Appendix 3

Summary of Chapter 5

1 An assessment of the proposed construction methods is made initially on the basis of first principles of ecological science. Following this, the methods actually employed by the developer are considered.

2 Floating roads have been widely used on peat but in current usage they are truly floating only when used as temporary structures. For longer-term use, 'floating' roads are supplied with marginal drains along their length in order to prevent flooding of the roadway.

3 The method of 'floating' roads is not generally associated with extended heavy traffic and is an untried method at Cashlaundrumlahan.

4 Flooding tends to occur because the roadway sinks into the acrotelm and also because the line of the road rarely follows the natural drainage lines of the bog surface; consequently the road tends to pond water immediately upslope and cause drying out of the peat downslope.

5 Ponded water is a hazard because it causes pressure on the roadway; if it overtops the roadway it can erode the surface of the road.

6 Removal of ponded water can be a hazard if it is suddenly released onto the bog surface by a pump or temporary culvert because the peat surface cannot withstand such powerfully erosive forces.

7 The only effective way to prevent ponding of water is to ensure that roadways are adequately drained – a fact acknowledged by the developers, although the planning proposal emphasises that there will be no drainage.

8 Excavation of turbine bases generally creates a pond of water that must be safely removed (see Point 6).

9 Excavation of turbine bases leaves peat faces at the margins of the excavation permanently exposed to the atmosphere, especially in deep peat or on sloping ground. These faces are subject to long-term drainage and cracking, even if backfilled with aggregate because aggregate is more porous than peat.

10 In most cases the excavations are not completely filled either with aggregate or water, because the volume of aggregate would be too great and infilling with water would cause buoyancy and leaching problems. Drainage is therefore usually an important part of base excavation.

11 Concerns about bird strikes against turbine towers and blades suggest that good bird data are needed for Derrybrien, given that it will be one of the largest such windfarms in Europe but often suffers from low-visibility conditions.

Chapter 6

Impact interactions

GUIDANCE PROVIDED BY the European Commission (1999) emphasises that there is a legal requirement for an EIA to consider impacts which are of an indirect or cumulative nature or which occur as a result of interactions between factors. This applies to all aspects of an EIA but particularly to ecological issues. In the century or more since Ernst Haekel first coined the term 'ecology' and in the 70-odd years since Tansley (1935) first defined the concept of 'ecosystem', our appreciation of the complexity that underlies ecological systems has increased in equal measure with our increased knowledge.

Ecology certainly has direct linkages and impacts but, for any given ecosystem, there are many, many more links that are either indirect or cumulative or which result from a variety of interactions. It is reasonable to assume that an accurate view of the likely ecological impacts of a development can only be obtained by addressing these linkages and interactions. It is an issue that can (and should) be explored in some depth within an EIA. However, for the present exercise it is sufficient to provide some examples of ways in which such issues might be addressed.

6.1 *Indirect and Cumulative Impacts and Impact Interactions*

The European Commission has identified a range of approaches that can be adopted when considering indirect and cumulative impacts and impact interactions. They are provided for Member States as published guidance (European Commission 1999). The differing approaches are intended to be seen as complementary rather than as mutually exclusive options. The application of each is considered below.

6.1.1 *Expert opinion*

The authors of the present report are both internationally-recognised specialists in peatland ecology and conservation. Between them they have expertise in peatland biodiversity, peatland biogeography, peatland hydrology, peatland vegetation, blanket mire ecology, human impacts on peatland systems and international environmental legislation. For a fuller summary of their range of expertise and experience, the reader is directed to the biographies at the front of this report. For expert opinion about engineering and soils, Dr Trevor Orr from Trinity College Dublin has been engaged to produce a separate report. Full consultation has been maintained between the authors of these two reports in order to avoid one of the commoner problems of using expert opinion, as identified by the European Commission (1999) guidance:

> There may be a tendency for experts to complete their own chapters of an Environmental Statement in isolation from other experts. This runs against the nature of many cumulative and indirect impacts and impact interactions, because they often involve more than one scientific discipline or environmental receptor. Care should be taken to ensure that when producing the Environmental Statement, that effective communication is translated into the report.

6.1.2 *Consultation*

The authors consulted with a wide range of specialists and information sources during the production of this report. There has been communication with localities as geographically scattered as England, Ireland, Scotland, Wales, Switzerland, Denmark, New Zealand and the Falkland Islands. Bodies consulted include, in the UK, the Forestry Commission, Scottish Natural Heritage, English Nature

and the Countryside Council for Wales; in Ireland, Dúchas, Ordnance Survey Ireland, Derrybrien Citizens' Action Group and the Irish Peatland Conservation Council; in Switzerland, the Institute for Forest, Snow and Landscape Research; in New Zealand, Landcare Research and, in the Falklands, the Falkland Islands Council.

This range of consultations provided valuable information about land instability, bog bursts and bog slides under a variety of conditions and in a variety of locations. It also helped clarify the relationship between these events and human impacts, opportunities for modelling the relationship between peat depths and landforms, the impact of forestry on peat soils and details of the widespread nature of the ecological impacts resulting from the Derrybrien bog slide.

6.1.3 *Checklists*

A simple checklist (as opposed to a weighted matrix – see below) can be produced for the Derrybrien case, listing the key elements in the case based on the range of environmental factors to be considered and the types of activities anticipated for the development. An example for Derrybrien is presented in table 6.1. It should be noted that development activities have been modified from those given in the original proposal (for example, road drainage is included) in order to give a fuller picture of the likely impacts based on a realistic view of the necessary on-site actions.

6.1.4 *Spatial analysis*

Examples of spatial analysis using GIS have already been provided in this report. For example the relationship between peat depth and forest cover was discussed in section 3.2.2 while the pattern of turbine sites in relation to existing and new roads was described in section 5.1.1. Further examples of spatial analysis will be found later, relating factors such as peat depth, forest cover, stream-courses, surface gradients, residential areas and impact boundaries.

This is one of the most powerful tools for identifying potential relationships between impacts and for then integrating these relationships to assess the combined result. A considerable amount of analysis could be undertaken using just the datasets listed above and, with the addition of a limited amount of additional information such as hen harrier sightings, brook lamprey distribution, sub-soil geology or catchment boundaries, a series of reasonably sophisticated environmental analyses could be undertaken. It is not the task of this report to undertake such analyses but rather to identify the fact that detailed spatial analyses are eminently possible and worthwhile. Section 10 provides an example of how they might be employed.

