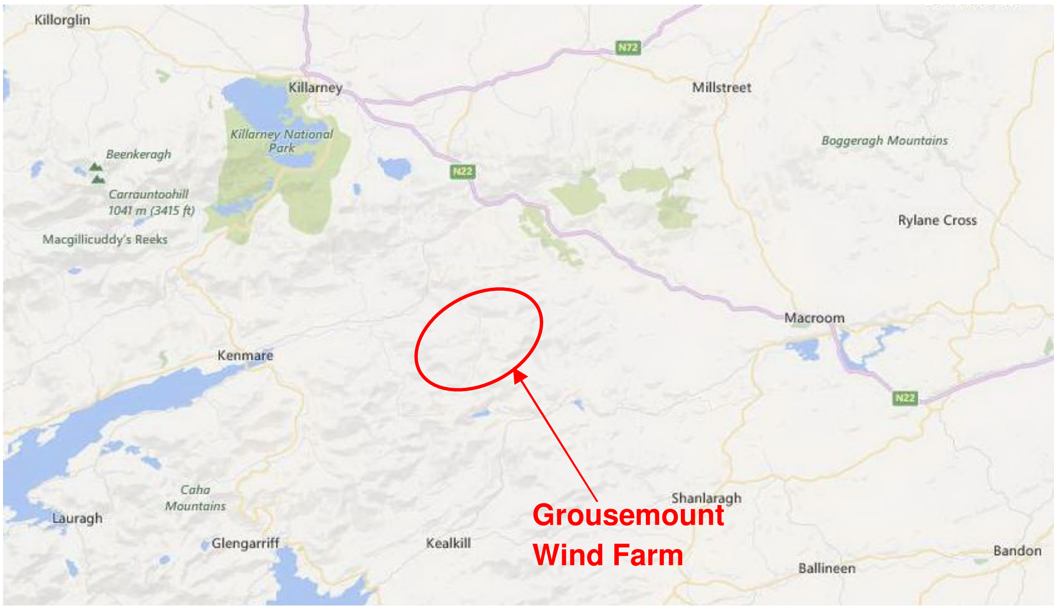

Figure 2-1 Grousemount Wind Farm Site Location (Google Maps)

The R569 Regional Road passes within approximately 5 km of the site to the west at Moreley's Bridge. Access to the site from here is via a third class road. Alternatively it may be accessed directly from the N22 via the same third class road from Ballyvourney.

The overall area of the site is approximately 1,465 hectares (ha).

2.2 Topography

The site is located on a remote mountain area with steep gradients heading towards mountain crests and some relatively flat to gently sloping ground (e.g. valley inverts, saddles and bowl shaped topographical features). The wind farm development covers both sides of the River Roughty valley running approximately South to North.

The turbines are located at elevations between 306 and 493 mOD.

An ordnance survey map of the site is shown in Figure 2-2.

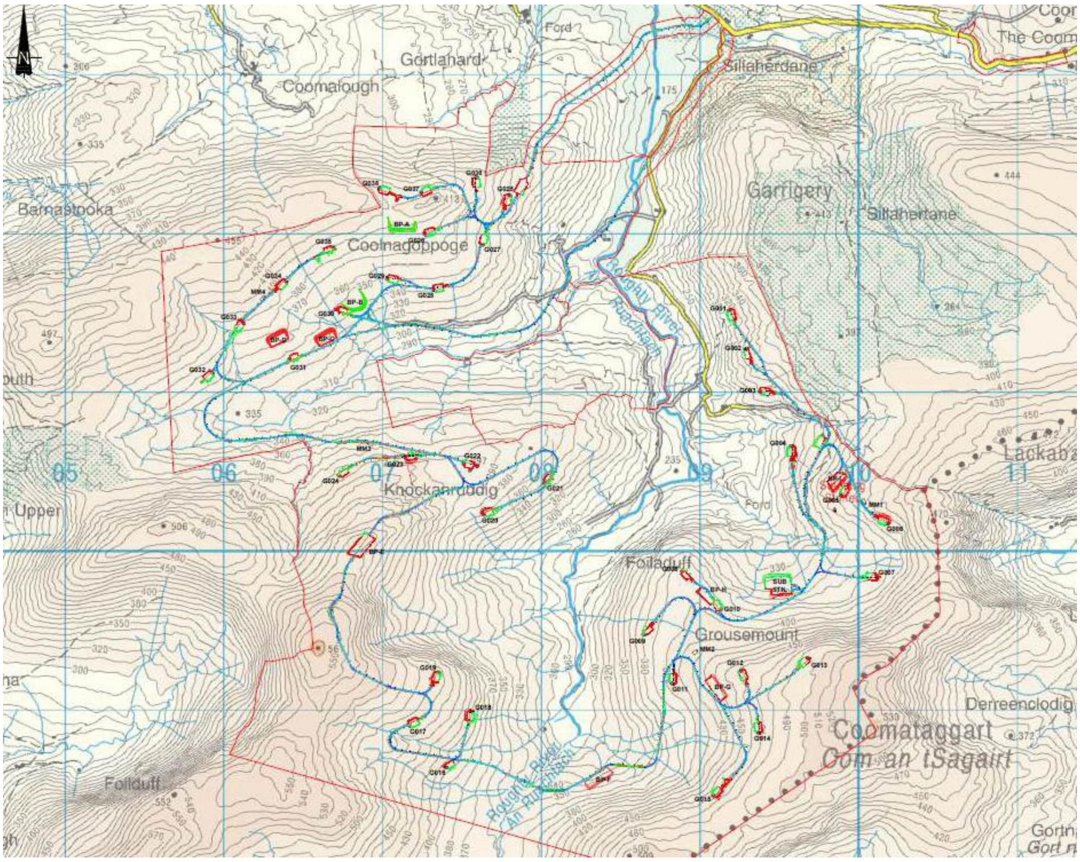

Figure 2-2 Ordnance Survey Map of Grousemount Wind Farm (OSI)

2.3 Geology

Published geological mapping from the Geological Survey of Ireland (GSI) is presented in Figure 2-3. This shows the underlying bedrock at the turbine locations comprises purple siltstone and fine sandstone from the Bird Hill Formation. A small section of the northern end of the site comprises cross bedded sandstone and siltstone of the Slaney Sandstone Formation.

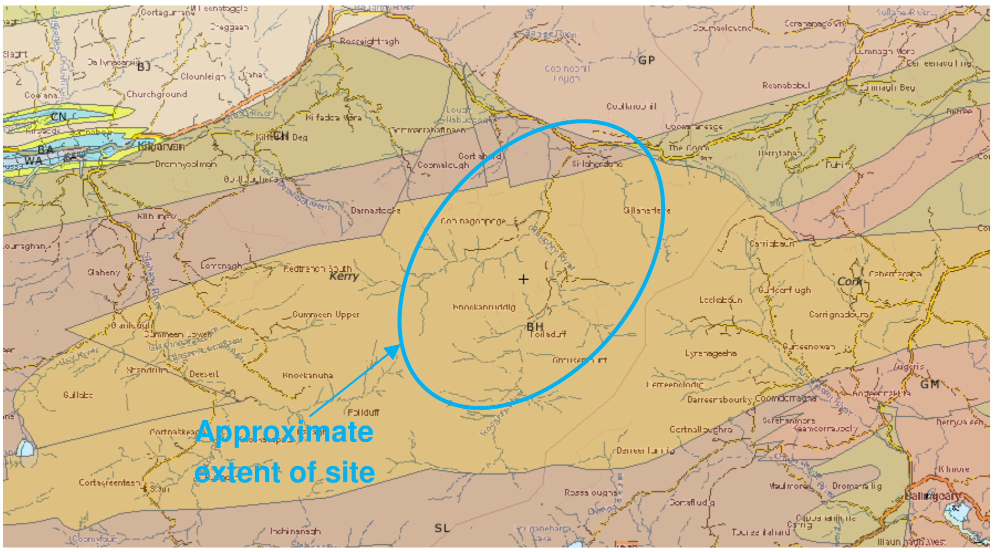

Figure 2-3 Bedrock Geology (GSI)

2.4 Hydrology

2.4.1 Watercourses

The site is located within the South West River Basin District (SWRBD) with surface water from the site forming the upper reaches of the River Roughty, an important fishery, which flows through Kilgarvan to enter the sea at Kenmare Bay.

2.4.2 Groundwater

Groundwater was observed at less than 30% of the trial pit locations. Seepage was primarily from ground level, and through the subsoil layers on occasion. Where water ingress was noted in the trial pits the side walls became unstable, in particular in cases where seepage was from ground level.

The GSI National Draft Bedrock Aquifer map indicates that the bedrock aquifer can be classified as either a poor aquifer where bedrock is generally unproductive except for local zones, or a locally important aquifer where bedrock is moderately productive only in local zones.

2.4.3 Precipitation

The nearest weather station to Grousemount Wind Farm is at Valentia Observatory located approximately 60 km west of the proposed wind farm.

The mean monthly rainfall at Valentia Observatory is presented in Figure 2-4 below.

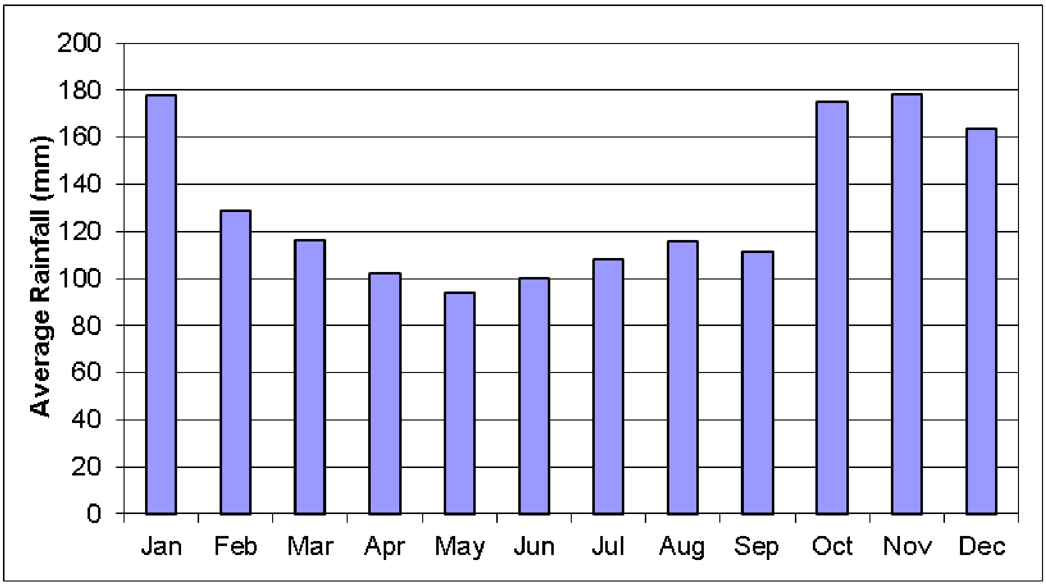

Figure 2-4 Mean monthly rainfall at Valentia Observatory 1985 – 2014 (Met Éireann)

Met Éireann also publishes rainfall maps based on an observation period of 30 years. Figure 2-5 below indicates a mean annual rainfall within the range of 1,600 – 2,000 mm / year for Grousemount Wind Farm between 1981 and 2010.

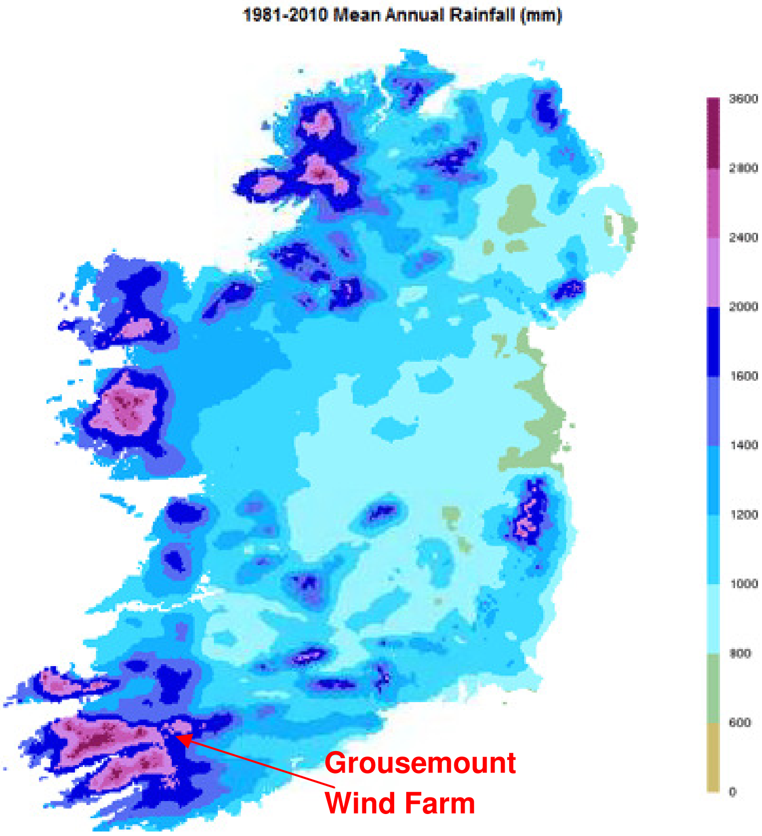

Figure 2-5 Mean Yearly Rainfall 1981 – 2010 (Met Éireann)

There is no data on snowfall available for the site.

2.5 Land Use

The lands at the site consists mainly of overgrown grassland with little evidence of grazing. Land cover is predominantly rock, heath and peat.

The site is not being used for turf cutting.

Apart from the section of Coillte property at the site entrance from the main public road, there are no forestry plantations on the site.

2.6 Ecology

The development site is not part of any area designated for nature conservation.

The site is dominated by wet heath vegetation which is a common habitat in the upland regions of Co. Kerry and Co. Cork where it is found on shallow peat and in areas of degraded blanket bog. Other important habitats such as dry heath and scrub woodland also occur but have a relatively restricted distribution. Limited areas of blanket bog occur on deeper peat at higher altitudes and especially on plateau areas.

Detailed information on the ecology of the site, which can be found in the Environmental Impact Statement, lies outside the scope of this report.

2.7 Landslide Database

GSI have a land slide database containing locations and details of recorded landslides throughout the Republic of Ireland. Two recorded landslides have taken place within 10 km of Grousemount Wind Farm.

- Fuhiry: A peat slide took place approximately 4 km northeast of the wind farm site in 1997 following a period of heavy rain and flooding. The slide occurred in a woodland area near an existing road and caused infrastructure damage.
- Gortacreenteen: A debris slide took place approximately 6 km southwest of the wind farm site in 2004 following a period of heavy rain and flooding. The slide occurred near a peat bog area and caused infrastructure damage covering a stretch of over 1 kilometre.

2.8 Aerial Photography

Aerial photographs of the site is available to view on the Ordnance Survey Mapviewer website. Aerial photographs of the site from 1995, 2000 and 2005 were examined and features relevant to the geotechnical assessment noted. More recent satellite images from Google Maps and Bing Maps were also examined.

The aerial photography didn't give signs of peat instability on the site or the surrounding areas.

The aerial photography can be seen on drawing QR320171-MWC-P-1017 in Appendix A.

2.9 Desktop Information Sources

- Google Maps
- Bing Maps
- Geological Survey of Ireland
- Ordnance Survey Ireland
- Met Éireann
- LiDar
- Aerial photography

3 Site Investigations

3.1 Site works

Extensive peat probing has been carried out by ESBI during numerous site walkovers to determine the depth of peat across the site.

A site investigation comprising trial pits along the access tracks, turbine locations and other infrastructure locations, along with rotary boreholes and geophysics at the turbine, substation and borrow pit locations, was commenced by IGSL in Spring 2015. The rotary borehole works on site are ongoing and are expected to be completed by late Autumn 2015.

The site investigation works were carried out under two separate contracts by the same contractor; one covering turbines T1 – T24 and all associated infrastructure referred to as Grousemount Wind Farm, and the second covering turbines T25 – T38, the substation and all other associated infrastructure referred to as Barnastooka Wind Farm. These two contracts relate to two previously permitted wind farms which are being amalgamated to produce this proposed larger Grousemound Wind Farm development.

The results of the ground investigation carried out by IGSL to date are contained in Appendix B. The ground investigation reports will be finalised before the end of 2015 following the completion of the site works and any outstanding soil and rock laboratory tests.

The locations of all trial pits excavated at Grousemount Wind Farm are shown on drawings QR320171-MWC-P-1020 (Sheets 1 – 7) contained in Appendix A.

3.2 Summary of ground conditions

The ground conditions across the Grousemount Wind Farm site generally comprise of peat overlying glacial till over sandstone and siltstone bedrock.

The peat on the site is described as soft, dark brown / black and fibrous with many rootlets which extend into the subsoil layer in places.

Peat depths are less than 1 m at just over 80% of the turbine locations and less than 0.5 m at over 50% of the turbine locations. Turbine T22 is the only turbine where the peat depth (recorded at 2.2 m) is greater than 2.0 m.

Peat depths are less than 1 m along almost 80% of the site access tracks and less than 0.5 m along approximately 50% of the access tracks. There are only two pockets along the access tracks where the peat depth is in excess of 2.0 m; one at Chainage 500 on the site access towards turbine T30 and another along the main spine road between the junctions of turbines T24 and T35, north of the River Roughty catchment. Here the peat depths are 2.2 m and 2.4 m respectively.

Peat depths at the substation location vary from 0.4 m – 2.5 m.

Apart from Borrow Pit A and Borrow Pit C, the peat depths at the borrow pit / repository locations are less than 1 m. Borrow pits A and C each have a pocket of deeper peat with depths of 1.4 m and 1.3 m respectively.

An important feature of the peat stability risk assessment is the subsoil condition of the strata located directly beneath the peat layer and the nature of the interface between the peat and the subsoil immediately beneath.

In the majority of the trial pits, soft to firm sandy gravelly silt was encountered directly beneath the peat. The thickness of this stratum varies from 0.2 m to 2.0 m. There are a few select locations across the site where the peat lies directly on gravel, cobbles and boulders or weathered rock, in particular along the main spine access track near Borrow Pit E.