6.1.5 *Network and systems analysis*

Two forms of network analysis are presented in the European Commission (1999) guidance for indirect impacts and impact interactions. The first gives an example of a network chain that could have been written (albeit in a much simplified form) with Derrybrien in mind:

The second is more like an ecosystem map or a mind map. Such a diagram was generated before beginning this report to clarify potential linkages, indirect impacts and impact interactions. Fig 6.2 may appear rather crude or rough-and-ready but this is precisely the stage when such diagrams are at their most useful. Once something has been neatly typed and formatted, it becomes much less easy psychologically to make radical changes whereas something that has the look of a 'work in progress' positively invites more input. It performed a valuable service in identifying, at a very early stage in the process, linkages that might otherwise have been overlooked and the broad interconnected topics that should make up the present review.

6.1.6 *Matrices*

A matrix is a more refined version of a checklist in that it approaches the subject matter from a more complex perspective and generally includes some judgement values. The two illustrations of 'stepped matrices' provided in the European Commission (1999) guidance could readily be applied to the

Environmental Resourse	Potential impact from key construction activities											
	Road Construction				Turbine bases				Turbine operation			
	Drainage	Vehicle weight	Quarrying (blasting)	Laying ballast	Peat removal	Ponding & drainage	Vehicle weight	Quarrying (blasting)	Hard-standing	Roads*	Drainage	Turbine blades
Peat soil	Y		Y		Y			Y		Y	Y	
Peatland hydrology	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
Peatland vegetation	Y			Y	Y	Y			Y		Y	
Carbon emissions	Y				Y	Y					Y	
Peat stability	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
Water flows	Y		Y	Y	Y	Y		Y	Y	Y	Y	
Water quality	Y		Y	Y	Y	Y		Y	Y	Y	Y	
Hen harrier			Y					Y				Y
Brook lamprey	Y					Y					Y	
WFD reference waters**	Y		Y	Y	Y	Y		Y	Y	Y	Y	

** i.e. Road maintenance
** WFD = Water Framework Directive

Table 6.1: An example of the kind of checklist table that can be drawn up to consider the wind farm proposals at Derrybrien.

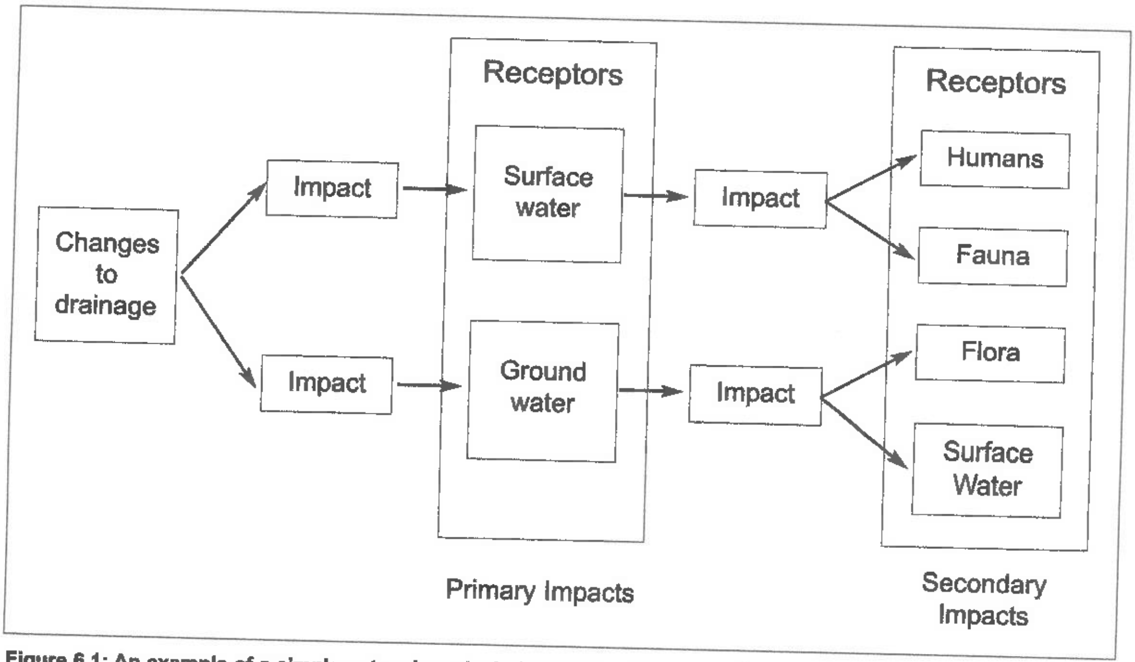


Figure 6.1: An example of a simple network analysis (taken from European Commission 1999).

Derrybrien case. In doing so, they would undoubtedly have the potential to add a significant level of detailed understanding to the EIA and highlight a number of critical issues.

6.1.7 *Carrying capacity or threshold analysis*

Analysis of carrying capacity is directed towards identification of the extent to which the ecosystem, or parts of it, are able to withstand given levels of impact. In the case of Derrybrien it might be argued that detailed survey of the hen harrier population could clarify both the size of the population (if any) and the type of territory used by the birds. This could be matched with evidence of any avoidance behaviour in relation to wind turbines to determine the overall pressure that the wind farm may place on the hen harrier population.

Alternatively (or rather, in addition), analysis of carrying capacity could be directed towards the engineering impacts of the wind farm on the mechanical properties of the peat soil to determine areas of low stability and thus with low potential impact thresholds. This is precisely what was carried out following the large bog burst of October 2003 in an effort to assess whether the situation was now stable and whether work could continue.

6.1.8 *Modelling*

Modelling can take many forms and at Derrybrien the developers undertook modelling of both noise and visual impact using spatial information consisting of a digital terrain model (DTM), the turbine locations and models of sound transfer. Assessments were made about the likely visual impact of the turbines from various localities together with quantitative figures for noise levels at various distances from the site. In cases like this, modelling involves the addition of a known behaviour or property of a feature and then relating it to a set of spatial information to make judgements about likely impacts.

Much of the early part of the present report is concerned with the properties and behaviour of peat and blanket peat systems. Towards the end of the report, such understanding is used in conjunction with a range of spatial data (e.g. peat depth, slope angle, presence of forestry) to make predictions about possible impacts resulting from wind farm activities.

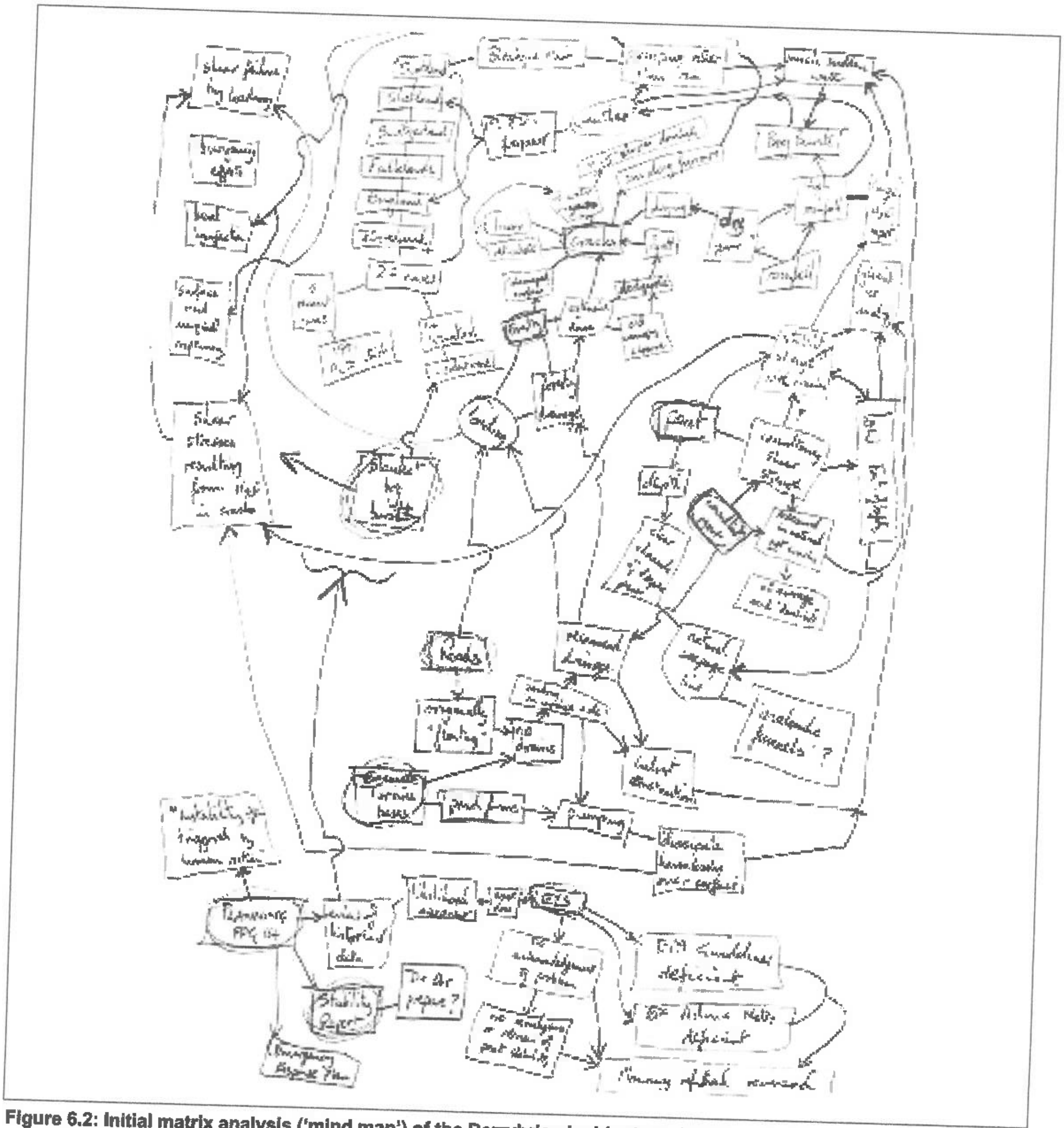


Figure 6.2: Initial matrix analysis ('mind map') of the Derrybrien incident produced as the first stage in preparing the present report. The informal appearance of the diagram invites further input and cross-referencing that might otherwise be constrained by a more formal printing of the diagram.

6.2 *Geographical boundary for the EIA – integrated assessment*

Reference has already been made (section 2.1) to the fact that determination of the geographic boundary for the EIA process in any given case must be an iterative process. Information is gathered; this reveals factors that were perhaps not originally anticipated; these factors involve potential impacts beyond the originally-defined impact boundary; the EIA boundary is re-drawn, embracing new areas; these areas contain factors that must now be considered; these may connect with other factors that involve additional areas; the boundary is re-drawn and so the process continues until a boundary has been defined that embraces all reasonable issues.

At the start of this report, the defined area for impact assessment was taken to be defined by the wind farm boundary. Much of what has been considered since indicates a clear need to enlarge this. Questions of peat stability are evidently a major issue, particularly given the identified disruption to

the peat caused by forestry operations and the developers' acknowledged problems with drainage.

The definition of peatland ecosystem for conservation purposes involves identification of all the ground necessary to maintain the hydrological integrity of the system. In the case of blanket mire systems, this generally means that whole mire complexes (macrotopes, section 2.4.1) be identified as the conservation unit because each individual peat unit is linked to its neighbours by a hydrological connection within the peat – damage one unit and this may lead to knock-on effects in adjacent units. The issue is explored in some depth by Lindsay et al. (1988) in relation to the Flow Country of Caithness and Sutherland. By extension, this principle also applies to EIA of blanket mire systems because EU legislation requires that such connections are included within the assessment process.

The first iterative stage in considering the EIA boundary should therefore involve a review of the blanket mire complex at Cashlaundrumlahan to determine the extent of the hydrological connections resulting from the interconnected deep peat that dominates the site. Areas of deep peat outside the development boundary but contiguous with the peat on the summit should be considered for inclusion because they are directly linked through their hydrological connections.

It is possible to define an approximate boundary of the Cashlaundrumlahan summit blanket mire complex on this basis. However, this does not necessarily embrace issues relevant to conservation of hen harrier and other moorland birds nor does it address the very significant issues of stability raised in this report. It is clear that the loss of peat stability could have far-reaching consequences because the summit area forms the headwaters for several catchment systems. Problems on the mountain summit may be felt throughout parts of any or all of these catchments. It is, of course, possible to point to effects that are already evident at Derrybrien and draw conclusions about the potential area of impact should there be further instances of instability.