Bedrock encountered in the trial pits and the rotary boreholes excavated to date is sandstone or siltstone. Approximately 80% of the trial pits excavated terminated at a depth shallower than that specified due to an obstruction of possible bedrock. This depth varied from 0.1 mBGL to 3.5 mBGL. From the borehole records, the quality of the rock appears to improve with depth.

Groundwater was observed at less than 30% of the trial pit locations. Seepage was primarily from ground level, and through the subsoil layers on occasion. Where water ingress was noted in the trial pits the side walls became unstable, in particular in cases where seepage was from ground level.

4 Site Observations

4.1 Site walkover

The site walkover surveys followed proposed routes to the turbines, substation, anemometer mast, borrow pit and repository locations. Observations were made at each location. A trial pit was excavated as close as possible to each location.

The following drawings contained in Appendix A summarise information on the site obtained from site observations and desktop study.

- QR320171-MWC-P-1001: Overall Site Layout
- QR320171-MWC-P-1020 (Sheets 1 – 7): Site Layout 1:2,500 scale including all site investigation locations
- QR320171-MWC-P-1017: Aerial Map
- QR320171-MWC-P-1018: Peat Depth Map
- QR320171-MWC-P-1019: Ground Slope Map

4.2 Turbines and hardstands

The critical input values for the turbine and hardstand locations are presented in Table 4-1 below.

Turbines & Hardstand No.	Ground Conditions and Topography
T1	• Peat depth: < 0.5 m ⇨ No further assessment required based on this depth of peat.
T2	• Peat depth: < 0.5 m ⇨ No further assessment required based on this depth of peat.
T3	• Peat depth: < 1 m • Ground Slope: > 7°; SW • Distance from nearest watercourse: < 200 m • Turbine / hardstand in grasslands.
T4	• Peat depth: < 0.5 m ⇨ No further assessment required based on this depth of peat.
T5	• Peat depth: < 1 m • Ground Slope: 3° - > 10°; NW

Turbines & Hardstand No.	Ground Conditions and Topography
	• Distance from nearest watercourse: 200 – 300 m • Turbine / hardstand in grasslands.
T6	• Peat depth: 0.5 m • Ground Slope: > 7°; SW • Distance from nearest watercourse: > 300 m • Turbine / hardstand in grasslands.
T7	• Peat depth: 1.7 m • Ground Slope: > 7°; W • Distance from nearest watercourse: < 200 m • Turbine / hardstand in grasslands.
T8	• Peat depth: 0.7 m • Ground Slope: 7° - > 10°; N • Distance from nearest watercourse: > 300 m • Turbine / hardstand in grasslands.
T9	• Peat depth: > 1.5 m • Ground Slope: 3° - > 10°; W • Distance from nearest watercourse: > 300 m • Turbine / hardstand in grasslands.
T10	• Peat depth: 1.0 – 1.7 m • Ground Slope: 0° - >10°; NE • Distance from nearest watercourse: < 200 m • Turbine / hardstand in grasslands.
T11	• Peat depth: 0.8 m • Ground Slope: 0° - 5°; SW • Distance from nearest watercourse: > 300 m • Turbine / hardstand in grasslands.
T12	• Peat depth: < 0.5 m ⇨ No further assessment required based on this depth of peat.
T13	• Peat depth: 0.5 – 1 m • Ground Slope: 3° - > 10°; NW

Turbines & Hardstand No.	Ground Conditions and Topography
	• Distance from nearest watercourse: > 300 m • Turbine / hardstand in grasslands.
T14	• Peat depth: 0.8 m • Ground Slope: > 7°; W • Distance from nearest watercourse: < 200 m • Turbine / hardstand in grasslands.
T15	• Peat depth: 1.2 m • Ground Slope: > 7°; NW • Distance from nearest watercourse: 200 – 300 m • Turbine / hardstand in grasslands.
T16	• Peat depth: 0.7 m • Ground Slope: > 7°; SE • Distance from nearest watercourse: < 200 m • Turbine / hardstand in grasslands.
T17	• Peat depth: 1.2 m • Ground Slope: > 7°; SE • Distance from nearest watercourse: < 200 m • Turbine / hardstand in grasslands.
T18	• Peat depth: 0.6 m • Ground Slope: >7°; E • Distance from nearest watercourse: > 300 m • Turbine / hardstand in grasslands.
T19	• Peat depth: < 0.5 m ⇨ No further assessment required based on this depth of peat.
T20	• Peat depth: 0.5 m • Ground Slope: > 7°; SE • Distance from nearest watercourse: < 200 m • Turbine / hardstand in grasslands.
T21	• Peat depth: 0.5 m • Ground Slope: > 7°; SE

Turbines & Hardstand No.	Ground Conditions and Topography
	• Distance from nearest watercourse: < 200 m • Turbine / hardstand in grasslands.
T22	• Peat depth: 2.2 m • Ground Slope: 0° - 7°; NW • Distance from nearest watercourse: < 200 m • Turbine / hardstand in grasslands.
T23	• Peat depth: 1.3 m • Ground Slope: > 7°; NE • Distance from nearest watercourse: < 200 m • Turbine / hardstand in grasslands.
T24	• Peat depth: 1.7 m • Ground Slope: 3° - > 10°; NW • Distance from nearest watercourse: < 200 m • Turbine / hardstand in grasslands.
T25	• Peat depth: 0.5 m • Ground Slope: > 7°; E • Distance from nearest watercourse: < 200 m • Turbine / hardstand in grasslands.
T26	• Peat depth: 0.5 m • Ground Slope: 0° - >10°; SE • Distance from nearest watercourse: < 200 m • Turbine / hardstand in grasslands.
T27	• Peat depth: < 0.5 m ⇨ No further assessment required based on this depth of peat.
T28	• Peat depth: 0.5 m • Ground Slope: 0° - > 10°; E • Distance from nearest watercourse: < 200 m • Turbine / hardstand in grasslands.
T29	• Peat depth: 0.8 m • Ground Slope: 0° - > 10°; S

Turbines & Hardstand No.	Ground Conditions and Topography
	• Distance from nearest watercourse: < 200 m • Turbine / hardstand in grasslands.
T30	• Peat depth: < 1 m • Ground Slope: 0° - > 10°; SE • Distance from nearest watercourse: < 200 m • Turbine / hardstand in grasslands.
T31	• Peat depth: 0.5 m • Ground Slope: 0° - > 10°; SE • Distance from nearest watercourse: 200 – 300 m • Turbine / hardstand in grasslands.
T32	• Peat depth: < 0.5 m ⇨ No further assessment required based on this depth of peat.
T33	• Peat depth: 0.6 m • Ground Slope: 0° - >10°; SE • Distance from nearest watercourse: < 200 m • Turbine / hardstand in grasslands.
T34	• Peat depth: 0.6 m • Ground Slope: > 7°; SE • Distance from nearest watercourse: < 200 m • Turbine / hardstand in grasslands.
T35	• Peat depth: < 1 m • Ground Slope: 0° - > 10°; SE • Distance from nearest watercourse: < 200 m • Turbine / hardstand in grasslands.
T36	• Peat depth: < 0.5 m ⇨ No further assessment required based on this depth of peat.
T37	• Peat depth: 1 m • Ground Slope: >7°; NW • Distance from nearest watercourse: < 200 m

Turbines & Hardstand No.	Ground Conditions and Topography
	• Turbine / hardstand in grasslands.
T38	• Peat depth: 0.6 – 2.4 m • Ground Slope: >7°; N • Distance from nearest watercourse: < 200 m • Turbine / hardstand in grasslands.

Table 4-1 Critical PSRA Factors at Turbine / Hardstand Locations

4.3 Access tracks

The critical input values for the access tracks are presented in Table 4-2. The access tracks where peat depths are greater than 0.5 m have been assessed individually and assigned an individual tag. The worst case scenario for each of the critical input values has been selected for each section of access track.

Access Track No.	Ground Conditions / Topography
Access Track (AT) 1: T1 – T2 Junction	• Peat depth: 0.7 m • Ground Slope: >10°; E • Distance from nearest watercourse: < 200 m • Access track in grasslands.
AT2: T2 Spur	• Peat depth: < 0.5 m ⇨ No further assessment required based on this depth of peat.
AT3: T2 Junction – T3 Junction	• Peat depth: < 0.5 m ⇨ No further assessment required based on this depth of peat.
AT4: T3 Spur	• Peat depth: < 0.5 m ⇨ No further assessment required based on this depth of peat.
AT5: T3 Junction – Public Road	• Peat depth: < 0.5 m ⇨ No further assessment required based on this depth of peat.
AT6: Public Road – T6 Junction	• Peat depth: 1.4 m • Ground Slope: > 10°; E • Distance from nearest watercourse: < 200 m • Access track in grasslands.

Access Track No.	Ground Conditions / Topography
AT7: T6 Junction – T6	• Peat depth: < 0.5 m ⇨ No further assessment required based on this depth of peat.
AT8: T6 Junction – T4 Junction	• Peat depth: 1 m • Ground Slope: > 10°; E • Distance from nearest watercourse: < 200 m • Access track in grasslands.
AT9: T4 Spur	• Peat depth: < 1 m • Ground Slope: > 10°; E • Distance from nearest watercourse: 200 – 300 m • Access track in grasslands.
AT10: T4 Junction – T7 Junction	• Peat depth: 1.2 m • Ground Slope: 0° - > 10°; W • Distance from nearest watercourse: < 200 m • Access track in grasslands.
AT11: T7 Spur	• Peat depth: 0.6 m • Ground Slope: 0° - > 10°; E • Distance from nearest watercourse: < 200 m • Access track in grasslands.
AT12: T7 Junction – T10 Junction	• Peat depth: 1.8 m • Ground Slope: 3° - > 10°; N • Distance from nearest watercourse: < 200 m • Access track in grasslands.
AT13: T10 Junction – T8	• Peat depth: 0.8 m • Ground Slope: 0° - > 10°; NE • Distance from nearest watercourse: < 200 m • Access track in grasslands.
AT14: T10 Junction – T9	• Peat depth: 1.5 m • Ground Slope: 3° - 7°; NW, N, NE • Distance from nearest watercourse: > 300 m • Access track in grasslands.

Access Track No.	Ground Conditions / Topography
AT15: T9 Junction – T11 Junction	• Peat depth: 1.4 m • Ground Slope: 3° - 7°; NW • Distance from nearest watercourse: < 200 m • Access track in grasslands.
AT16: T11 Junction – Borrow Pit G	• Peat depth: 1.1 m • Ground Slope: 0° - > 10°; SW • Distance from nearest watercourse: > 300 m • Access track in grasslands.
AT17: Borrow Pit G – T13	• Peat depth: < 1 m • Ground Slope: > 7°; NW • Distance from nearest watercourse: < 200 m • Access track in grasslands.
AT18: T12 Spur	• Peat depth: < 1 m • Ground Slope: > 7°; W • Distance from nearest watercourse: < 200 m • Access track in grasslands.
AT19: T14 Spur	• Peat depth: < 1 m • Ground Slope: > 7°; W • Distance from nearest watercourse: < 200 m • Access track in grasslands.
AT20: Borrow Pit G – T15 Spur Ch. 900	• Peat depth: 0.8 m • Ground Slope: > 7°; W, NW • Distance from nearest watercourse: < 200 m • Access track in grasslands.
AT21: T15 Spur Ch. 900 – T15	• Peat depth: 1.3 m • Ground Slope: >7°; NW • Distance from nearest watercourse: < 200 m • Access track in grasslands.
AT22: T11 Junction – Borrow Pit F	• Peat depth: 0.9 m • Ground Slope: >7°; W • Distance from nearest watercourse: < 200 m

Access Track No.	Ground Conditions / Topography
	• Access track in grasslands.
AT23: Borrow Pit F – River Roughty	• Peat depth: 1.3 m • Ground Slope: 0° - > 10°; N • Distance from nearest watercourse: < 200 m • Access track in grasslands.
AT24: River Roughty – T16	• Peat depth: < 0.5 m ⇨ No further assessment required based on this depth of peat.
AT25: T16 - T18	• Peat depth: 1.3 m • Ground Slope: > 7°; SE • Distance from nearest watercourse: < 200 m • Access track in grasslands.
AT26: T16 – T17	• Peat depth: 1.3 m • Ground Slope: 3° - > 10°; SE • Distance from nearest watercourse: < 200 m • Access track in grasslands.
AT27: T17 – Ch. 1850 (including T19 spur)	• Peat depth: 1.5 m • Ground Slope: > 7°; E • Distance from nearest watercourse: > 300 m • Access track in grasslands.
AT28: Ch. 1850 – Ch. 1400	• Peat depth: 0.6 m • Ground Slope: 3° - > 10°; E • Distance from nearest watercourse: < 200 m • Access track in grasslands.
AT29: Ch. 1400 – Borrow Pit E	• Peat depth: 1.9 m • Ground Slope: 0° - > 10°; N • Distance from nearest watercourse: < 200 m • Access track in grasslands.
AT30: Borrow Pit E – Main Spine Road Parts 3 & 4 Intersection	• Peat depth: 1.9 m • Ground Slope: 3° - > 10°; NE • Distance from nearest watercourse: < 200 m

Access Track No.	Ground Conditions / Topography
	• Access track in grasslands.
AT31: T20 Spur	• Peat depth: 1.1 m • Ground Slope: 0° - > 10°; E • Distance from nearest watercourse: < 200 m • Access track in grasslands.
AT32: Main Spine Road Parts 3 & 4 Intersection – T24 Junction	• Peat depth: 0.8 m • Ground Slope: 0° - 5°; E • Distance from nearest watercourse: < 200 m • Access track in grasslands.
AT33: T22 Spur	• Peat depth: < 0.5 m ⇨ No further assessment required based on this depth of peat.
AT34: T24 Spur	• Peat depth: 1.3 m • Ground Slope: 0° - > 10°; NW • Distance from nearest watercourse: > 300 m • Access track in grasslands.
AT35: T24 Junction – T35 Junction	• Peat depth: 2.4 m • Ground Slope: 0° - > 10°; N • Distance from nearest watercourse: < 200 m • Access track in grasslands.
AT36: T35 Spur	• Peat depth: 0.7 m • Ground Slope: 0° - > 10°; SE • Distance from nearest watercourse: < 200 m • Access track in grasslands.
AT37: T35 Junction – T31	• Peat depth: 0.6 m • Ground Slope: 3° - > 10°; SE • Distance from nearest watercourse: < 200 m • Access track in grasslands.
AT38: T31 – T30 Site Access Junction	• Peat depth: < 0.5 m ⇨ No further assessment required based on this depth of peat.

Access Track No.	**Ground Conditions / Topography**
AT39: T30 Site Access (Ch. 1450 – Ch. 2350)	• Peat depth: 1.3 m • Ground Slope: 3° - > 10°; SE • Distance from nearest watercourse: < 200 m • Access track in grasslands.
AT40: T30 Site Access (Ch. 650 – Ch. 1450)	• Peat depth: < 0.5 m ⇨ No further assessment required based on this depth of peat.
AT41: T30 Site Access (Ch. 0 – Ch. 650)	• Peat depth: 2.2 m • Ground Slope: 3° - > 10°; SE • Distance from nearest watercourse: < 200 m • Access track in grasslands.
AT42: T30 Site Access Junction – T29 Junction	• Peat depth: 0.6 m • Ground Slope: 0° - > 7°; SE • Distance from nearest watercourse: < 200 m • Access track in grasslands.
AT43: T30 Spur	• Peat depth: < 0.5 m ⇨ No further assessment required based on this depth of peat.
AT44: T29 Spur	• Peat depth: < 0.5 m ⇨ No further assessment required based on this depth of peat.
A45: T29 Junction – T27	• Peat depth: 0.6 m • Ground Slope: 0° - > 10°; S, SE • Distance from nearest watercourse: < 200 m • Access track in grasslands.
AT46: T27 – T30 Site Access Junction	• Peat depth: 1.2 m • Ground Slope: 3° - > 10°; E • Distance from nearest watercourse: < 200 m • Access track in grasslands.
AT47: T26 Spur	• Peat depth: 0.9 m • Ground Slope: 3° - > 10°; SE • Distance from nearest watercourse: < 200 m

Access Track No.	Ground Conditions / Topography
	• Access track in grasslands.
AT48: T38 Spur (Ch. 80 – Ch. 300)	• Peat depth: < 0.5 m ⇨ No further assessment required based on this depth of peat.
AT49: T38 Spur (Ch. 300 – Ch. 410)	• Peat depth: 0.8 m • Ground Slope: 3° - > 10°; N • Distance from nearest watercourse: < 200 m • Access track in grasslands.
AT50: T36 Spur	• Peat depth: 0.8 m • Ground Slope: 3° - > 10°; E • Distance from nearest watercourse: < 200 m • Access track in grasslands.
AT51: T25 Site Access (Ch. 400 – Ch. 1650)	• Peat depth: 1.4 m • Ground Slope: 3° - > 10°; NE • Distance from nearest watercourse: > 300 m • Access track in grasslands.
AT52: T25 Site Access (Ch. 230 – Ch. 400) farmland	• Peat depth: < 0.5 m ⇨ No further assessment required based on this depth of peat.
AT53: T25 Site Access (Ch. 0 – Ch. 230) Coillte	• Peat depth: < 0.5 m ⇨ No further assessment required based on this depth of peat.
AT54: Everwind Wind Farm Site Entrance	• Peat depth: < 0.5 m ⇨ No further assessment required based on this depth of peat.
AT55: Coillte track through Everwind Wind Farm	• Peat depth: < 1 m • Ground Slope: 3° - > 10°; SW • Distance from nearest watercourse: < 200 m • Access track in grasslands.

Table 4-2 Critical PSRA Factors at Access Track Locations

4.4 Other infrastructure

The critical input values for the other infrastructure locations are presented in Table 4-3 below.