The area of the Cashlaundrumlahan summit mire macrotope has consequently been combined with the lines of watercourses that might be at similar risk to the type of impact already suffered by the Owendalulleegh River, Lough Cutra, possibly the Coole system and potentially even the Kinvarra outflow.[1] This revised boundary embraces the courses of the Boleyneendorrish River and its lower connections and the Duniry River as far as Lough Derg. Given the effect of the October 2003 bog slide on Lough Cutra, the northern part of Lough Derg is also included, at least as far south as the inflows of rivers near Gorteeny and Ballindery where their combined volumes would go some way to diluting any inputs from the Duniry River. This revised boundary can be seen in fig 6.3.

Although initially the EIA geographical limit was taken to be the area of the development and the immediate slopes of Cashlaundrumlahan, this boundary has changed substantially. The range of statutory environmental designations and features of conservation interest will now be considered in the context of this final boundary.

6.3 *Statutory designations and features of conservation value*

Having determined a boundary for the EIA, it is important to determine whether any statutory conservation sites lie within the boundary because these will impose some of the strongest constraints on development. In some cases, there will be no conflict and there may even be benefits to be gained for both the development and for the designated area. More often than not, however, a development gives rise to some form of potentially negative impact.

The listings and site descriptions given below are adapted from various official accounts to be found on the web-sites of Dúchas The Heritage Service, the Ramsar Convention and the Convention on Biological Diversity (see the web sites listed in the references).

6.3.1 *Habitats Directive – Special Areas for Conservation (SACs)*

A total of five SACs lie within or adjacent to the EIA boundary and have some potential, however small, to suffer impact from the development. These are Lough Cutra, Coole Garryland Complex, Lough Derg, Caherglassaun Turlough and the Galway Bay Complex. They are considered below.

1 Minutes of meeting, 4 November 2003, SHRB, Wildlife Service, GCC, ESB.

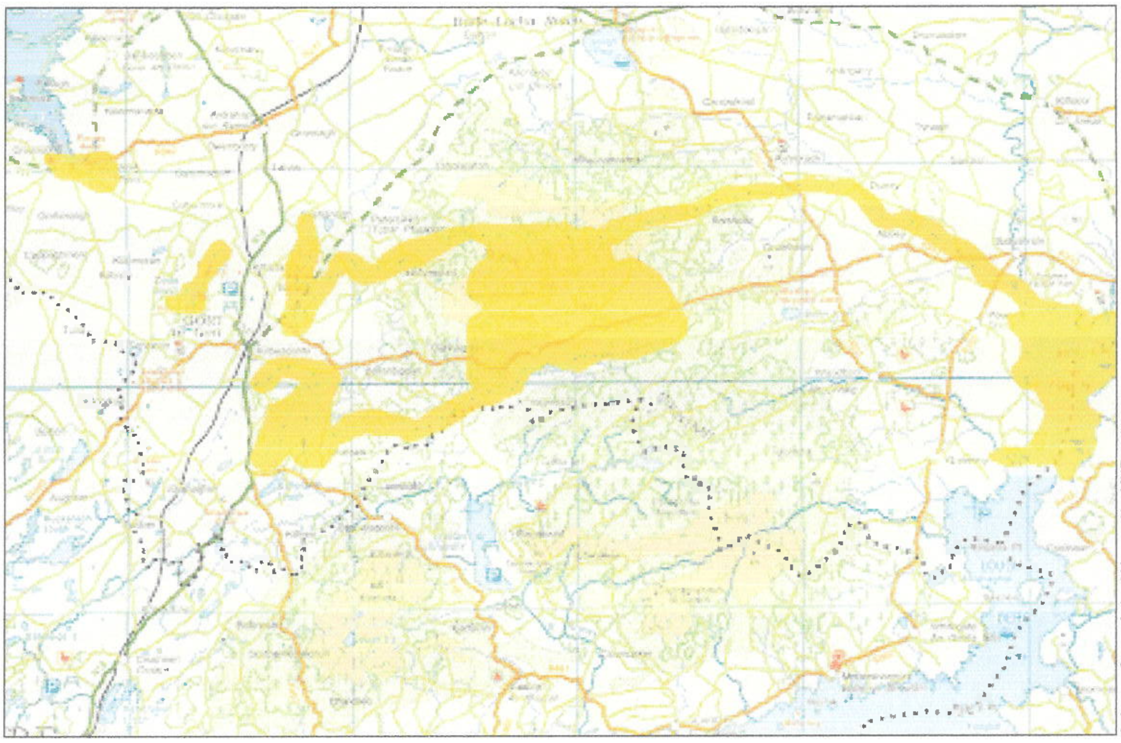


Figure 6.3: A map showing the total area (shaded orange) that might be affected by wind farm development on Cashlaundrumlahan and which should thus form part of the EIA process. Parts of the catchment drainage systems are connected through underground karst systems and are thus not easy to follow along their whole length.

Lough Cutra

This site is a candidate SAC on the basis of its Annex I alkaline fen and for the Annex II lesser horseshoe bat (*Rhinolophus hipposideros*). Both the Owendalulleagh River that feeds into Lough Cutra and the lake itself support a significant population of the brook lamprey (*Lampetra planeri*), another Annex II species.

Possible impacts on the alkaline fen depend largely on the main source of water for the fen. If this comes from alkaline springs, major changes to the main body of the lake water may not have a substantial effect but, if the alkaline water is largely derived from the lake itself, then a large influx of acidic and peat-laden water from a substantial bog-slide may give rise to significant changes in the fen vegetation.

Such changes would also undoubtedly markedly change the invertebrate population of the water body and they may have an effect on the lesser horseshoe bat (*Rhinlophus hipposideros*) population if significant feeding takes place over the lake.

Finally, the brook lamprey relies on two quite distinct habitats in its life-cycle (Kelly & King 2001). It requires clear water and a gravel bed for spawning then the larvae require soft organic-rich silt in which to bury themselves for the three to four years during which they mature to adults. The spawning grounds invariably lie upstream from the larval beds and, in the case of Lough Cutra, tend to be either towards the inflow of the Owendalulleagh River or in the river itself. They are therefore closer to the wind farm development than the silt beds of the larvae and would be seriously threatened by an influx of peat material washing from the site.

Coole Garryland Complex

This consists of a series of karstic turloughs, a type listed as a priority Annex I habitat. A characteristic feature of such turloughs is that they are fed by extremely clear alkaline waters, which in turn control the range of species associated with the turloughs.

An influx of acidic peat sediment (as a result of a bog-slide, for example), would substantially alter these conditions, leading to a decrease in the water's pH as well as potentially depositing quantities of highly acidic peat sediment onto the vegetation of the turlough, smothering the lower-growing species and causing harm to more sensitive plant tissues.

Lough Derg

Lough Derg is one of the largest bodies of freshwater in Ireland. The candidate SAC embraces only its northern shore, from the mouth of the Cappagh River in the north-west to just below Black Lough at the north-eastern shore, but it is the part of the lake into which the Duniry River flows.

It possesses two Annex I priority habitats that are associated with the water body itself, rather than habitats found in the associated hinterland – *Cladium mariscus* fen and alluvial woodland. In addition, Lough Derg supports important populations of lamprey species (listed under Annex II), including an apparently self-sustaining landlocked population of sea lamprey (*Petromyzon marinus*). This landlocked population, where the fish do not complete a seaward migration, is unique in an Irish context. The endangered fish species pollan (*Coregonus autumnalis pollan*) is also recorded in Lough Derg, one of only three sites in western Europe. Atlantic salmon (*Salmo salar*) is an Annex II species and spawns within the lake while otter (*Lutra lutra*) is known to use the lake and is protected by the Wildlife Act 1976 as well as being listed in the Irish Red Data Book.

As with Lough Cutra, an influx of peat sediment resulting from a bog slide could potentially impact significantly on the alkaline fen communities and the fish population of this part of the lake.

Caherglassaun Turlough

Caherglassaun is an Annex I turlough which, unusually, has a large permanent lake at its core. A bat roost associated with the site has both lesser horseshoe bat and Natterer's bat (*Myotis nattereri*), which is listed in the Irish Red Data Book. As with the Coole/Garryland Complex, this is likely to be adversely affected by an influx of acidic peat sediment while changes to the invertebrate fauna of the permanent lake may significantly alter the food supply for both bat species.

Galway Bay Complex

This site arguably has a tenuous connection to the EIA boundary because, as with the Coole/Garryland Complex and Caherglassaun Turlough, sections of the connection are underground within a karst cave system. It is therefore difficult to be sure of the extent to which a change in water quality in the upper reaches of directly-impacted river systems might be seen at the coastal outflow. At most, any effect is likely to be localised within such a large site but, if that part of the site contains particular features of interest, the effect may still be significant.

6.3.2 Birds Directive : Special Protection Areas (SPAs)

Four sites within the EIA boundary are listed as SPAs: Lough Cutra, the Coole/Garryland Complex, Lough Derg and the Galway Bay Complex.

In all four cases, the bird populations of interest comprise waterfowl species. Impacts on these would depend on changes in fish, aquatic invertebrates, or aquatic plant populations. All three are possible if the waters are affected by significant acidic peat sediment.

6.3.3 *Water Framework Directive*

The European Union (EU) Water Framework Directive (WFD) was introduced in October 2000. It focuses on the management of River Basin Districts and one of its stipulations is that European rivers and lakes[2] that are affected by human activity shall achieve good ecological status, or the highest level of ecological status that is possible given specifically justified human needs, before October 2015.

[2] The minimum requirement is that rivers with catchment areas greater than 10 km^2 and lakes with areas greater than 0.5 km^2 shall be included but Member States may set lower thresholds if appropriate.

- Recommendation 6.1 – Conservation of peatlands
- Resolution VII.10 – Wetland Risk Assessment Framework
- Resolution VII.16 – The Ramsar Convention and impact assessment: strategic, environmental and social.

6.3.5 *Convention on Biological Diversity (CBD)*

The CBD provides a wide range of principles that now increasingly underpin national polices and legislation. Although there are no forms of protected site explicitly established through the CBD, the following Articles have relevance to the impact assessment process:

- Preamble
- Article 6 – General measures for conservation and sustainable use
- Article 7 – Identification and monitoring
- Article 8 – in-situ conservation
- Article 10 – Sustainable use of components of biological diversity
- Article 14 – Impact assessment and minimising adverse impacts.

The Preamble provides a fundamental concept of the CBD, namely the precautionary principle, which should be applied wherever appropriate:

> Noting also that where there is a threat of significant reduction or loss of biological diversity, lack of full scientific certainty should not be used as a reason for postponing measures to avoid or minimise such a threat.

Article 6 requires that the principles of the CBD apply through all policies, including planning.

Article 7 identifies the need for biodiversity action planning.

Article 8 identifies the objectives of biodiversity action planning which, in Ireland, has led to publication of the National Biodiversity Plan (Government of Ireland 2002). Within this NBP, there are at least two specific actions of relevance to wind farm development at Derrybrien:

> 47. Ireland will implement fully the CBD and relevant biodiversity-related conventions, etc. to which Ireland is already a Party (e.g. CBD, CITES, Ramsar, Bonn, Berne, Bats Agreement, International Convention for the Regulation of Whaling, World Heritage, Convention on Biological Diversity).
>
> 79. Maintain and expand the catchment-based national strategy for the protection and improvement of water quality in rivers and lakes by the establishment by Local Authorities of comprehensive projects for river basin management in relation to all inland and coastal waters and groundwaters. These projects will provide a major input, to be complemented by other appropriate measures by other public authorities, to the implementation of the EU Water Framework Directive and the achievement of at least 'good status' in relation to all waters.

Article 10 encourages support for activities that involve sustainable use of biological resources.

Article 14 requires that EIA is carried out as part of development control and in relation to this, at least three subsequent Decisions of the Conference of Parties have provided more detail about the necessary focus for such EIA:

- Decision V/6 – Ecosystem approach
- Decision V/18 – Impact assessment, liability and redress
- Decision VI/7 – Identification, monitoring, indicators and assessments.

6.3.6 *Scenic Amenity Areas*

The Slieve Aughty Mountains were classified within the Galway County Development Plan as being Category 2: High Scenic Amenity Areas (HSAAs). These scenic amenity areas are described as exhibiting a significant degree of visual and aesthetic interest. The development control objectives for such areas are:

- Recommendation 6.1 – Conservation of peatlands
- Resolution VII.10 – Wetland Risk Assessment Framework
- Resolution VII.16 – The Ramsar Convention and impact assessment: strategic, environmental and social.

6.3.5 Convention on Biological Diversity (CBD)

The CBD provides a wide range of principles that now increasingly underpin national polices and legislation. Although there are no forms of protected site explicitly established through the CBD, the following Articles have relevance to the impact assessment process:

- Preamble
- Article 6 – General measures for conservation and sustainable use
- Article 7 – Identification and monitoring
- Article 8 – in-situ conservation
- Article 10 – Sustainable use of components of biological diversity
- Article 14 – Impact assessment and minimising adverse impacts.