Other Infrastructure	**Ground Conditions / Topography**
Substation	• Peat depth: 1 – 3 m • Ground Slope: 0° - > 10°; N • Distance from nearest watercourse: < 200 m • Access track in grasslands.
Borrow Pit A	• Peat depth: 0.4 – 1.4 m • Ground Slope: 0° - > 10°; SE • Distance from nearest watercourse: < 200 m • Borrow pit in grasslands.
Borrow Pit B	• Peat depth: < 1 m • Ground Slope: 3° - 7°; SE • Distance from nearest watercourse: < 200 m • Borrow pit in grasslands.
Borrow Pit C	• Peat depth: 0.2 – 1.3 m • Ground Slope: 0° - > 10°; SE • Distance from nearest watercourse: < 200 m • Borrow pit in grasslands.
Borrow Pit D	• Peat depth: < 1 m • Ground Slope: 0° - > 10°; SE • Distance from nearest watercourse: > 300 m • Borrow pit in grasslands.
Borrow Pit E	• Peat depth: 0.1 – 1.2 m • Ground Slope: 3° - > 10°; NW, N, NE • Distance from nearest watercourse: > 300 m • Borrow pit in grasslands.
Borrow Pit F	• Peat depth: 0.3 – 0.7 m • Ground Slope: > 10°; NW, N • Distance from nearest watercourse: < 200 m • Borrow pit in grasslands.

Other Infrastructure	Ground Conditions / Topography
Borrow Pit G	• Peat depth: 0.2 – 1.2 m • Ground Slope: > 10°; SW • Distance from nearest watercourse: < 200 m • Borrow pit in grasslands.
Borrow Pit H	• Peat depth: 0.5 – 0.8 m • Ground Slope: 0° - > 10°; NE • Distance from nearest watercourse: 200 – 300 m • Borrow pit in grasslands.
Borrow Pit I	• Peat depth: < 1 m • Ground Slope: : 0° - > 10°; NW • Distance from nearest watercourse: < 200 m • Borrow pit in grasslands.
Anemometer Mast 1	• Peat depth: < 0.5 m ⇨ No further assessment required based on this depth of peat.
Anemometer Mast 2	• Peat depth: 1.9 m • Ground Slope: 0° - > 10°; NW • Distance from nearest watercourse: < 200 m • Anemometer mast in grasslands.
Anemometer Mast 3	• Peat depth: < 0.5 m ⇨ No further assessment required based on this depth of peat.
Anemometer Mast 4	• Peat depth: < 0.5 m ⇨ No further assessment required based on this depth of peat.

Table 4-3 Critical PSRA Factors at Other Infrastructure Locations

5 Evaluation of Stability

5.1 General

The evaluation of the stability of peat at the site is carried out using a Peat Stability Risk Assessment (PSRA). The following section provides the details and results of the first stage PSRA for the site. The PSRA is based on the Natural Scotland Scottish Executive “Peat Landslide Hazard and Risk Assessment: Best Practice Guide for Proposed Electricity Generation Developments” (2006) which has also been recommended in the Irish Wind Energy Association (IWEA) “Best Practice Guidelines for the Irish Wind Energy Industry” (2008), and is supplemented by the experiences of ESBI on previously developed sites. This document set out four categories of risk and recommends various mitigation / avoidance actions for each category for each.

Peat stability risk is categorised as insignificant, significant, substantial or serious. Construction can take place in areas where risk categories range from insignificant to substantial with varying mitigation requirements. The insignificant and significant categories represent areas where the risk of peat instabilities are either considered negligible in a standard construction environment or considered manageable by the adoption of specific additional mitigation measures respectively.

5.2 Methodology for Peat Stability Risk Assessment

The PSRA quantifies the risk level by assessing the likelihood of a peat instability event and the impact of that event. The risk rating is the product of the likelihood and the impact.

$$\text{Risk Rating} = \text{Likelihood} \times \text{Impact}$$

Figure 5-1 Risk Rating Formula

The likelihood is evaluated by considering all the available geotechnical, topographical, hydrological and hydrogeological characteristics of the site. The amount of information available depends of the level of site investigation that has been carried out.

Factors that are considered to be indicative of slope instability such as peat depth, subsoil conditions and slope angles are measured. Other factors, which have an indirect affect on peat stability, such as drainage, topography, vegetation, land use and previous peat slides in the locality are also assessed.

An impact assessment is carried out based on factors related to the volume of peat in a potential peat slide and the effect of a peat slide down slope. These factors include peat volume, downslope topography and sensitivity of ecological environment in environment, infrastructure and buildings in potential flow paths.

In the PSRA, 22 likelihood factors and nine impact factors are scored on a scale of 0 to 3. A score of 0 indicates the factor is not relevant and scores of 1 – 3 are assigned depending on the risk associated with the factor from 1 (low) to 3 (high).

Likelihood factors which have the greatest influence on a potential peat failure and impact factors which have the greatest influence on the severity of the consequences are given a weighting to reflect their relative importance.

The score for each factor is multiplied by the weighting and the total of all the factor scores is expressed as a ratio of the maximum possible score.

The maximum possible score only includes the factors that have been used in the assessment i.e. factors with a score of 0 are not relevant and so do not contribute to the maximum possible score.

$$\textbf{Likelihood Score} = \frac{\Sigma\ (\text{Likelihood Factor Score x Factor Weighting})}{\Sigma\ (3 \text{ x Factor Weighting})^*}$$

$$\textbf{Impact Score} = \frac{\Sigma\ (\text{Impact Factor Score x Factor Weighting})}{\Sigma\ (3 \text{ x Factor Weighting})^*}$$

****only non zero factors counted***

Figure 5-2 Likelihood and Impact Score Formulae

Table 5-1 shows the four categories that the likelihood and impact scores fall into from negligible to high.

Likelihood Score	
0.0-0.3	Negligible
0.3-0.5	Low
0.5-0.7	Medium
0.7-1.0	High

Impact Score	
0.0-0.3	Negligible
0.3-0.5	Low
0.5-0.7	Medium
0.7-1.0	High

Table 5-1 Likelihood and Impact Scoring System

The risk rating is determined by multiplying the likelihood score by the impact score. The risk rating ranges between 0 and 1 and four risk levels are determined based on the risk rating result. The risk levels are given in Table 5-2 and are used to determine the level of site investigation required. A further explanation of the risk ratings is given following the table.

Risk Rating	Risk Level	Action Required
0.0 - 0.18	Insignificant	Normal Site Investigations (SI)
0.19 - 0.42	Significant	Targeted SI. Design of specific mitigation measures. Part time supervision during construction.
0.43 - 0.66	Substantial	Avoid construction or mitigate against hazard in the area if possible. Detailed SI and design of specific mitigation measures. Full time supervision during construction.
0.67 - 1.0	Serious	Avoid construction in this area.

Table 5-2 Risk Ratings and Risk Levels

Insignificant: Essentially there is no peat depth of consequences on site. There is no likelihood of a peat instability occurring and no significant impact. Good construction practice should be followed but no peat stability risk exists. This amounts to areas where peat depth is less than 0.5 m and this is further supported in the Irish document “Best Practice for Wind Energy Development in Peatlands” issued by the Department of the Environment, Community and Local Government.

Significant: Peat exists on site greater than depths of 0.5 m. However, the combination of the risk of an instability event occurring and impact is relatively low. Good construction practice should be followed with elimination of the risk through mitigation by design. Periodic supervision by a geotechnical engineer is required to ensure adequacy of the designed mitigation.

Substantial: In this case peat depths are greater than 0.5 m depth. A number of broad scenarios can occur which will place the risk assessment of a site into the substantial category and are as follows:

a) The risk of an instability event is high but the impact of such an event occurring is low (e.g. a depth of peat greater than 1.0 m on a north facing slope of 3° – 7° close by a sensitive river which would be likely to develop a medium volume of peat flow). In this case only a localised impact may occur and no significant impact will occur overall. Further site investigation serves to refine the risk rating. The detailed design is carried out based on this information with specific mitigation measures. Contractors and site geotechnical staff develop method statements to minimise and mitigate the risk which are signed off. It also requires supervision and monitoring of ground conditions by a geotechnical engineer.

b) The risk of an instability event is low and the impact of such an occurrence is high (e.g. a depth of peat greater than 1.0 m on a south facing slope of less than 3° but far removed from a sensitive river which, in the case of an instability event, would be likely to develop a large volume of peat flow). In the unlikely event that such an instability event occurs then the impact will be substantial. Mitigation is as above.

c) The risk of an instability event is high and the impact of such an occurrence is also high (e.g. a depth of peat greater than 1.0 m on a north facing slope of 3° – 7° but far removed from a sensitive river which would be likely to develop a large volume of peat flow). In this case the impact of the occurrence will be substantial.

Serious: In this case peats depths, slope and potential level of impacts are high with the risk of occurrence very high also. Mitigation is generally not possible and it is not therefore possible to reduce the risk to a manageable or safe level. Construction should not proceed at locations with this risk category

5.3 Factors affecting peat stability

Table 5-3 presents a list of likelihood factors that effect the outcome of the peat stability assessment at the site combined with associated comments relevant to this particular site.

Likelihood Factors	Explanation	Comments
Peat Characteristics		
Peat depth	This factor is a critical factor in stability of peat on slopes and is therefore highly weighted	Depth based on peat probes and trial pits.
Peat stability condition	This factor indicates strength and stability of the peat.	Based on trial pits excavated by IGSL.
Subsoil Conditions		
Subsoil type	The nature of the subsoil can have an effect on the likelihood of an instability issue, i.e. firm glacial till materials present a lesser risk than soft sensitive soils.	Based on trial pits excavated by IGSL.
Transition zone and peat subsoil interface	The nature of the interconnection between the peat and the mineral subsoil impacts on the stability.	Based on trial pits excavated by IGSL.
Topography		
Elevation	Historically sites with elevations > 200 mOD have been more prone to peat slides.	Elevations at Grousemount Wind Farm are all greater than 200 mOD.
Slope aspect	Slopes to the north, north	The turbines, hardstands,

Likelihood Factors	Explanation	Comments
	west and north east present a higher risk of peat instability than to the east, south and west due to increased difficulty in drying.	roads and other proposed areas of construction at Grousemount Wind Farm are sloping in various directions.
Ground slope	The angle of the ground slope tends to have a significant impact on the stability of peat slopes and this is therefore highly weighted.	Slopes across the site are generally steep; >10° across a large proportion of the site.
Slope characteristics downslope	This includes the nature of the slope, i.e. whether planar or convex and the distance to the break in the slope.	Slope characteristics downslope features are based on LiDar data.
Hydrology		
Distance from defined water course	This facture tends to affect the likelihood of an event with the sites closer to defined water courses presenting more risk.	Measurements to the nearest identified desktop watercourse has been applied.
Surface water	This factor indicates a high water table level which can suggest a potential for failure.	Based on aerial photography and site walkover.
Evidence of piping	Peat pipes are natural drains within the peat which can provide pathways for significant amounts of runoff. An accidental blockage of a peat pipe could result in peat failure.	There is no evidence of piping in the peat in the proposed construction areas based on the site walkover. The PSRA is to be updated should any evidence of piping be noted during detailed design and construction stages.
Direction of existing drainage ditches	Drainage ditches that are aligned cross slope can have an effect on the overall stability of a slope	Based on aerial photography and site walkover.

Likelihood Factors	Explanation	Comments
	face.	
Annual rainfall	The annual rainfall level for the site effects how saturated the peat a the site can become and thus effect the strength of the peat, the peat subsoil interface and the load on the peat.	Based on Met Éireann rainfall data. Taken as >1400 mm per annum.
Slide History		
Previous slides in the locality	This factor is relatively heavily weighted and suggests that if a peat slide has occurred at the site or within a 10 kilometre radius then there is a graduated risk of an occurrence at the site. However, this does not account for the relative nature of the site topographies or peat depths.	Two recorded landslides have taken place within 10 km of Grousemount Wind Farm; Fuhiry which took place approximately 4 km northeast of the wind farm site in 1997, and Gortacreenteen debris slide which took place approximately 6 km southwest of the wind farm site in 2004. Both slides occurred following periods of heavy rain and flooding.
Evidence of peat movement	This factor evaluates the effect of any existing on-site peat movement indicators such as tension cracks.	Creep, ravelling and local slips of very shallow peat (< 0.5 m deep) on very steep slopes (> 15° – 20°) were noted in some areas during the site walkover. The PSRA is to be updated should any further evidence of peat movement on the site be noted during detailed design and construction stages.
Other factors		
Vegetation	This is an indicator of the type of peat at the site and the hydrological	The site predominantly comprises of grasses, rushes and heathers.

Likelihood Factors	Explanation	Comments
	nature of the site.	
Peat working	This factor evaluates the effect of various peat workings on the stability of the peat.	Cutaway / turbary peat workings were noted near proposed turbine T22 and also along the spur road to proposed turbine T20.
Existing road type	This in an indicator of the depth of peat in the area and the likelihood of some stabilising measures.	There are no existing roads across the majority of the site, however it has been assumed that solid roads would be constructed across the site based on the results of the site investigation.
Time of year of construction	This is linked to the rainfall level at various stages through the year.	A conservative time of year, i.e. late summer / autumn, has been assumed for all locations across the site.

Table 5-3 Likelihood factors affecting peat stability

Table 5-4 presents a list of likelihood factors that effect the outcome of the peat stability assessment at the site combined with associated comments relevant to this particular site.

Impact Factors	Explanation	Comments
Volume of peat in potential peat flow	This is the most heavily weighted factor of all factors. It is calculated based on the distance from the nearest defined watercourse and the depth of peat in the area.	A medium (1,000 – 20,000 m^3) peat flow has been calculated for a failure at each of the locations analysed. At some locations a small peat flow volume may be valid however a conservative approach for this factor has been adopted.
Downslope features	This factor accounts for the type / shape of down slope features.	Downslope features are based on LiDar data. Downslope valleys exist across the majority of the site.
Proximity to defined valley	This is the distance from	Distance taken from

Impact Factors	Explanation	Comments
	the site to the nearest defined river valley.	topographical maps.
Valley profile	This factor accounts for the shape of the valley of the river in question.	Profiles are generally steep across the site.
Downstream aquatic environment	Reflects the severity of the impact a peat slide event would have on the receiving aquatic environment.	Assumed to be sensitive throughout the site due to the River Roughty, and important fishery.
Public roads in potential peat flow path	Rates the impact of a peat slide striking a public road.	There are a number of regional and local roads near the northern section of the main wind farm site. At the majority of locations assessed it has been deemed that a peat slide would strike watercourses prior to striking existing roads.
Overhead lines in potential peat flow path	Rates the impact of a peat slide striking a service line.	There are a number of low voltage electricity lines near the north-eastern section of the main wind farm site. At the majority of locations assessed it has been deemed that a peat slide would strike watercourses prior to striking existing overhead lines.
Buildings in potential peat flow path	Rates the impact of a peat slide striking a habitable structure.	There are a number of residential dwellings near the north-eastern section of the main wind farm site. At the majority of locations assessed it has been deemed that a peat slide would strike watercourses prior to striking existing buildings.
Capability to respond	Rates the capability of the	Assumed to be good

Impact Factors	Explanation	Comments
(access and resources)	site staff to respond to a peat instability event.	based on site facilities during construction.

Table 5-4 Impact factors affecting peat stability

5.4 Assessment Areas

As is outlined in the “Peat Landslide Hazard and Risk Assessment: Best Practice Guide for Proposed Electricity Generation Developments” areas with peat present up to depth of 0.5 m do not require a PSRA to be carried out. This has been applied at each turbine and hardstand location, length or road and other infrastructure locations where this is found to be the case.

6 Results prior to mitigation measures

6.1 Turbines and hardstands

The results of the PSRA indicate that the peat stability risk rating at the turbine and hardstand locations vary from insignificant to substantial. The detailed risk assessment at each location is presented in Appendix C. An individual rating for each location is presented in Table 6-1 below.

Turbine / Hardstand No.	PSRA Rating
T1	**Insignificant**
T2	**Insignificant**
T3	**Significant**
T4	**Insignificant**
T5	**Significant**
T6	**Significant**
T7	**Substantial**
T8	**Significant**
T9	**Significant**
T10	**Significant**
T11	**Significant**
T12	**Insignificant**
T13	**Significant**
T14	**Insignificant**
T15	**Significant**
T16	**Significant**
T17	**Significant**
T18	**Significant**
T19	**Insignificant**
T20	**Significant**
T21	**Significant**
T22	**Substantial**
T23	**Significant**
T24	**Substantial**
T25	**Substantial**

Turbine / Hardstand No.	PSRA Rating
T26	**Significant**
T27	**Insignificant**
T28	**Significant**
T29	**Significant**
T30	**Significant**
T31	**Significant**
T32	**Insignificant**
T33	**Significant**
T34	**Significant**
T35	**Substantial**
T36	**Insignificant**
T37	**Significant**
T38	**Significant**

Table 6-1 Turbine Sites Risk Rating

The PSRA results for the turbine and hardstand locations before mitigation measures are also presented graphically on Figure 6-1 and Figure 6-2. These graphs put the risk ratings for Grousemount Wind Farm into context as the results are presented along with risk ratings for sites of known peat failures. Those sites are Derrybrien, Garvagh Glebe North, Garvagh Glebe South, which are ESB Wind Farms, and a peat slide that occurred in Kerry in 2008.

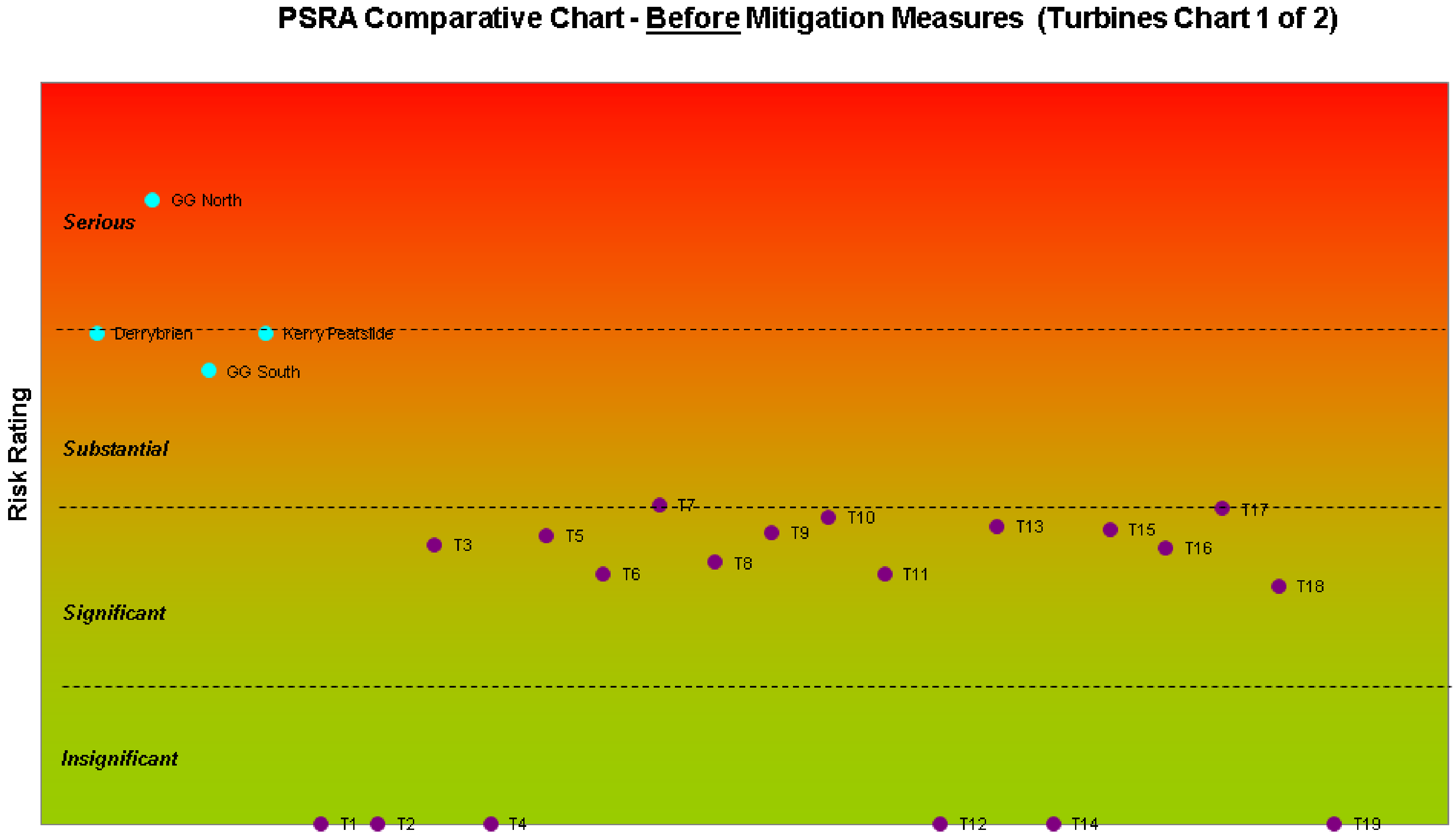

Figure 6-1 PSRA Comparative Chart Before Mitigation Measures (Turbines Chart 1 of 2)

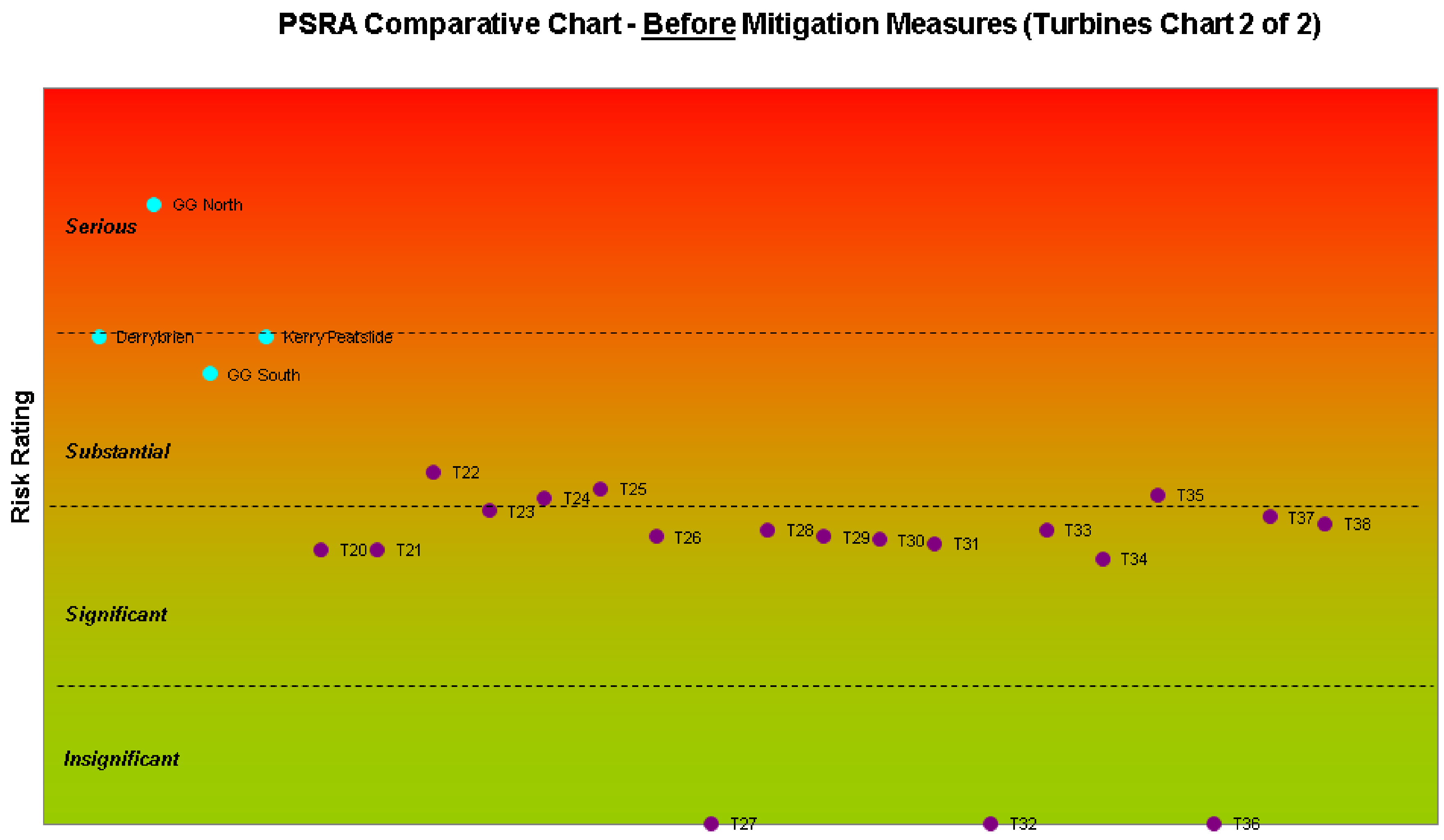

Figure 6-2 PSRA Comparative Chart Before Mitigation Measures (Turbines Chart 2 of 2)

6.2 Access tracks

The results of the PSRA indicate that the peat stability risk rating along the access tracks varies from insignificant to substantial. The detailed risk assessment at each location is presented in Appendix C. An individual rating for each location is presented in Table 6-2 below.

Access Track No.	PSRA Rating
AT 1: T1 – T2 Junction	**Substantial**
AT2: T2 Spur	**Insignificant**
AT3: T2 Junction – T3 Junction	**Insignificant**
AT4: T3 Spur	**Insignificant**
AT5: T3 Junction – Public Road	**Insignificant**
AT6: Public Road – T6 Junction	**Substantial**
AT7: T6 Junction – T6	**Insignificant**
AT8: T6 Junction – T4 Junction	**Substantial**
AT9: T4 Spur	**Significant**
AT10: T4 Junction – T7 Junction	**Substantial**
AT11: T7 Spur	**Significant**
AT12: T7 Junction – T10 Junction	**Substantial**
AT13: T10 Junction – T8	**Significant**
AT14: T10 Junction – T9	**Significant**
AT15: T9 Junction – T11 Junction	**Substantial**
AT16: T11 Junction – Borrow Pit G	**Significant**
AT17: Borrow Pit G – T13	**Significant**
AT18: T12 Spur	**Significant**
AT19: T14 Spur	**Significant**
AT20: Borrow Pit G – T15 Spur Ch. 900	**Significant**
AT21: T15 Spur Ch. 900 – T15	**Substantial**
AT22: T11 Junction – Borrow Pit F	**Significant**
AT23: Borrow Pit F – River Roughty	**Substantial**
AT24: River Roughty – T16	**Insignificant**
AT25: T16 - T18	**Significant**
AT26: T16 – T17	**Substantial**

Access Track No.	PSRA Rating
AT27: T17 – Ch. 1850 (including T19 spur)	Significant
AT28: Ch. 1850 – Ch. 1400	Significant
AT29: Ch. 1400 – Borrow Pit E	Substantial
AT30: Borrow Pit E – Main Spine Road Parts 3 & 4 Intersection	Substantial
AT31: T20 Spur	Substantial
AT32: Main Spine Road Parts 3 & 4 Intersection – T24 Junction	Substantial
AT33: T22 Spur	Insignificant
AT34: T24 Spur	Significant
AT35: T24 Junction – T35 Junction	Substantial
AT36: T35 Spur	Significant
AT37: T35 Junction – T31	Significant
AT38: T31 – T30 Site Access Junction	Insignificant
AT39: T30 Site Access (Ch. 1450 – Ch. 2350)	Significant
AT40: T30 Site Access (Ch. 650 – Ch. 1450)	Insignificant
AT41: T30 Site Access (Ch. 0 – Ch. 650)	Significant
AT42: T30 Site Access Junction – T29 Junction	Significant
AT43: T30 Spur	Insignificant
AT44: T29 Spur	Insignificant
A45: T29 Junction – T27	Significant
AT46: T27 – T30 Site Access Junction	Substantial
AT47: T26 Spur	Significant
AT48: T38 Spur (Ch. 80 – Ch. 300)	Insignificant
AT49: T38 Spur (Ch. 300 – Ch. 410)	Significant
AT50: T36 Spur	Substantial
AT51: T25 Site Access (Ch. 400 –	Significant

Access Track No.	PSRA Rating
Ch. 1650)	
AT52: T25 Site Access (Ch. 230 – Ch. 400) farmland	**Insignificant**
AT53: T25 Site Access (Ch. 0 – Ch. 230) Coillte	**Insignificant**
AT54: Everwind Wind Farm Site Entrance	**Insignificant**
AT55: Coillte track through Everwind Wind Farm	**Significant**

Table 6-2 Access Tracks Risk Rating

The PSRA results for the access track locations before mitigation measures are also presented graphically on Figure 6-3 to Figure 6-5 below. These graphs put the risk ratings for Grousemount Wind Farm into context as the results are presented along with risk ratings for sites of known peat failures. Those sites are Derrybrien, Garvagh Glebe North, Garvagh Glebe South, which are ESB Wind Farms, and a peat slide that occurred in Kerry in 2008.

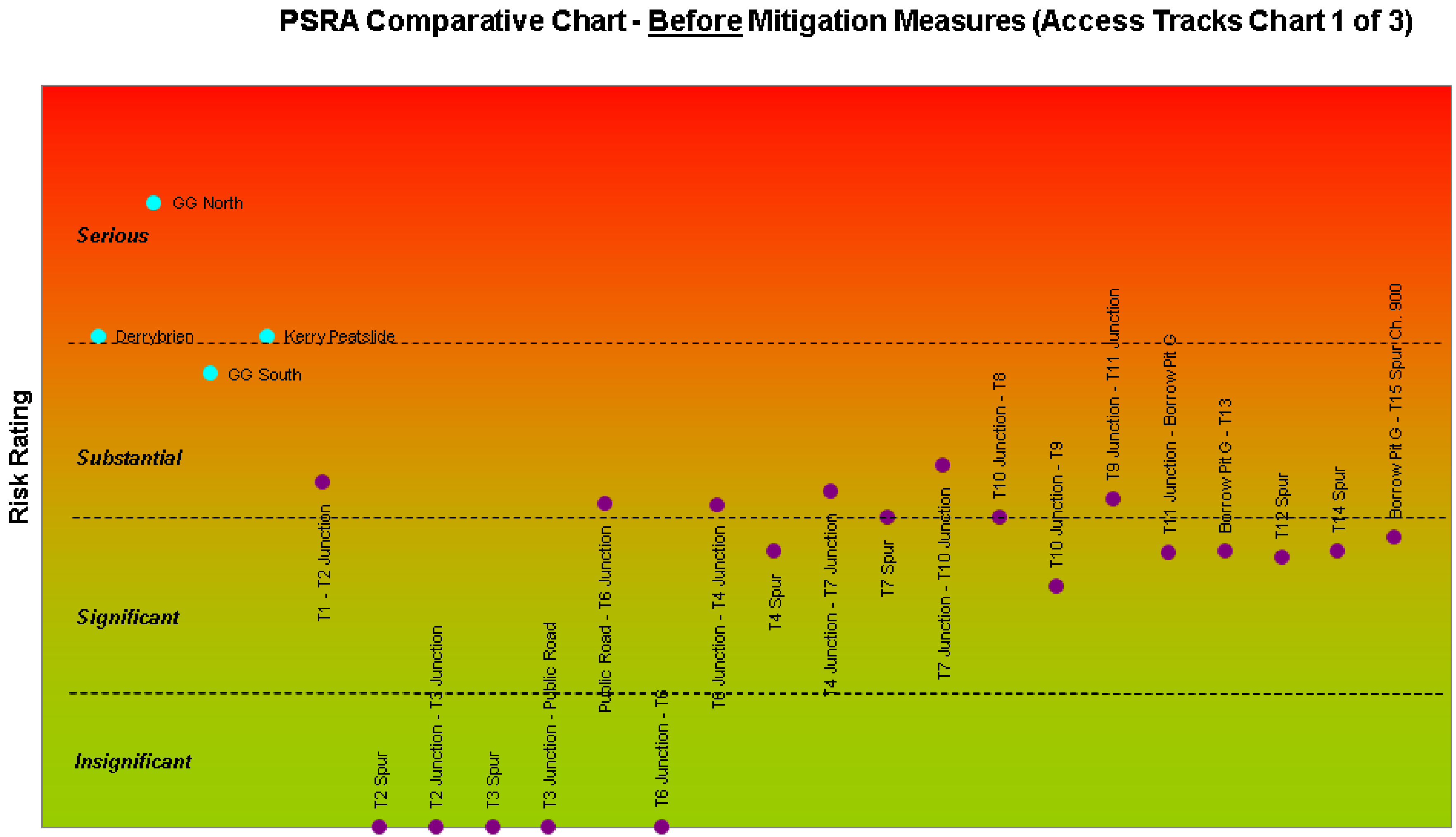

Figure 6-3 PSRA Comparative Chart Before Mitigation Measures (Access Tracks Chart 1 of 3)

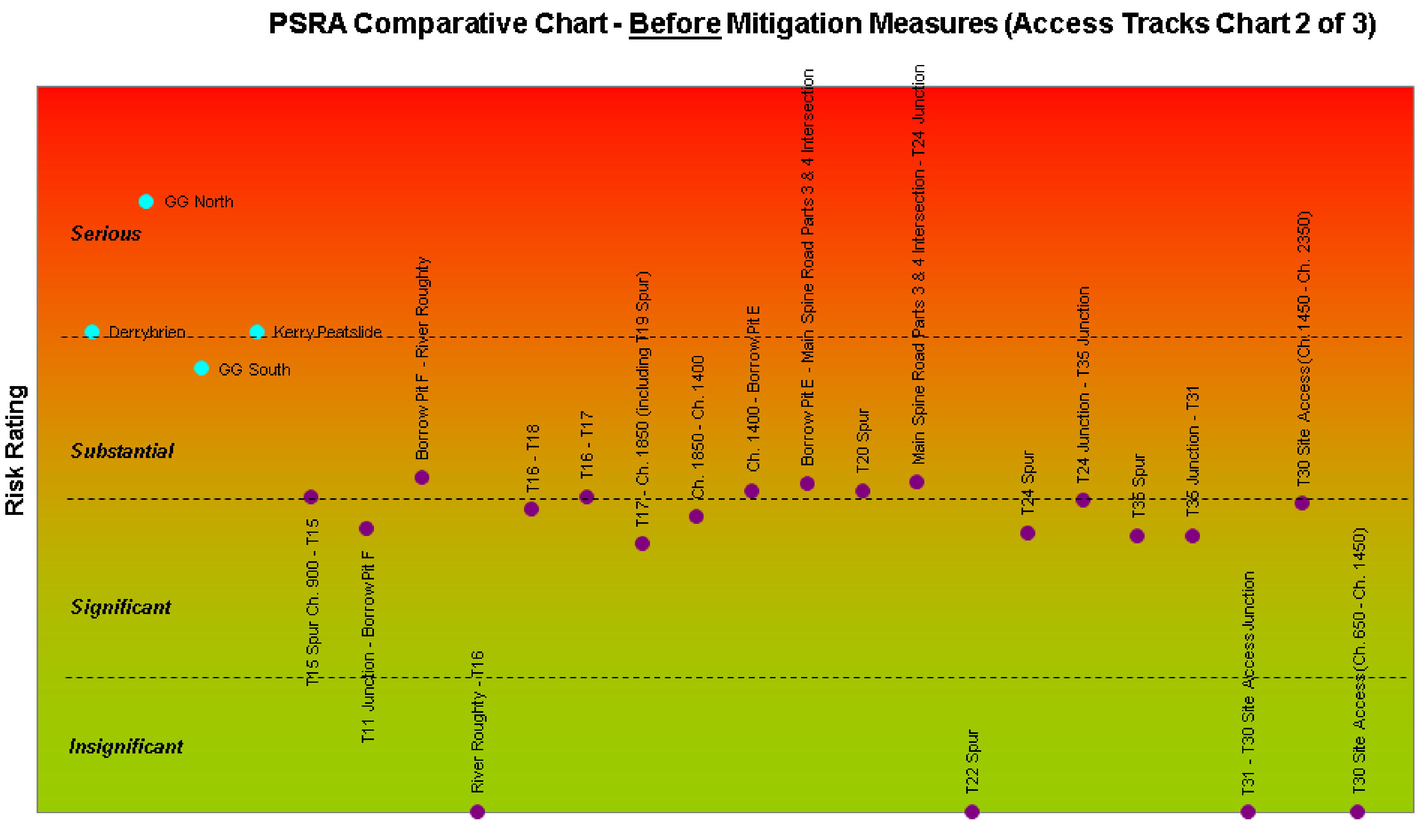

Figure 6-4 PSRA Comparative Chart Before Mitigation Measures (Access Tracks Chart 2 of 3)