The *Preamble* provides a fundamental concept of the CBD, namely the precautionary principle, which should be applied wherever appropriate:

> Noting also that where there is a threat of significant reduction or loss of biological diversity, lack of full scientific certainty should not be used as a reason for postponing measures to avoid or minimise such a threat.

Article 6 requires that the principles of the CBD apply through all policies, including planning.

Article 7 identifies the need for biodiversity action planning.

Article 8 identifies the objectives of biodiversity action planning which, in Ireland, has led to publication of the National Biodiversity Plan (Government of Ireland 2002). Within this NBP, there are at least two specific actions of relevance to wind farm development at Derrybrien:

> 47. Ireland will implement fully the CBD and relevant biodiversity-related conventions, etc. to which Ireland is already a Party (e.g. CBD, CITES, Ramsar, Bonn, Berne, Bats Agreement, International Convention for the Regulation of Whaling, World Heritage, Convention on Biological Diversity).

> 79. Maintain and expand the catchment-based national strategy for the protection and improvement of water quality in rivers and lakes by the establishment by Local Authorities of comprehensive projects for river basin management in relation to all inland and coastal waters and groundwaters. These projects will provide a major input, to be complemented by other appropriate measures by other public authorities, to the implementation of the EU Water Framework Directive and the achievement of at least 'good status' in relation to all waters.

Article 10 encourages support for activities that involve sustainable use of biological resources.

Article 14 requires that EIA is carried out as part of development control and in relation to this, at least three subsequent Decisions of the Conference of Parties have provided more detail about the necessary focus for such EIA:

- Decision V/6 – Ecosystem approach
- Decision V/18 – Impact assessment, liability and redress
- Decision VI/7 – Identification, monitoring, indicators and assessments.

6.3.6 Scenic Amenity Areas

The Slieve Aughty Mountains were classified within the Galway County Development Plan as being Category 2: High Scenic Amenity Areas (HSAAs). These scenic amenity areas are described as exhibiting a significant degree of visual and aesthetic interest. The development control objectives for such areas are:

Ecological status is assessed on the basis of four biological quality elements, defined in terms of the taxonomic composition and abundance of phytoplankton, macrophytes and phytobenthos, benthic invertebrate fauna and fish, respectively. Good ecological status is achieved when the total effect of human pressures is insufficient to cause more than slight deviation in the biological quality elements from their natural condition.

In contrast to the simplicity of the objective, the prescribed mechanisms for compliance are complex. Reference standards are to be defined through establishment of typologies that characterise the natural biota (the condition of high ecological status) for individual biogeographical regions and river types, the latter being distinguished on the basis of physical attributes including altitude, geology and catchment area. Changes in the biological condition of each modified water body compared to the appropriate standard are then to be measured and classified on a scale of ecological status with divisions 'high', 'good', 'moderate', 'poor' and 'bad'. For watercourses falling into the latter three classes, all practical mitigation of physical and chemical impacts is to be applied, ideally restoring them to good ecological status, by the end of the Directive's implementation phase.

Article 4.1 requires, furthermore, that:

- Member States shall implement the necessary measures to prevent deterioration of the status of all bodies of surface water . . .
- Member States shall protect, enhance and restore all bodies of surface water . . . with the aim of achieving good surface water status at the latest 15 years after the date of entry into force of this Directive . . .

The Owendalulleagh River has been selected as a 'reference river' for Ireland under the Directive on the basis of its extremely high quality. There is thus a legal requirement to maintain this river in its (pre-October 2003) condition.

6.3.4 *The Ramsar Convention*

Two Ramsar sites are contained within, or adjoin, the EIA boundary: Coole Lough & Garryland Wood and Inner Galway Bay.

Coole Lough & Garryland Wood

This is described as the most important turlough complex in Ireland. It supports many rare species of flora and fauna and communities associated with the transition between turlough and woodland. Water levels fluctuate widely. The lakes are fringed by aquatic vegetation grading into grassland, tall grass and herb communities.

Inputs of water laden with acidic peat particles resulting from a bog slide could have a significant effect on this essentially alkaline system, as described above.

Inner Galway Bay

This area provides important habitat for marine life along Ireland's west coast. The site supports the richest seaweed flora on the Irish coast (500+ species) and 65 per cent of the Irish marine algal flora occur in the area. The site supports internationally and nationally important numbers of several waterbird species.

Though distant from the Cashlaundrumlahan drainage pattern and connected by a complex system of karstic drainage, the flow from the south face of Cashlaundrumlahan passes through Lough Cutra and eventually flows into Galway Bay. The impact potential is almost certainly very slight but it is not entirely absent.

In addition to the sites on the Ramsar List, a number of other Ramsar Convention Resolutions and Recommendations are relevant to the case:

- Resolution VI.5 – Inclusion of subterranean karst wetlands as a wetland type under the Ramsar Classification System

> To restrict development which would detract from the amenity value of the zoned areas [indicated in the relevant maps] where such development would be visually inappropriate and out of character, or could not be satisfactorily blended into its surroundings (Galway County Council 1997).

This designation applies to the Slieve Aughty Mountains as a whole. It would therefore be important to consider the full scale of impacts likely to arise from the wind farm development and judge whether there is the potential for such impacts to detract from the amenity value of the designated areas. Given that the visual impact of a wind farm on a landscape is one of the most commonly-cited reasons for objection to such development, it might be expected that a detailed analysis of visual impacts and sighting lines would need to be undertaken to determine whether the development would be visually inappropriate.

Less obvious, however, is the potential for significant impacts on freshwater systems within the EIA study area, given the identified instability of the peat matrix at Cashlaundrumlahan. Release of significant amounts of peat into these watercourses and lakes may, for example, result in a reduced amenity value for fishing and other water-based activities.

Summary of Chapter 6

1. The assessment of possible impacts is based on a considerable range of expertise and experienced, drawn from a wide range of sources, including the UK, Switzerland, Denmark and the Falkland Islands.
2. Examples are given of various possible methods that can help in the assessment of indirect, cumulative and interactive impacts resulting from the development.
3. A geographical boundary for the EIA is defined, based on the various issues raised in the scoping and impact assessment process.
4. The EIA boundary contains or adjoins five SACs, four SPAs, two Ramsar Sites and a reference river for the Water Framework Directive.
5. The Convention on Biological Diversity (CBD) commits the Government of Ireland to the precautionary principle, as well as to biodiversity action planning that seeks to protect and improve water quality in rivers and lakes.
6. Galway County Council's Development Plan identifies the need to consider possible environmental impacts within the Slieve Aughty Mountains HSAA.