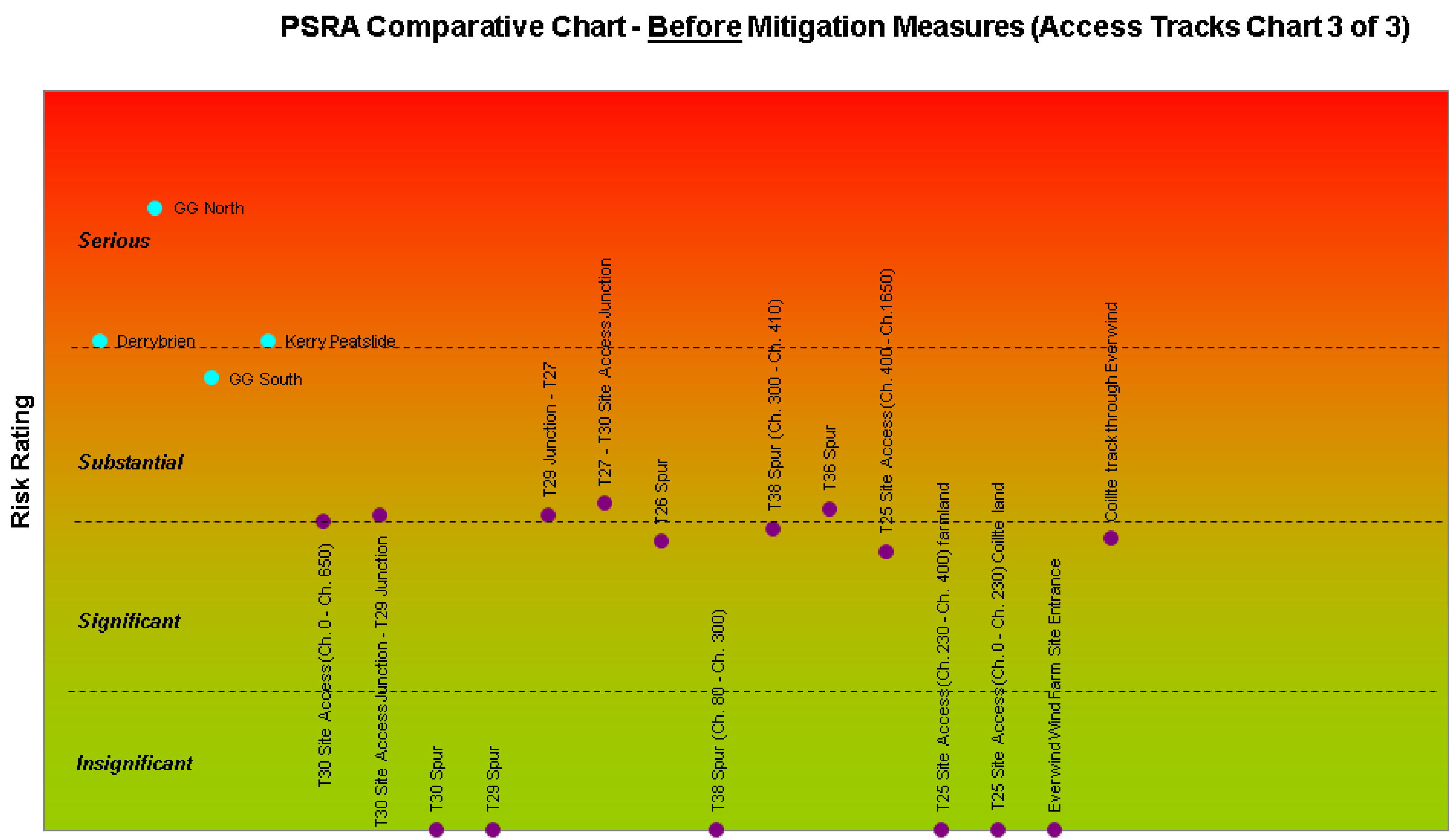

Figure 6-5 PSRA Comparative Chart Before Mitigation Measures (Access Tracks Chart 3 of 3)

6.3 Other infrastructure

The results of the PSRA indicate that the peat stability risk rating at other infrastructure locations varies from insignificant to substantial. The detailed risk assessment at each location is presented in Appendix C. An individual rating for each location is presented in Table 6-3 below.

Other Infrastructure	PSRA Rating
Substation	**Substantial**
Borrow Pit A	**Significant**
Borrow Pit B	**Significant**
Borrow Pit C	**Significant**
Borrow Pit D	**Significant**
Borrow Pit E	**Significant**
Borrow Pit F	**Significant**
Borrow Pit G	**Significant**
Borrow Pit H	**Significant**
Borrow Pit I	**Significant**
Anemometer Mast 1	**Insignificant**
Anemometer Mast 2	**Substantial**
Anemometer Mast 3	**Insignificant**
Anemometer Mast 4	**Insignificant**

Table 6-3 Other Infrastructure Risk Rating

The PSRA results for the other infrastructure locations before mitigation measures are also presented graphically on Figure 6-6. This graph put the risk ratings for Grousemount Wind Farm into context as the results are presented along with risk ratings for sites of known peat failures. Those sites are Derrybrien, Garvagh Glebe North, Garvagh Glebe South, which are ESB Wind Farms, and a peat slide that occurred in Kerry in 2008.

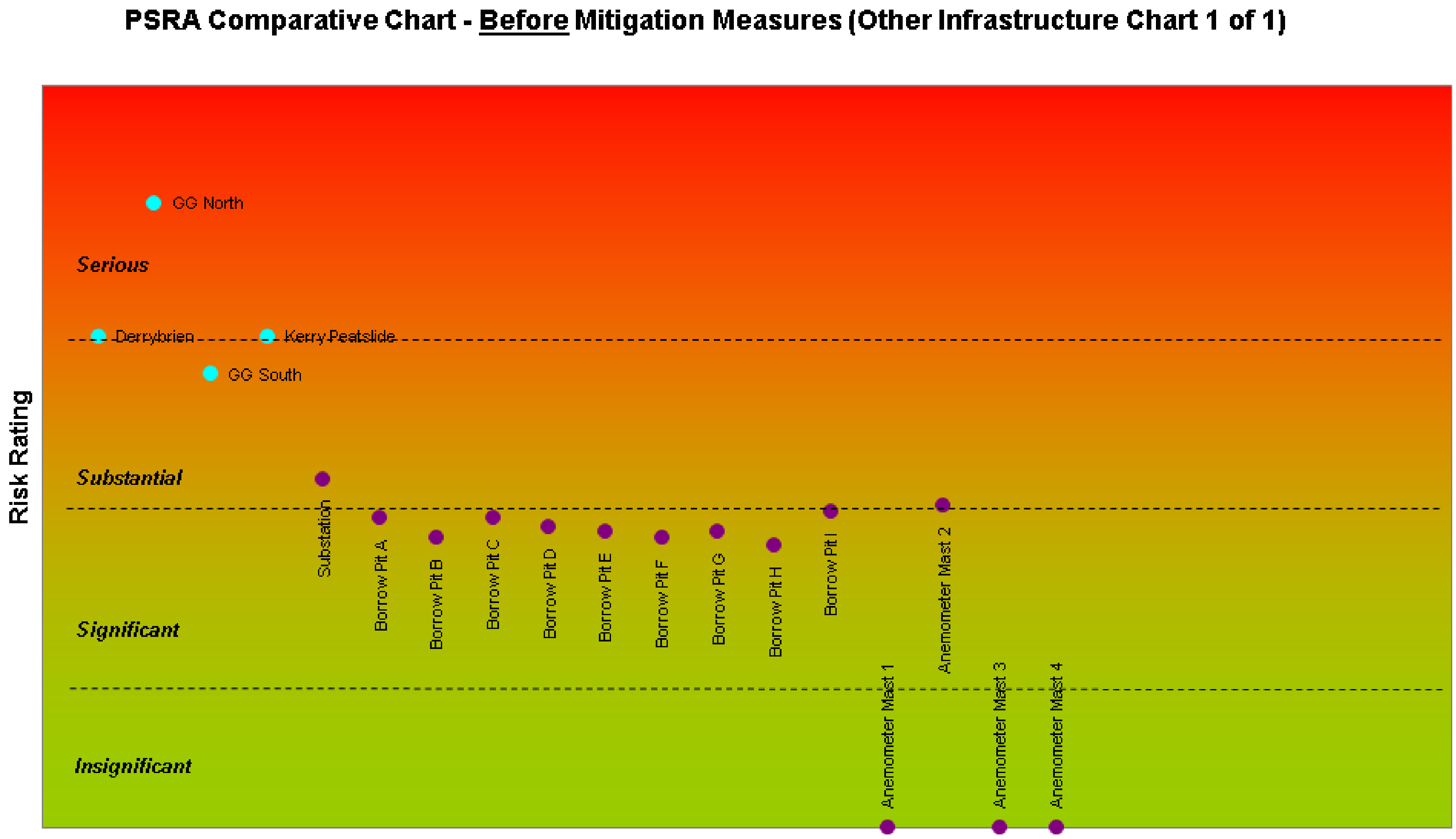

Figure 6-6 PSRA Comparative Chart Before Mitigation Measures (Other Infrastructure Chart 1 of 1)

7 Mitigation Measures

7.1 Mitigation Design and Implementation

The general process for risk mitigation that is applied in such sites can be demonstrated by the flow chart in Figure 7-1 below. The level of site investigation, design and control varies in order to minimise the risk as the project progresses through different stages; from pre-planning to detailed design to construction to operation and maintenance.

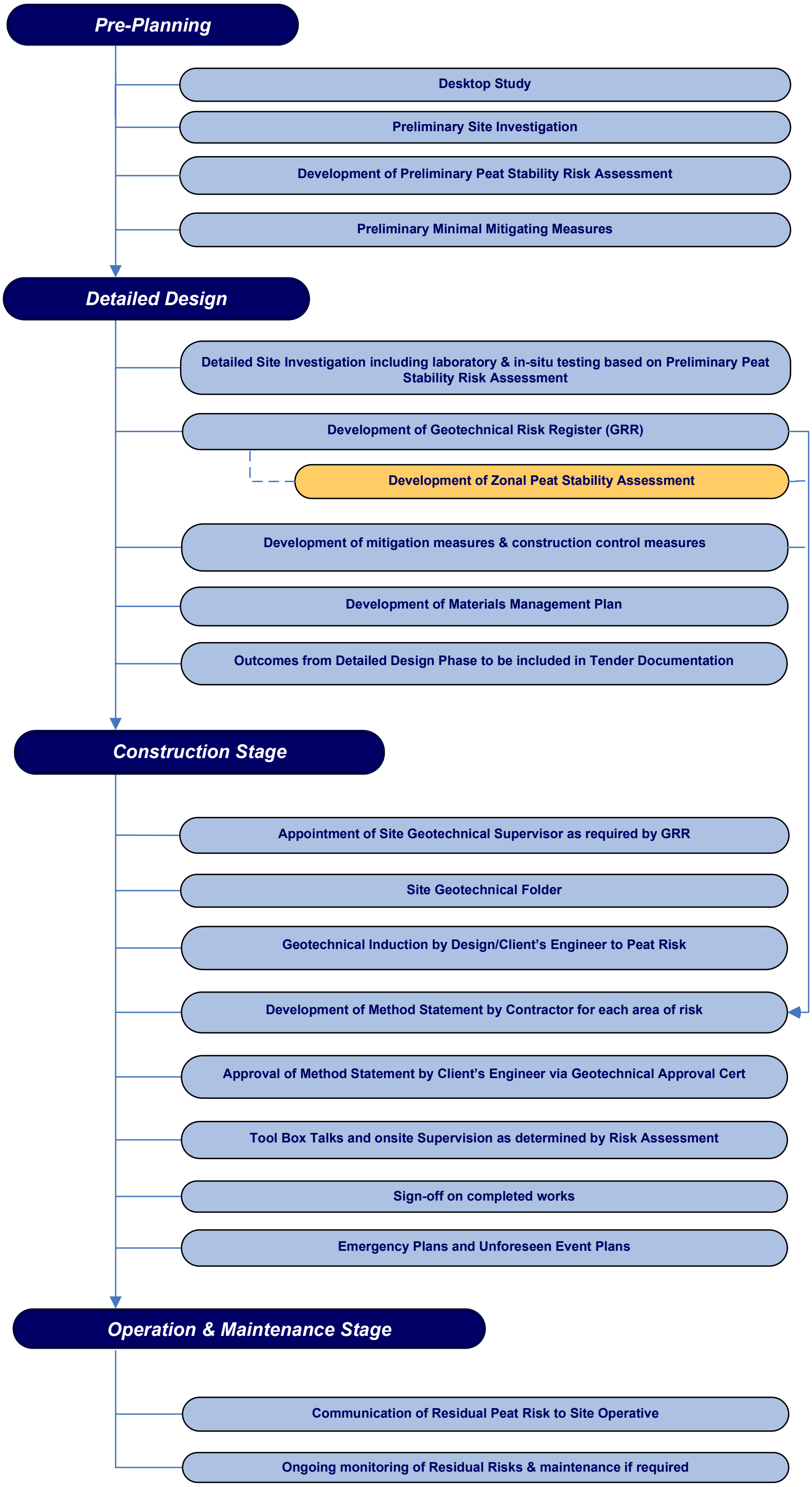

Figure 7-1 Peat Stability Risk Mitigation Process

The process can be summarised as follows:

Pre-Planning Phase:

The following outlines an overview of the tasks for the pre planning phase:

- Carry out a desk top study of the site.
- Carry out a preliminary site investigation.
- Carry out a PSRA for the site based on the site investigation and desk top study.
- Define a risk category for the site based on the PSRA so that the minimum requirements for the detailed design and construction phase are determined or the site is rejected based on severity of peat instability risk.

Detailed Design:

The following outlines an overview of the tasks for the detailed design phase:

- Carry out detailed site investigation if required by the PSRA inclusive of in situ testing and laboratory testing in specific risk areas on the site.
- Develop a Geotechnical Risk Register (GRR).
- For the site to encapsulate all geotechnical risks associated with the areas of the site in question. This will include, if required, a Zonal Peat Stability Assessment (ZPSA) to determine the revised risk at specific areas identified by the PSRA based on the detailed design and detailed site investigation. A ZPSA involves dividing the site up in to areas chosen where ground and hydrological conditions are similar and/or where the construction methodology is similar. A detailed risk assessment is then carried out by a multi-disciplinary team including Engineering Geologist, Engineering Geomorphologist, Geotechnical Engineer, Hydrogeologist / Hydrologist and Ecologist.

These zones then become distinct units in the construction programme for which separate permits are required. The certification is provided by the Client Appointed Geotechnical Engineer / Site Geotechnical Supervisor. The certification and supervision procedures used during construction are described below in the Construction Phase.

- Determine specific detailed mitigation measures that will be included in the construction process for each section of work.
- Develop a Materials Management Plan (MMP). The purpose of an MMP is to quantify accurately the volume of material for disposal due to the development. Estimates of the volume of peat generated in construction are made during the pre-planning phase. These estimates will be re-visited in the design phase as the detailed site investigation will provide better information and enable more accurate estimates to be made. The “in-situ” volume will be factored to take account of the bulking of excavated materials.

- Include outcomes of the detailed design process in the tender documentation to ensure that contractors are aware of the risks associated with the site.

Construction Phase:

The following outlines an overview of the tasks for the construction phase:

- Client's Geotechnical Engineer to provide a Geotechnical Induction to all contractor supervisory staff.
- Client to appoint a Site Geotechnical Supervisor to carry out supervision of site works as required. The Site Geotechnical Supervisor will be required to inspect that works are carried in accordance with the requirements of the ZPSA, identifying new risks and ensuring all method statements for works are in place and certified.
- Retain a Site Geotechnical Folder which contains all the geotechnical aspects of the site including but not limited to GRR, site investigation information, method statements etc.
- Contractor to develop a Method Statement for the works to be carried out in each of the ZPSA areas cognisant of the required mitigating measures.
- Client's Geotechnical Engineer / Site Geotechnical Supervisor to approve the method statement via a Geotechnical Approval Cert.
- Contractor to provide tool box talks and on site supervision prior to and during the works.
- Daily sign off by supervising staff on completed works.
- Implementation of emergency plan and unforeseen event plan by the contractor.

Operation and Maintenance Phase:

The following outlines an overview of the tasks for the operation and maintenance phase:

- Communication of residual peat risk to appropriate site operatives.
- Ongoing monitoring of residual risks and maintenance if required. Such items would consist of regular inspection of drains to prevent blockages, inspections of specific areas after a significant rainfall event.

The tasks identified in the pre-planning phase have been carried out for this development. The minimum mitigation requirements for the subsequent phases are presented in the remainder of this section of the report.

7.2 Preliminary Design Mitigation Measures

At preliminary design stage we have carried out a comprehensive PSRA for the development and have advised on the layout of the access roads, turbines and crane hardstandings taking the results into account in order to reduce peat stability risks.

The following mitigation measures have been implemented during the preliminary design stage:

- A comprehensive desk study and ground investigation was carried out to characterise the peat and subsoil conditions across the site and to identify peat stability risk factors, including topography, hydrology and hydrogeology.
- Earthworks volumes were calculated using the site investigation data, LiDar and Autocad Civil 3D software.
- The site layout has been optimised during the detailed site investigations to avoid or minimise risks identified; e.g. realigning access tracks to shallower peat areas.
- A spoil management strategy has been developed to store the vast majority of peat within excavated borrow pits and bunded peat repositories on the site so that the risk of a peat slide from uncontrolled peat storage is negligible. There are nine proposed borrow pits / repositories located across the site; BP-A to BP-I. The quantities of stone to be excavated from each location and quantities of peat and spoil to be retured to each location has been calculated.
- It is proposed to export up to 23,000 m^3 of excavated peat at the initial stage of construction when the borrow pits are opened and no space is available locally to store the spoil peat material.
- It is proposed to permanently sidecast a small fraction of the excavated peat (up to 69,000 m^3) on the site up to a maximum height of 1 m in areas with gradients of 5° or less.
- Peer review by a specialist independent geotechnical engineer with over 5 years experience in construction on upland peat sites indicating that the peat stability risk assessments were carried out to industry best practice and that the lowest risk methodology is proposed for storing peat (letter of review contained in Appendix D).

7.3 Detailed Design Mitigation Measures

The layout of the wind farm has been designed during the pre-planning stage with a view to avoiding and minimising geotechnical risks as far as possible. As the project proceeds into the detailed design stage, ongoing detailed site investigation works will be completed which may identify new risk. Comprehensive site investigation has been carried out to date to enable the completion of peat stability risk assessments, with all trial pitting works completed. The rotary borehole works are currently ongoing on site, the results of which will enable detailed design of the approved elements of the work.

The following mitigation measures are recommended during the detailed design stage:

- A GRR will be developed for the site.
- All roads to be solid construction unless approved by a geotechnical engineer.
- The formation levels for turbines will be finalised following the detailed design site investigations when rotary boreholes will be drilled at all turbine locations to determine the depth to rock. The trial pits carried out to date indicate that piling will not be required and that conventional spread footings should be adequate on either stiff glacial till or weathered rock.
- A detailed materials management plan will be written following detailed design. This plan should specify where material excavated from each turbine or length of access track is to be disposed.
- Suitable areas for sidecasting up to 69,000 m^3 of material will be identified. Side casting of materials, where permitted, will generally take place upslope of roads or as approved by the Site Geotechnical Supervisor.
- A ZPSA will be carried out for each turbine, length of access track and other infrastructure on the site. This is a peer reviewed peat stability risk assessment carried out following the detailed site investigation. The input of geotechnical, hydrology, ecology and other experts is recommended.

7.4 Construction Mitigation Measures

7.4.1 Documentation

Construction works in areas of significant risk, where required by the ZPSA, will be strictly controlled by the Client’s Site Geotechnical Supervisor and other site supervisory staff. The following Quality Assurance procedures are proposed:

- Contractor to be supplied with a GRR detailing geotechnical risks.
- Construction methods will be directed by the Client’s Geotechnical Engineer / Site Geotechnical Supervisor and strictly adhered to by the Contractor.
- Contractor to produce individual method statements for work in peat taking due account of the peat related risks and other geotechnical risks detailed in the GRR.
- Client’s Geotechnical Engineer to approve the Contractor’s Method Statement by the issuing of a certificate.
- No work in peat will take place without a Geotechnical Approval Certificate.
- Client’s Geotechnical Engineer to provide a Geotechnical Induction to all contractor supervisory staff.
- A toolbox talk is required for the Contractor’s operatives prior to commencing work in the peat area.

- Excavation in peat areas is subject to part time supervision by the Site Geotechnical Supervisor at this site depending on the outcome of the GRR and the ZPSA.
- A daily record of peat excavations will be completed by the Site Geotechnical Supervisor. Any new risks that come to light will be communicated to the Geotechnical Engineer.

7.4.2 Construction control measures

The following control measures will be enforced during construction of the wind farm in areas of deep peat:

- No stockpiling of materials or parking plant on peat.
- Minimise tracking machinery on peat.
- Minimise length of unsupported excavations in peat.
- Side slopes of cuttings in peat will be trimmed back to stable permanent side slopes. In soft potentially unstable peat a berm of mineral soil will be constructed across the top of the cutting slopes to support the peat face.
- No work is to be carried out down slope of a peat excavation at any time.
- Water build up in excavations is to be avoided.
- Peat excavations are not to be left unsupported for extended periods or overnight.
- The use of vibrating rollers not permitted (dead weight permitted).
- Stringlines with posts at 10 m centres downslope of access tracks and turbines. They will be installed prior to commencement of construction and remain in place for the duration of the works to monitor for any potential movements.
- Upslope cut-off drains to be installed in advance of construction.
- The existing drainage patterns in the peat will be maintained as far as is practicable.
- There will be no uncontrolled discharges of water onto peat.
- If there is any deviation from the agreed work methodology, or if work practices are unsafe, the Site Geotechnical Supervisors will give instructions to the Contractor’s Supervisor or directly to the Site Operatives.
- The Site Geotechnical Supervisor will suspend work if work practices or weather conditions are unsafe.

7.4.3 General spoil management risk mitigation measures

Controlled handling and deposition of excess peat and mineral soil from the excavations for the road and turbine excavations is an integral component of peat stability risk management for a wind farm site. Uncontrolled deposition of spoil and excessive loading on peat in high risk areas can lead to a bearing capacity failure or a large scale translational peat slide due to the increased shear stress at the base of the peat under the applied surcharge load.

To reduce the risk of a peat slide due to spoil management the following general risk mitigation measures will be adopted:

- Export the initial excavated peat material when there is no area available on site for storage.
- Store peat and mineral soil in borrow pits and repository areas secured with rockfill bunds.
- No permanent sidecast storage of mineral soil is permitted on the peat.
- Sidecasting of peat will be to a maximum height of 1 m on gradients of 5° or less, generally upslope of solid constructed roads in areas approved by the site geotechnical supervisor. Boundary markers will be used within the sidecasting area to control the extent and depth of excavated peat placed during sidecasting. The sidecast peat will be spread out evenly over the surface of the slope to promote runoff and to prevent ponding of rainwater in the remoulded peat. Interceptor drains will be constructed upslope from the sidecast peat to prevent the peat from becoming saturated from surface runoff.
- Excavated peat to be inspected by a geotechnical engineer to ensure that it is stable on the slopes at the time of deposition and it will be monitored for signs of creep or movement over the course of construction. The highest risk would be in the short term when the remoulded peat has been freshly placed on the slopes. Over time the material will dry out and re-vegetate, which will improve the strength and stability of the excavated material, allowing the peat to regenerate.

7.4.4 Specific spoil management risk mitigation measures

Spoil will be created from excavated access tracks, the wind turbine foundations and associated hardstandings, and Coomataggart Substation. The total volume of materials to be excavated for the various components of the development is estimated as shown in Table 7-1.

Location	Volume (m^3)
Main Access Tracks	174,800
Spur Access Tracks	100,036
Turbines & Hardstandings	151,718
Coomataggart Substation	28,567
Total	*455,121*

Table 7-1 Excavated Material Volumes

It is proposed to export 23,000 m^3 of spoil material at the initial stage of construction and permanently sidecast up to 69,000 m^3 of peat in suitable areas on the site. This results in a volume of 363,121 m^3 of excavated material to be stored in repositories across the site.

Drawing QR320171-MCW-P-1020 Sheets 1 to 7 showing the borrow pit and potential peat repositories are located in Appendix A. Nine borrow pits (BP-A to BP-I) are located across the site. It is proposed to construct an engineered rockfill berm on the downslope side of four of the borrow pits (BP-A, BP-B, BP-D and BP-G) to create peat repositories. An additional three of the borrow pits (BP-F, BP-H and BP-I) will also be used as repositories; filled to the current ground level requiring no support berms.

The peat storage capacity of the repositories and the peat produced from the site infrastructure construction has been calculated using AutoCAD Civil 3D combined with LiDAR, survey, probe data and site investigation results. The net storage capacity of each of the repositories, which excludes the volume of peat excavated at each borrow pit location and needs to be returned to each location following the excavation of the rock, is summarised in Table 7-2.

Location	Net Storage capacity (m^3)
BP-A	104,750
BP-B	72,000
BP-C	0
BP-D	137,000
BP-E	0
BP-F	51,750
BP-G	90,000
BP-H	46,250
BP-I	54,500
Total	*556,250*

Table 7-2 Peat Repository Net Storage Capacity

Trenter, N.A. (2001) recommends a bulking factor of 1.25 to 1.45 for peat and 1.20 to 1.40 for cohesive soils. With a respository net storage capacity of 556,250 m^3 and a volume of 363,121 m^3 of excavated material to be stored in repositories, this results in an allowable bulking factor of 1.53. This indicates that there is more than sufficient capacity in the peat repositories on the site to store the excavated spoil material.

7.4.5 Repositories

Four of the nine borrow pit locations which have been designed as repositories will have engineered rock fill embankments on their lower sides to contain the peat and mineral soil stored within them (BP-A, BP-B, BP-D and BP-G). The berms will be constructed on the firm ground below the peaty layer thus acting as a shear key against failure. The outer embankment slopes will be formed at 1V:1.5H and the inner slopes to 1V:1H.

The peat and mineral soil will be placed in the repository areas by end-tipping from dump trucks at suitable access points off the site roads or perimeter berms. The material will then be spread out across the deposition areas using long reach excavators on the berms, and with wide tracked excavators suitable for working on the intact material. The spoil material will be supported by the rock fill berms at all times. No material will be placed in the repositories until the downslope rock fill berms have been constructed. The berms at the peat repositories will be built up in stages as necessary and can have a finished constructed level at a lower level than shown if the peat volumes are less than anticipated. The final surface of the placed peat (< 2°) will be much flatter than the existing peat slopes.

Figure 7-2 shows an example of the successful storage of peat on an existing ESBI designed wind farm for ESB Wind Development.

Figure 7-2 Rockfill peat repository on an existing ESB Wind Farm

7.4.6 Cut slopes in peat

Where peat is exposed on permanent slopes in cuttings it will be trimmed back to stable slopes of 1V:1H or flatter. For deeper peat or where the peat is too soft to trim it back to permanent slopes of 1V:1H then a berm of rockfill will be constructed along the edge of the slope to support the peat.

Temporary support will be provided to the sides of the turbine excavations during the construction of the turbine unless the sides can be battered back to a stable temporary slope for the duration of the turbine construction. This is not only a requirement for peat stability, it is also a health and safety consideration to protect personnel working inside the excavation.

In relatively shallow peat, typically less than about 2.0 – 2.5 m deep, where the peat strength and groundwater conditions are favourable it is often possible to trim the sides of the excavation in peat back to stable slopes of about 1V:1H to 1V:3H. The slope angle should be determined by a geotechnical engineer following the observational approach.

Figure 7-3 shows an excavation in peat up to about 2.5 – 3.0 m deep on a previous ESB Wind Farm site in Co. Tyrone where the peat conditions were very favourable and the sides were trimmed back to temporary slopes of about 1V:1H during construction.

Figure 7-3 Turbine excavation trimmed back to a stable temporary side slope

Areas where it may be possible to trim back the side slopes of turbine excavations are often indicated by stable trial pits in peat with little or no ingress of groundwater during excavation. Relatively high undrained shear strengths from a hand vane (> 10 kPa) would also indicate where the side slopes could be stable. It should be confirmed by inspection by a geotechnical engineer on site during excavation.

Where there are deep deposits of weak amorphous peat with a high groundwater table and significant groundwater ingress in the excavation it will generally be necessary to provide some temporary support to the peat slopes during or in advance of excavation to prevent any shear failure in the peat and to stabilise the excavation. This can normally be achieved with sheetpiles or by constructing a rockfill berm around the perimeter of the turbine excavation over the full depth of peat in advance of excavation. Rockfill berms are normally constructed in a trench using the controlled displacement of peat. This involves initially excavating to a stable depth in the peat and then pushing coarse rockfill into the weak peat below this level to refusal on the underlying mineral soil. The weak peat is displaced largely upward and removed in the process to form a berm with a matrix of rockfill supported on the mineral soil. The rockfill berm is then constructed up to original ground level to support the peat over the full height.

The berm is constructed in a continuous operation around the perimeter of the turbine, starting on the upslope side. The peat inside the berm is subsequently excavated out to complete the turbine excavation to formation. The berm has to be set out in advance to allow sufficient clearance to provide stable temporary side slopes in the mineral soil above formation. The berms are usually up to 4.0 m wide to support a mechanical excavator used to construct the berm. The inside face is subsequently trimmed back to a stable angle of repose at about 1V:1H. It may be necessary to construct such a berm along the upslope side of turbine T38 where the peat is deeper in the proposed cutting for the turbine hardstand area.

Figure 7-4 shows a turbine excavation in 4.5 m of very soft and weak peat where a rockfill berm was constructed around the perimeter of the excavation to support the peat.

Figure 7-4 Rockfill berm around an area of deep peat on a previous ESB Wind Farm

8 Results post mitigation measures

8.1 Methodology

The hazard likelihood and impact of failure have been re-assessed on the basis of the general design and construction risk mitigation measures that have been recommended in Section 6 of this report. The interpretation of the Likelihood and Impact of a peat slide after implementation of risk mitigation measures is open to engineering judgement.

However, ESBI has adopted the following general principles in its assessment:

- The potential Impact of a peat slide at a particular location cannot be reduced significantly unless positive measures are taken to effectively contain the peat or sediment along potential flow paths prior to construction. The potential impact can be reduced slightly with effective contingency planning where there are readily accessible points of intervention to rapidly implement containment measures in the event of a peat slide.
- However, effective design and construction risk mitigation measures can be used to reduce the Likelihood of a peat slide to a low or negligible level, even in high risk areas. ESBI's interpretation of the mitigated risk of a peat slide in each location assessed is based on its experience implementing these measures to successfully complete the construction of the access roads, crane hardstandings and turbines on previous wind farm projects.

With the appropriate design and construction risk mitigation measures recommended in this report, and with appropriate controls during construction, it should be possible to reduce the Likelihood of Occurrence, L, to < 0.3 (Negligible), for all of the areas.

The primary risk mitigation measures that reduce the likelihood of a slide include constructing the roads and hardstandings by excavate / replace down onto the underlying glacial till or weathered rock below the peat, and the implementation of specific spoil handling procedures to control storage of excavated peat and mineral soil.

ESBI has assumed that the impact of a peat slide, I, would remain the same even after the mitigation measures have been implemented. Therefore the Impact of Occurrence, I, will remain between insignificant to significant which is tolerable and acceptable with regular attention to monitor the risk throughout construction.

8.2 Turbines and hardstands

The results of the PSRA indicate that the risk of peat instability at the turbine and hardstand locations vary from insignificant to significant post mitigation measures, as summarised in Table 8-1 below.

Grousemount Wind Farm Peat Stability Risk Assessment								
Area	Before mitigation measures				After mitigation measures			
	L	I	Risk Rating	Level	L	I	Risk Rating	Level
TURBINES								
T1 Turbine & Hardstanding	0.00	0.00	0.00	Insignificant	0.00	0.00	0.00	Insignificant
T2 Turbine & Hardstanding	0.00	0.00	0.00	Insignificant	0.00	0.00	0.00	Insignificant
T3 Turbine & Hardstanding	0.59	0.64	0.38	Significant	0.10	0.64	0.06	Insignificant
T4 Turbine & Hardstanding	0.00	0.00	0.00	Insignificant	0.00	0.00	0.00	Insignificant
T5 Turbine & Hardstanding	0.64	0.61	0.39	Significant	0.10	0.61	0.06	Insignificant
T6 Turbine & Hardstanding	0.56	0.61	0.34	Significant	0.10	0.61	0.06	Insignificant
T7 Turbine & Hardstanding	0.67	0.64	0.43	Substantial	0.10	0.64	0.06	Insignificant
T8 Turbine & Hardstanding	0.61	0.58	0.35	Significant	0.10	0.58	0.06	Insignificant
T9 Turbine & Hardstanding	0.65	0.61	0.39	Significant	0.15	0.61	0.09	Insignificant
T10 Turbine & Hardstanding	0.68	0.61	0.41	Significant	0.15	0.61	0.09	Insignificant
T11 Turbine & Hardstanding	0.58	0.58	0.34	Significant	0.10	0.58	0.06	Insignificant
T12 Turbine & Hardstanding	0.00	0.00	0.00	Insignificant	0.00	0.00	0.00	Insignificant
T13 Turbine & Hardstanding	0.69	0.58	0.40	Significant	0.10	0.58	0.06	Insignificant
T14 Turbine & Hardstanding	0.00	0.00	0.00	Insignificant	0.00	0.00	0.00	Insignificant
T15 Turbine & Hardstanding	0.65	0.61	0.40	Significant	0.15	0.61	0.09	Insignificant
T16 Turbine & Hardstanding	0.58	0.64	0.37	Significant	0.10	0.64	0.06	Insignificant
T17 Turbine & Hardstanding	0.67	0.64	0.42	Significant	0.15	0.64	0.10	Insignificant
T18 Turbine & Hardstanding	0.56	0.58	0.32	Significant	0.10	0.58	0.06	Insignificant
T19 Turbine & Hardstanding	0.00	0.00	0.00	Insignificant	0.00	0.00	0.00	Insignificant
T20 Turbine & Hardstanding	0.58	0.64	0.37	Significant	0.10	0.64	0.06	Insignificant
T21 Turbine & Hardstanding	0.58	0.64	0.37	Significant	0.10	0.64	0.06	Insignificant
T22 Turbine & Hardstanding	0.75	0.64	0.48	Substantial	0.30	0.64	0.19	Significant
T23 Turbine & Hardstanding	0.67	0.64	0.42	Significant	0.15	0.64	0.10	Insignificant
T24 Turbine & Hardstanding	0.69	0.64	0.44	Substantial	0.20	0.64	0.13	Insignificant
T25 Turbine & Hardstanding	0.63	0.73	0.45	Substantial	0.10	0.73	0.07	Insignificant
T26 Turbine & Hardstanding	0.61	0.64	0.39	Significant	0.10	0.64	0.06	Insignificant
T27 Turbine & Hardstanding	0.00	0.00	0.00	Insignificant	0.00	0.00	0.00	Insignificant
T28 Turbine & Hardstanding	0.63	0.64	0.40	Significant	0.10	0.64	0.06	Insignificant
T29 Turbine & Hardstanding	0.61	0.64	0.39	Significant	0.10	0.64	0.06	Insignificant
T30 Turbine & Hardstanding	0.60	0.64	0.38	Significant	0.10	0.64	0.06	Insignificant
T31 Turbine & Hardstanding	0.60	0.64	0.38	Significant	0.10	0.64	0.06	Insignificant
T32 Turbine & Hardstanding	0.00	0.00	0.00	Insignificant	0.00	0.00	0.00	Insignificant
T33 Turbine & Hardstanding	0.63	0.64	0.40	Significant	0.10	0.64	0.06	Insignificant
T34 Turbine & Hardstanding	0.62	0.58	0.36	Significant	0.10	0.58	0.06	Insignificant
T35 Turbine & Hardstanding	0.70	0.64	0.45	Substantial	0.10	0.64	0.06	Insignificant
T36 Turbine & Hardstanding	0.00	0.00	0.00	Insignificant	0.00	0.00	0.00	Insignificant
T37 Turbine & Hardstanding	0.65	0.64	0.42	Significant	0.10	0.64	0.06	Insignificant
T38 Turbine & Hardstanding	0.64	0.64	0.41	Significant	0.30	0.64	0.19	Significant

Table 8-1 Turbine PSRA results before and after mitigation measures

The PSRA results for the turbine and hardstand locations after mitigation measures are also presented graphically on Figure 8-1 and Figure 8-2 below.