Chapter 7

EIA and the Derrybrien planning process

THE KEY STAGES IN CONDUCTING an EIA were discussed in section 1 and demonstrated for the Derrybrien development in sections 1 to 6. This chapter will examine how the EIA was actualy carried out by Saorgus Energy Ltd and what part this played in the planning process.

Two reports were produced – an Environmental Impact Statement (EIS) for the first planning application and an Environmental Assessment (EA) for the third. The reports are very similar, with large sections of identical text, and they are not worth dealing with separately – differences are highlighted as they arise.

> Note: In reviewing the reports, quotations from them are printed in a sans-serif font and indented (as here) to demarcate them from the commentary. The two reports taken together are refered to as 'the reports', the first alone is referred to as the EIS and the second alone as the EA.

7.1 *Project Preparation*

The Derrybrien project was not one development but three because three separate planning applications were made to Galway County Council (section 1.2). The first, for 23 turbines, and the second, also for 23 turbines, were submitted in December 1997 and form the eastern and western extremities of the development. Both were initially rejected because they did not include adequate site-location maps but were subsequently re-submitted – still as separate proposals – on 23 January 1998. The third application, which was for 25 turbines and was submitted on 2 October 2000, in-filled the space between the first two (fig. 5.1).

It is not clear whether the developers always anticipated the single large scheme that the development became or whether the three plots of land (and the finance) became available through fortunate circumstances. If the intention was always to expand from the first 23 turbines, as seems probable from the timescale of submission and the fact that the third proposal linked the first two into a single unit, there is a valid argument that the planning process should have identified whether there was such an intention at the outset and that the developers should have been asked to produce at least an outline proposal for the whole scheme at an early stage.

7.2 *Notification to Competent Authority*

There is no requirement in Irish legislation for a developer to notify the planning authority of an intention to submit a planning application (section 1.3). Nonetheless, the authorities cannot have been totally ignorant of how the scheme was emerging as one a single large development.

7.3 *Screening*

Given these observations, it seems strange that the screening process by the planning authority did not highlight, or at least identify, the high probability that the first two proposals were part of a larger

scheme. Had it done so, the context in which planning decisions were taken would have been different and this might have had a bearing on the final outcome. As it is, there are anomalies in relation to the status under which the proposals were considered and the supporting documents provided. The screening process is designed to identify whether or not a proposal requires statutory EIA before it can be considered. The question is addressed in both reports.

7.3.1 *Mandatory EIA, 'salami-slicing' and the Planning Process*

> <u>Planning and Environmental Policy, Statutory EA Requirements, Designations and Requirements</u>
> In EPA Guidelines (1995), an EIS is not necessary for electrical generation projects of less than 300MW. This project clearly lies outside of these limits and an EIS is therefore not automatically required. However, Saorgus Energy has provided such a statement in the interests of public awareness of the low level of impact of this and similar wind energy projects.

Environmental Impact Statements were provided for the first of the three proposals and for the third. As discussed (section 1.4), there was no legal requirement to undertake EIA for the scale of wind farm development proposed at Derrybrien, either as individual proposals or as a single large development until the EU's Directive 97/11/EC was transposed into Irish law as Statutory Instrument No. 93/1999. The applications submitted in January 1998 were therefore correct in saying that there was no statutory requirement for EIA.

However, although it was submitted in October 2000, the Environmental Assessment for the application to construct the final 25 turbines also maintained that there is no legal requirement for EIA. This is wrong: S.I. No. 93/1999 came into force on 1 May 1999.

There is no reference in the Inspector's Report that finally awarded planning permission (on appeal – PL 07 122803, 25 October 2001) to this mistaken understanding about the EIA threshold although reference is made to the fact that supplementary environmental information had been requested.

The legal status of the EA produced for the final proposal is thus somewhat ambiguous and it remains the case that the second proposal was not supported by any explicit environmental statement at all and, except for a few rather generalised references in the EA for phase three, appears not to have been assessed at all.

This raises an important issue of planning procedure. Together, the three proposals represent, in the words of the developer, 'one of the largest wind farms in Europe'. It is difficult to reconcile good planning practice with such a substantial development not having been subject in its entirety to Environmental Impact Assesment or with parts of the development not having been subject to any form of assessment.

The European Commission's review of EIA implementation within Member States (European Commission 2003) identifies the tendency of developers to 'salami-slice' large developments by breaking them into several smaller proposals either to evade thresholds for mandatory EIA or to make the full impact of a large development appear much smaller by introducing it in stages.

The anomalous planning situation at Derrybrien would seem to be an example of the problems that result from not adequately controlling such 'salami slicing'.

7.3.2 *EIA – objective assessment or public relations exercise?*

Wathern (1988) describes EIA as 'a process for identifying the likely consequences, for the biogeophysical environment and for man's health and welfare, of implementing particular activities and for conveying this information at a stage when it can materially affect their decision, to those responsible for sanctioning the proposals'. The Essex Guide to Environmental Assessment (Essex Planning Officers' Association 1994) describes the primary purpose of an EIA with a clarity and robustness that leaves little room for misunderstanding. It must be:

> . . . an impartial objective assessment, not a best-case statement for the proposal – otherwise the integrity of the ES may be brought into question. Negative impacts should be given equal prominence with positive impacts and adverse impacts should not be disguised by euphemisms or platitudes.

The reports produced by Saorgus Energy have a very different objective – it is explicitly stated that there is no statutory requirement to produce either report (Saorgus Energy appears convinced that there was no requirement for it to produce an EIA for either application) but that the company chose to produce them in order to improve, 'public awareness of the low level of impacts of this and similar wind energy projects'.

A document produced with the explicit intention of promoting the low environmental impacts of a project is unlikely to be the same as an objectively assembled and tightly focused study that addresses the impacts of a particular project at the level of detail that might be expected from an EIA, especially one produced to a meet a statutory requirement.

Is, therefore, the 'Environmental Statement' produced by the developer in relation to Planning Application 00/4581 a public relations document or a formal submission under the terms of statutory EIA? The planning process did nothing to clarify this situation.