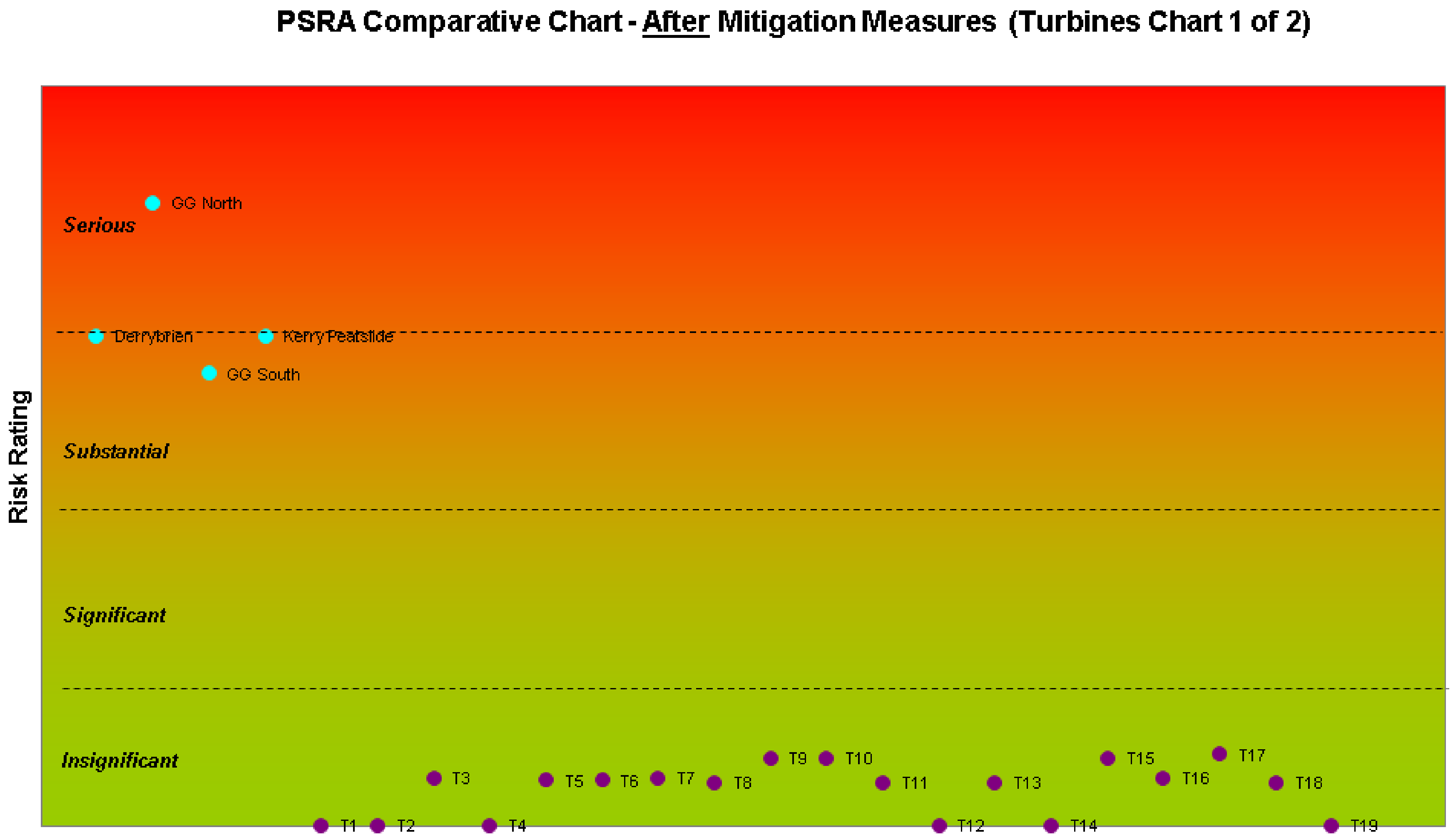

Figure 8-1 PSRA Comparative Chart After Mitigation Measures (Turbines Chart 1 of 2)

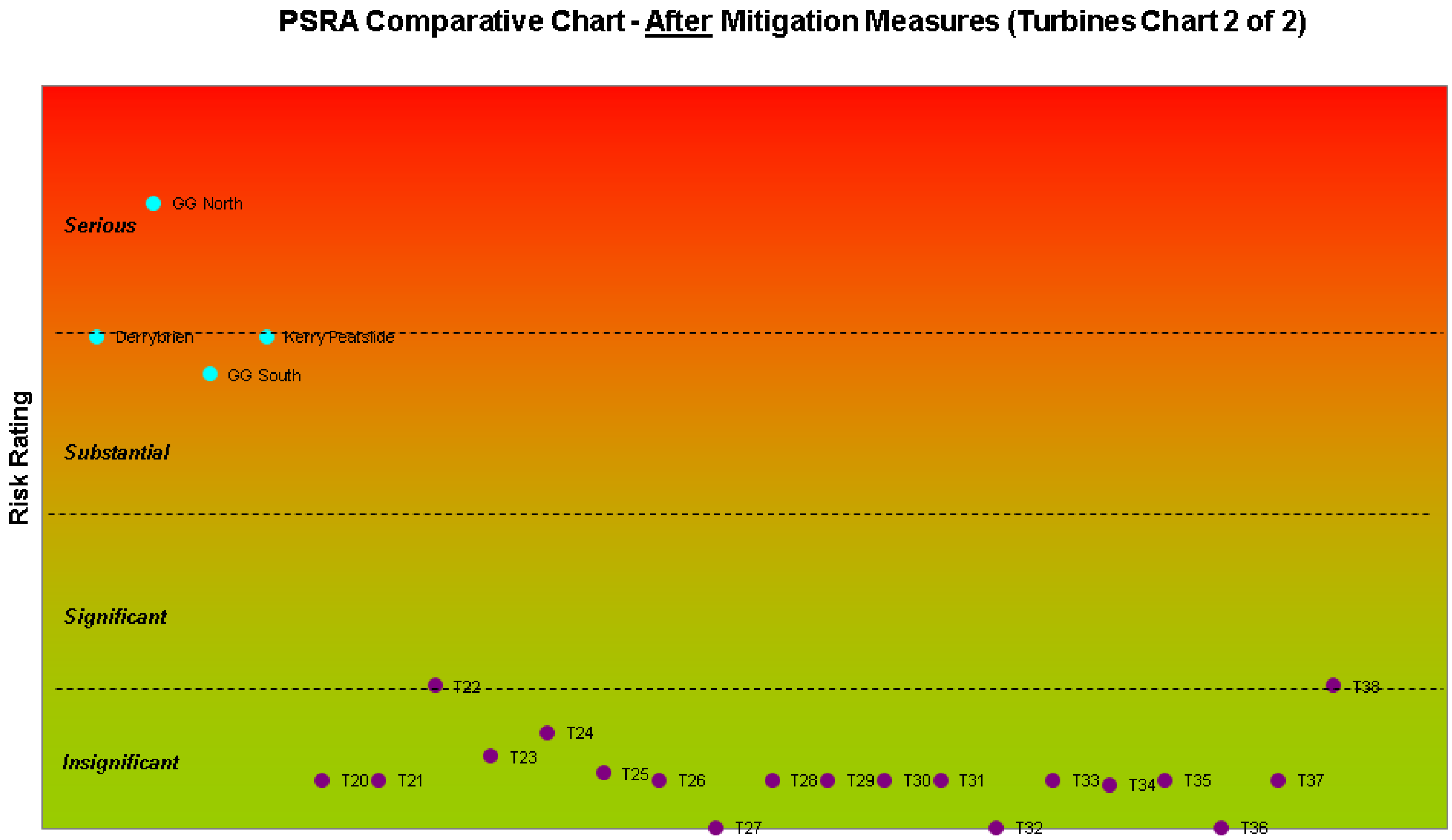

Figure 8-2 PSRA Comparative Chart After Mitigation Measures (Turbines Chart 2 of 2)

8.3 Access tracks

The results of the PSRA indicate that the risk of peat instability along the access tracks is insignificant post mitigation measures, as summarised in Table 8-2. The PSRA results for the access track locations after mitigation measures are also presented graphically on Figure 8-3 to Figure 8-5.

Grousemount Wind Farm Peat Stability Risk Assessment								
Area	Before mitigation measures				After mitigation measures			
	L	I	Risk Rating	Level	L	I	Risk Rating	Level
ACCESS TRACKS								
T1 - T2 Junction	0.61	0.76	0.46	Substantial	0.10	0.76	0.08	Insignificant
T2 Spur	0.00	0.00	0.00	Insignificant	0.00	0.00	0.00	Insignificant
T2 Junction - T3 Junction	0.00	0.00	0.00	Insignificant	0.00	0.00	0.00	Insignificant
T3 Spur	0.00	0.00	0.00	Insignificant	0.00	0.00	0.00	Insignificant
T3 Junction - Public Road	0.00	0.00	0.00	Insignificant	0.00	0.00	0.00	Insignificant
Public Road - T6 Junction	0.65	0.67	0.44	Substantial	0.20	0.67	0.13	Insignificant
T6 Junction - T6	0.00	0.00	0.00	Insignificant	0.00	0.00	0.00	Insignificant
T6 Junction - T4 Junction	0.68	0.64	0.43	Substantial	0.10	0.64	0.06	Insignificant
T4 Spur	0.61	0.61	0.37	Significant	0.10	0.61	0.06	Insignificant
T4 Junction - T7 Junction	0.71	0.64	0.45	Substantial	0.15	0.64	0.10	Insignificant
T7 Spur	0.65	0.64	0.42	Significant	0.10	0.64	0.06	Insignificant
T7 Junction - T10 Junction	0.76	0.64	0.49	Substantial	0.20	0.64	0.13	Insignificant
T10 Junction - T8	0.65	0.64	0.42	Significant	0.10	0.64	0.06	Insignificant
T10 Junction - T9	0.67	0.48	0.32	Significant	0.15	0.48	0.07	Insignificant
T9 Junction - T11 Junction	0.69	0.64	0.44	Substantial	0.15	0.64	0.10	Insignificant
T11 Junction - Borrow Pit G	0.64	0.58	0.37	Significant	0.15	0.58	0.09	Insignificant
Borrow Pit G - T13	0.58	0.64	0.37	Significant	0.10	0.64	0.06	Insignificant
T12 Spur	0.57	0.64	0.36	Significant	0.10	0.64	0.06	Insignificant
T14 Spur	0.58	0.64	0.37	Significant	0.10	0.64	0.06	Insignificant
Borrow Pit G - T15 Spur Ch. 900	0.61	0.64	0.39	Significant	0.10	0.64	0.06	Insignificant
T15 Spur Ch. 900 - T15	0.68	0.64	0.43	Substantial	0.15	0.64	0.10	Insignificant
T11 Junction - Borrow Pit F	0.61	0.64	0.39	Significant	0.10	0.64	0.06	Insignificant
Borrow Pit F - River Roughty	0.72	0.64	0.46	Substantial	0.15	0.64	0.10	Insignificant
River Roughty - T16	0.00	0.00	0.00	Insignificant	0.00	0.00	0.00	Insignificant
T16 - T18	0.65	0.64	0.42	Significant	0.15	0.64	0.10	Insignificant
T16 - T17	0.68	0.64	0.43	Substantial	0.15	0.64	0.10	Insignificant
T17 - Ch. 1850 (including T19 Spur)	0.64	0.58	0.37	Significant	0.15	0.58	0.09	Insignificant
Ch. 1850 - Ch. 1400	0.64	0.64	0.41	Significant	0.10	0.64	0.06	Insignificant
Ch. 1400 - Borrow Pit E	0.69	0.64	0.44	Substantial	0.20	0.64	0.13	Insignificant
Borrow Pit E - Main Spine Road Parts 3 & 4 Intersection	0.71	0.64	0.45	Substantial	0.20	0.64	0.13	Insignificant
T20 Spur	0.69	0.64	0.44	Substantial	0.15	0.64	0.10	Insignificant
Main Spine Road Parts 3 & 4 Intersection - T24 Junction	0.71	0.64	0.45	Substantial	0.10	0.64	0.06	Insignificant
T22 Spur	0.00	0.00	0.00	Insignificant	0.00	0.00	0.00	Insignificant
T24 Spur	0.67	0.58	0.38	Significant	0.15	0.58	0.09	Insignificant
T24 Junction - T35 Junction	0.67	0.64	0.43	Substantial	0.25	0.64	0.16	Insignificant
T35 Spur	0.60	0.64	0.38	Significant	0.10	0.64	0.06	Insignificant
T35 Junction - T31	0.60	0.64	0.38	Significant	0.10	0.64	0.06	Insignificant
T31 - T30 Site Access Junction	0.00	0.00	0.00	Insignificant	0.00	0.00	0.00	Insignificant
T30 Site Access (Ch. 1450 - Ch. 2350)	0.67	0.64	0.42	Significant	0.15	0.64	0.10	Insignificant
T30 Site Access (Ch. 650 - Ch. 1450)	0.00	0.00	0.00	Insignificant	0.00	0.00	0.00	Insignificant
T30 Site Access (Ch. 0 - Ch. 650)	0.65	0.64	0.42	Significant	0.25	0.64	0.16	Insignificant
T30 Site Access Junction - T29 Junction	0.67	0.64	0.42	Significant	0.10	0.64	0.06	Insignificant
T30 Spur	0.00	0.00	0.00	Insignificant	0.00	0.00	0.00	Insignificant
T29 Spur	0.00	0.00	0.00	Insignificant	0.00	0.00	0.00	Insignificant
T29 Junction - T27	0.67	0.64	0.42	Significant	0.10	0.64	0.06	Insignificant
T27 - T30 Site Access Junction	0.69	0.64	0.44	Substantial	0.15	0.64	0.10	Insignificant
T26 Spur	0.61	0.64	0.39	Significant	0.10	0.64	0.06	Insignificant
T38 Spur (Ch. 80 - Ch. 300)	0.00	0.00	0.00	Insignificant	0.00	0.00	0.00	Insignificant
T38 Spur (Ch. 300 - Ch. 410)	0.64	0.64	0.41	Significant	0.10	0.64	0.06	Insignificant
T36 Spur	0.68	0.64	0.43	Substantial	0.10	0.64	0.06	Insignificant
T25 Site Access (Ch. 400 - Ch.1650)	0.65	0.58	0.38	Significant	0.15	0.58	0.09	Insignificant
T25 Site Access (Ch. 230 - Ch. 400) farmland	0.00	0.00	0.00	Insignificant	0.00	0.00	0.00	Insignificant
T25 Site Access (Ch. 0 - Ch. 230) Coillte land	0.00	0.00	0.00	Insignificant	0.00	0.00	0.00	Insignificant
Everwind Wind Farm Site Entrance	0.00	0.00	0.00	Insignificant	0.00	0.00	0.00	Insignificant
Coillte track through Everwind	0.59	0.67	0.39	Significant	0.10	0.67	0.07	Insignificant

Table 8-2 Access tracks PSRA results before and after mitigation measures

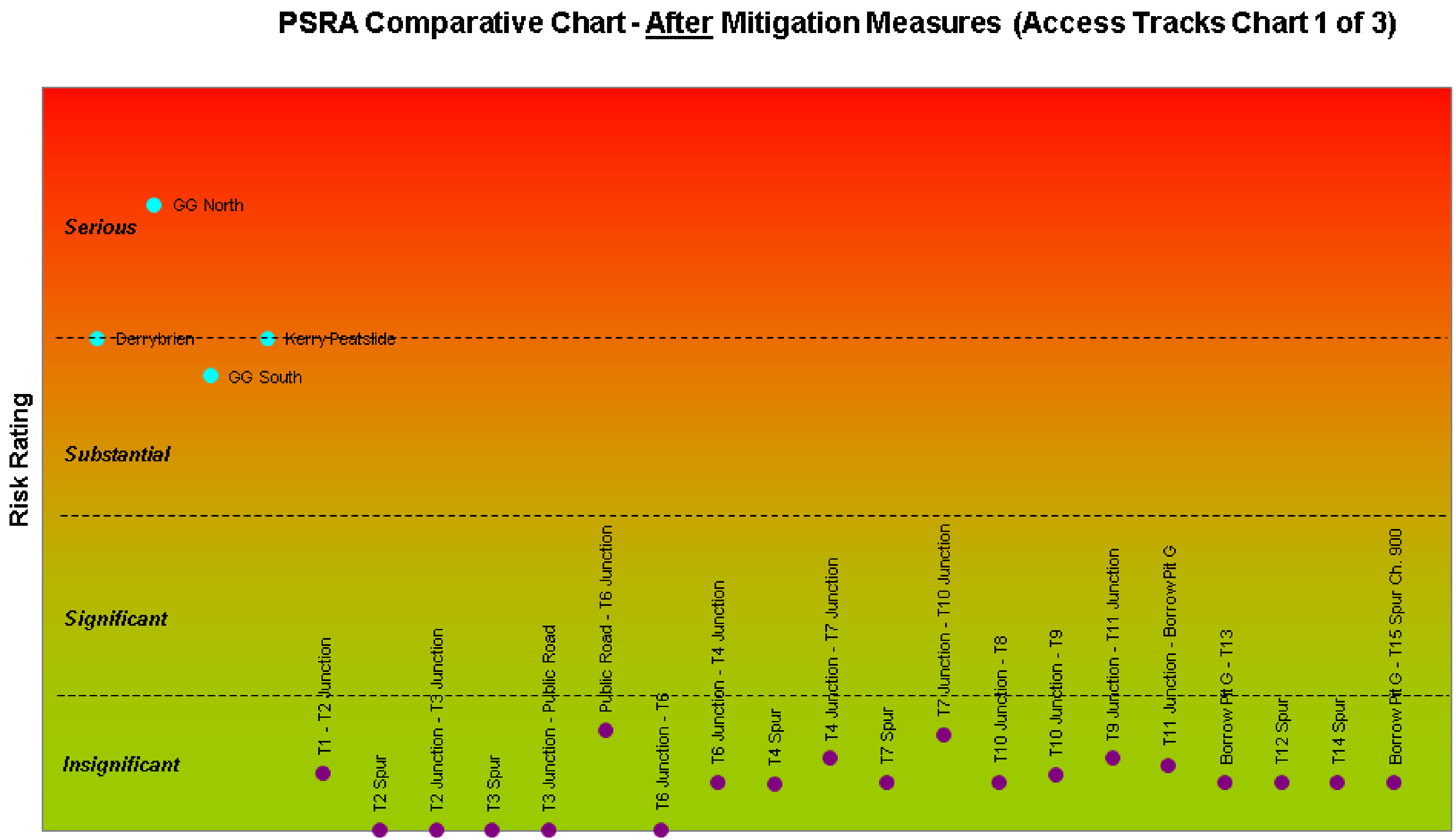

Figure 8-3 PSRA Comparative Chart After Mitigation Measures (Access Tracks Chart 1 of 3)

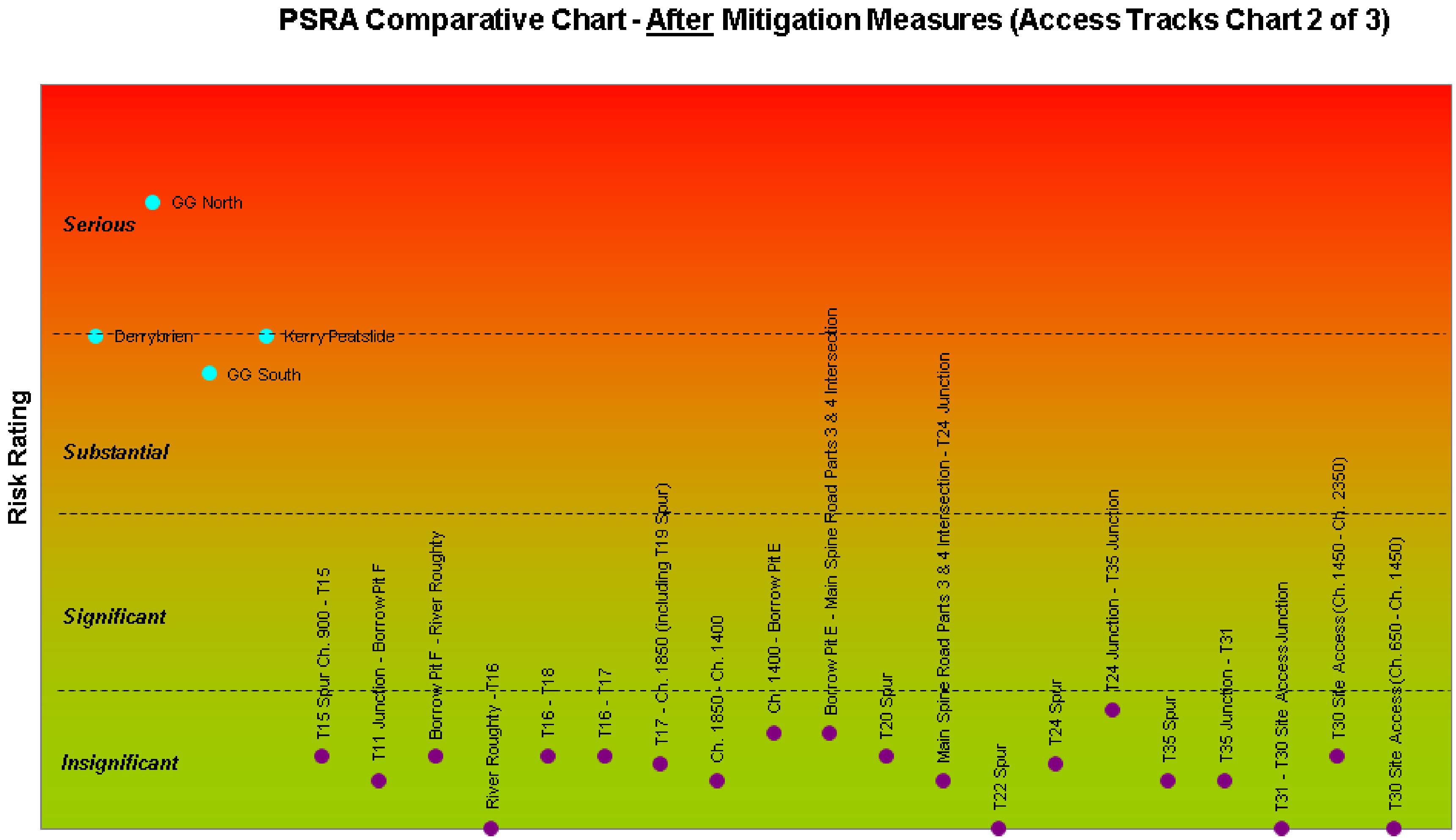

Figure 8-4 PSRA Comparative Chart After Mitigation Measures (Access Tracks Chart 2 of 3)

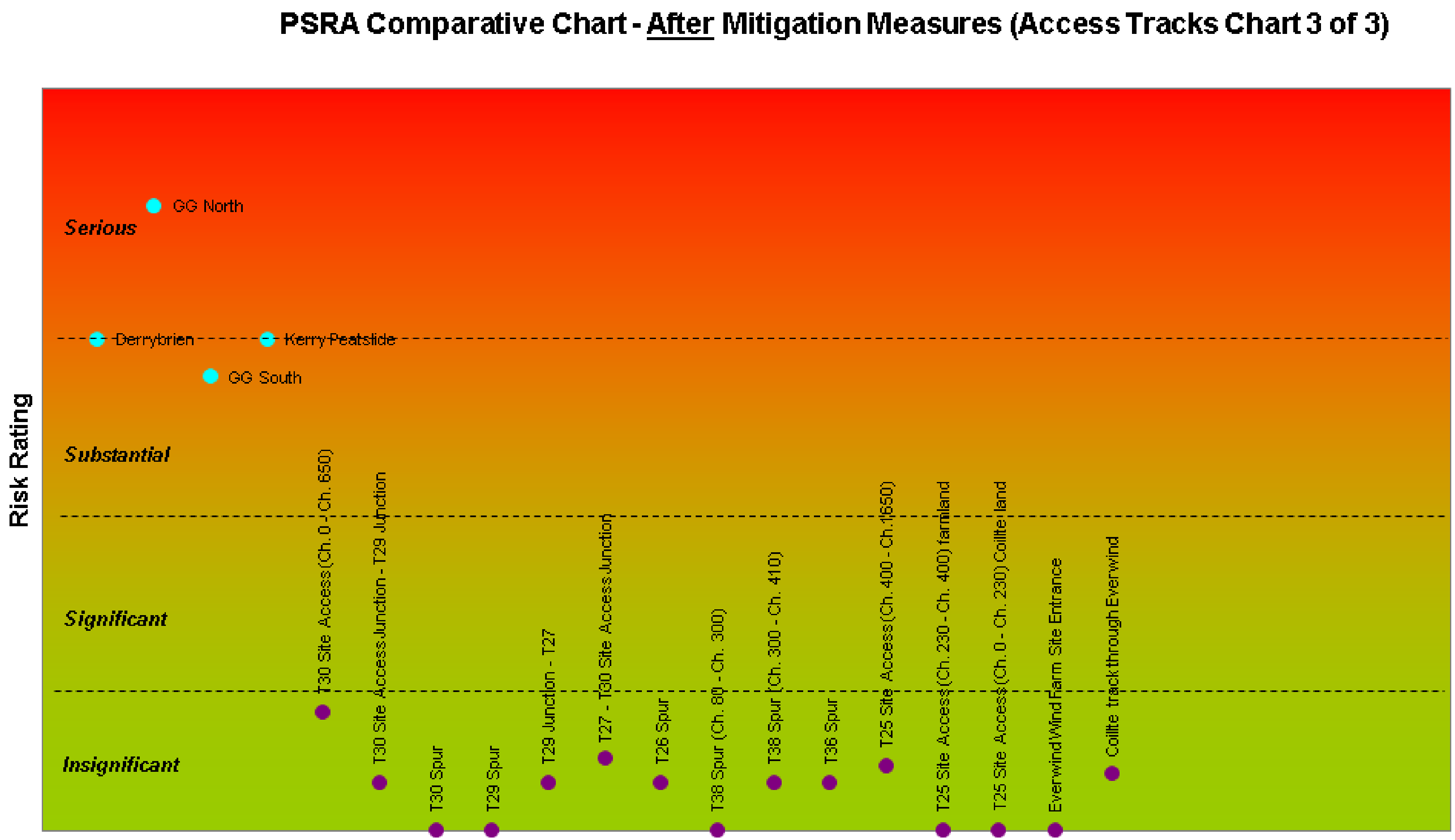

Figure 8-5 PSRA Comparative Chart After Mitigation Measures (Access Tracks Chart 3 of 3)

8.4 Other infrastructure

The results of the PSRA indicate that the risk of peat instability at other infrastructure locations is insignificant post mitigation measures, as summarised in Table 8-3 below.

Grousemount Wind Farm Peat Stability Risk Assessment								
Area	Before mitigation measures				After mitigation measures			
	L	I	Risk Rating	Level	L	I	Risk Rating	Level
OTHER INFRASTRUCTURE								
Substation	0.74	0.64	**0.47**	**Substantial**	0.25	0.64	**0.16**	**Insignificant**
Borrow Pit A	0.65	0.64	**0.42**	**Significant**	0.15	0.64	**0.10**	**Insignificant**
Borrow Pit B	0.61	0.64	**0.39**	**Significant**	0.10	0.64	**0.06**	**Insignificant**
Borrow Pit C	0.65	0.64	**0.42**	**Significant**	0.15	0.64	**0.10**	**Insignificant**
Borrow Pit D	0.67	0.61	**0.40**	**Significant**	0.10	0.61	**0.06**	**Insignificant**
Borrow Pit E	0.63	0.64	**0.40**	**Significant**	0.15	0.64	**0.10**	**Insignificant**
Borrow Pit F	0.61	0.64	**0.39**	**Significant**	0.10	0.64	**0.06**	**Insignificant**
Borrow Pit G	0.63	0.64	**0.40**	**Significant**	0.15	0.64	**0.10**	**Insignificant**
Borrow Pit H	0.63	0.61	**0.38**	**Significant**	0.10	0.61	**0.06**	**Insignificant**
Borrow Pit I	0.67	0.64	**0.42**	**Significant**	0.10	0.64	**0.06**	**Insignificant**
Anemometer Mast 1	0.00	0.00	**0.00**	**Insignificant**	0.00	0.00	**0.00**	**Insignificant**
Anemometer Mast 2	0.68	0.64	**0.43**	**Substantial**	0.20	0.64	**0.13**	**Insignificant**
Anemometer Mast 3	0.00	0.00	**0.00**	**Insignificant**	0.00	0.00	**0.00**	**Insignificant**
Anemometer Mast 4	0.00	0.00	**0.00**	**Insignificant**	0.00	0.00	**0.00**	**Insignificant**

Table 8-3 Other infrastructure PSRA results before and after mitigation measures

The PSRA results for the other infrastructure locations after mitigation measures are also presented graphically on Figure 8-6.

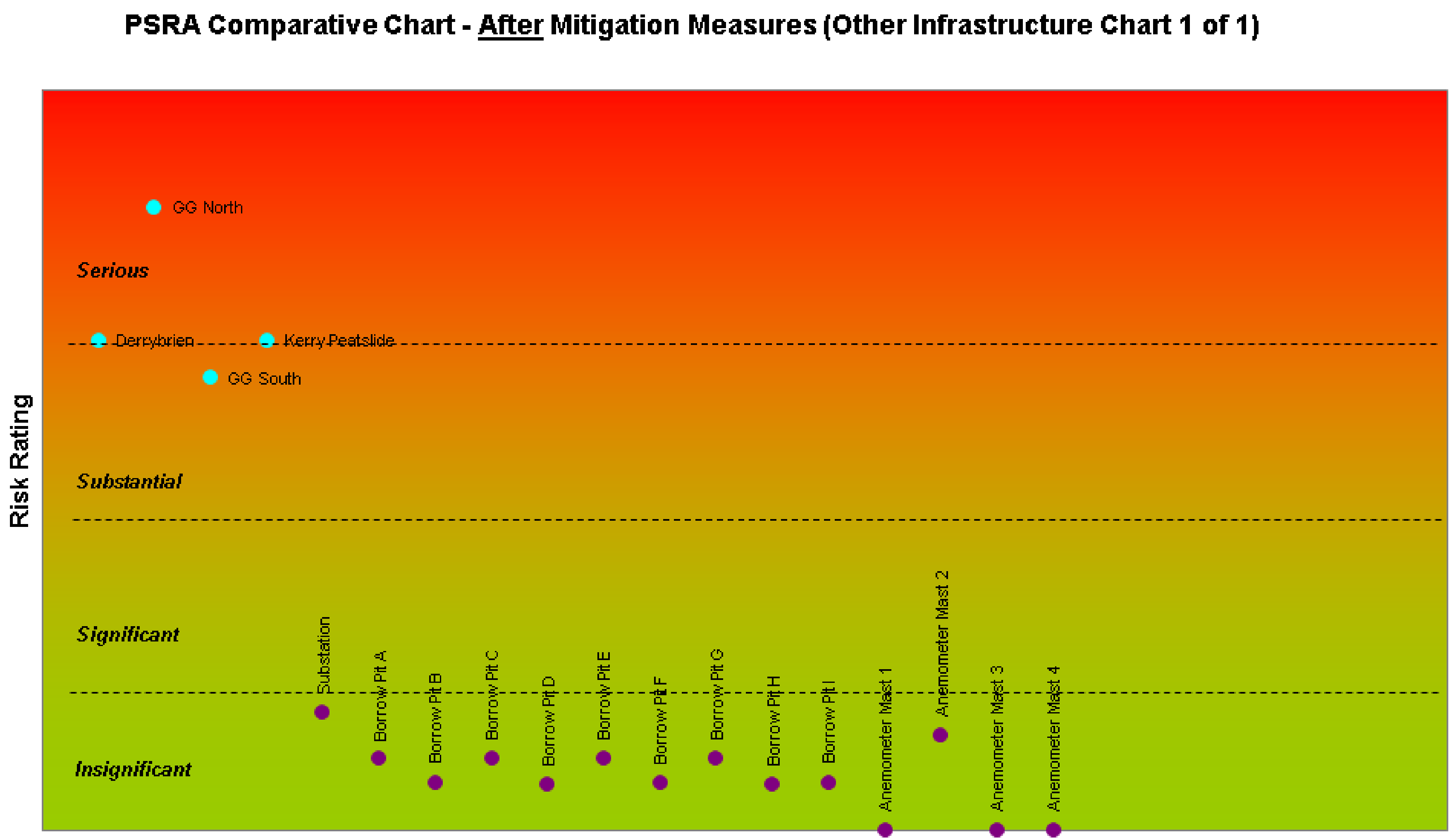

Figure 8-6 PSRA Comparative Chart After Mitigation Measures (Other Infrastructure Chart 1 of 1)

9 Conclusions

The peat stability risk assessments have shown that the peat stability risk ratings at Grousemount Wind Farm ranges from insignificant to substantial prior to the implementation of appropriate mitigation measures.

It has been demonstrated in Section 7.2 to Section 7.4 that after mitigation measures have been applied at preliminary design stage, detailed design stage and construction stage that the peat stability risk ratings across the site have been improved to insignificant and significant.

10 Recommendations

The following recommendations are made for the detailed design and construction stages of the development:

- A GRR will be developed for the site.
- The formation levels for turbines are to be finalised following the detailed design site investigations when rotary boreholes will be drilled at all turbine locations to determine the depth to rock.
- A materials management plan will be written for the site, estimating the volumes of excavated material and specifying how and where material is to be disposed.
- All peat rock and mineral soil excavated during construction will be separated. The rock will be used in the construction of the permanent works. The mineral soil will be landscaped and stored in a dedicated area. The peat will be stored in designed repository areas and borrow pits. No peat will be placed in the repository areas until the rockfill berms that act as a shear key are in place.
- Areas with gradients of 5° or less are to be identified for sidecasting up to 69,000 m^3 of peat to a maximum height of 1 m. Areas for sidecasting will be approved by the site geotechnical supervisor.
- A ZPSA will be developed at detailed design stage and incorporated in to the Method Statements for the works for specific areas of significant risk.
- A documentation and quality assurance system for construction in peat will be put in place.
- The construction methodology chosen will minimise the risk of peat instability. Construction control measures will be strictly enforced on site.

Appendix A Drawings

Appendix B Ground Investigation Report IGSL 2015

Appendix C Peat Stability Risk Assessments

Appendix D Independent Geotechnical Review Summary Letter