7.4 *Scoping*

A comprehensive scoping study should form the first (and in many ways the most important) stage of an EIA (Gilpin 1995, Weston 1997) because this determines what will be examined in terms of potential impacts (section 2.5). While an introductory paragraph (see below) within both of the reports can be regarded as a scoping statement, no evidence is provided to show that an integrated scoping exercise was carried out. At the very least, the first stage of scoping should involve a review of published scientific literature relevant to the site and the type of development proposed. Without it, assessment is undertaken in a vacuum: it is devoid of the experience of similar ventures elsewhere and in ignorance of the accumulated knowledge reflected in the literature. The lack of even a rudimentary literature review was a crucial omission from the reports.

> Structure of this Environmental Impact Statement
>
> This EIS has been structured according to guidelines published by the Environmental Protection Agency (1995). This document outlines both the subjects to be covered and the approach to be taken in dealing with them. These procedures have been followed in the preparation of this EIS. All likely impacts are considered in terms of:
>
> 1 Existing conditions
> 2 Potential or likely impacts
> 3 Proposals for mitigation of these impacts

As it says, this reflects the broad, general headings of the guidance provided by the EPA (1995) and, approached in the appropriate way, these can provide the key stages of an EIA with 'existing conditions' providing the opportunity for scoping, 'potential or likely impacts' covering the impact assessment phase and 'proposals for mitigation' being self-explanatory.

Unfortunately, the reports adopt a very literal interpretation of the stages and topics suggested by the guidelines. Each topic is taken as a discrete area of assessment in isolation from the others and is treated to a narrowly-focused 'background' review (essentially a highly constrained attempt at scoping for that particular topic) followed by an assessment of impacts and proposals for mitigation.

By making such a compartmentalised interpretation, the reports miss a key stage of scoping, which is the integration of impacts and effects *across* headings. The integration of indirect, cumulative and interactive impacts is an explicit part of EIA but it can only be achieved by bringing together the categories recommended by the EPA and using them as key components of a larger, integrated view of the development. Without this, an EIA cannot, as the saying goes, 'see the wood for the trees'. Unfortunately, the reports may see individual trees but there is no recognition that these trees can, and must, be considered as component parts of a larger system.

The brief scoping 'statement' is followed by a section not found in EPA guidlines whose purpose seems to be to promote the cause of the development rather than provide a dispassionate assessment of environmental pros and cons. It reflects an emphasis that is, yet again, inappropriate in an EIA.

Site selection process

Suitable characteristics of Derrybrien

The title is itself revealing – the focus is entirely on the 'suitability' of the site for wind farm development. There is nothing in EPA advice to encourage a site description based on 'suitability for wind farm development'. Such a description is inevitably biased towards factors tending to favour the development while minimising, or even omitting other, less favourable, factors that may nevertheless be significant. As noted above, this does not sit comfortably with a dispassionate and comprehensive attempt to describe the characteristics of a development site.

This emphasis on 'suitability' runs through much of the reports and gives rise to selective discussion about particular features in certain sections without reference to others. It is virtually impossible to obtain an overall picture of the site as a functioning whole. This gives rise to problems as the following extracts show:

> Proximity to neighbours
>
> Wind turbines need to be sited away from habitation. This is mainly because of the possibility of the turbines being audible at people's residences. The closest house is 2000 m from the nearest turbine and is shielded to a large extent by coniferous forestry . . .
>
> Interference with other land uses
>
> Forestry is at present the major land use in the area but changes in forestry practice mean that, when these trees are harvested, replanting will not occur due to low yields from forests planted on blanket bog. These trees are due to be harvested in the near future and therefore there will be no conflict with present land use.

These statements appear to contradict each another. On the one hand, the nearest neighbour is to be shielded from noise by extensive coniferous forestry while, on the other hand, there is no conflict with forestry because the plantations will soon be removed and not replaced. Again, there is a sense that positive aspects are emphasised without being balanced by potentially negative and conflicting aspects elsewhere. In short, there is little evidence of integrated thinking in either report – aspects are addressed in isolation in a way that favours the development.

7.5 *Impact assessment*

As noted, the bulk of the reports addresses environmental issues with a description of the existing environment, the expected impacts and, finally, the proposed mitigation measures. Within any single topic, there is some opportunity for scoping – but only in a limited way. The discussion of impacts is (with the exception of the visual impact and noise) constrained first by a lack of adequate information and second by the apparently limited understanding of ecological processes. As a result, the mitigation proposals are often inappropriate, impossible to comply with or just inadequate.

The compartmentalised approach is a major issue the problems of emphasis are illustrated by noting that 17 pages (26%) of the EIS and 11 pages (22%) of the EA are concerned with the visual impact of the wind farm while three pages (5%) of the EIS and four (8%) of the EA are devoted to noise impacts: the EIS devotes 32 per cent of its content to visual and noise impacts and the EA 29 per cent. This contrasts with the space devoted to habitat impacts (essentially confined to the section on flora) which amounts in total to only three per cent of the EIS and four of the EA.

Within an EIA, habitat can be addressed as a singular entity within the general review of flora and fauna. Alternatively, or additionally, it can be regarded as a complex entity arising from interactions between lithosphere, atmosphere, biosphere and hydrosphere and can be addressed in the light of impact interactions. What is not in doubt is that the habitat must be addressed at some stage because it generally represents an entity that is greater than the sum of its constituent parts.

Every habitat has unique properties that must be addressed if a true picture of possible impact is to be obtained. 'Ecological quality' should be measured by much more than just the presence or absence of particular plant or animal assemblages. However, the focus of ecological attention for both reports is directed almost entirely towards the two separate questions (with no attempt at integration) of

Site selection process

Suitable characteristics of Derryhien

The title is itself revealing – the focus is entirely on the 'suitability' of the site for wind farm development. There is nothing in EPA advice to encourage a site description based on 'suitability for wind farm development'. Such a description is inevitably biased towards factors tending to favour the development while minimising, or even omitting other, less favourable, factors that may nevertheless be significant. As noted above, this does not sit comfortably with a dispassionate and comprehensive attempt to describe the characteristics of a development site.

This emphasis on 'suitability' runs through much of the reports and gives rise to selective discussion about particular features in certain sections without reference to others. It is virtually impossible to obtain an overall picture of the site as a functioning whole. This gives rise to problems as the following extracts show:

> Proximity to neighbours
>
> Wind turbines need to be sited away from habitation. This is mainly because of the possibility of the turbines being audible at people's residences. The closest house is 2000 m from the nearest turbine and is shielded to a large extent by coniferous forestry . . .
>
> Interference with other land uses
>
> Forestry is at present the major land use in the area but changes in forestry practice mean that, when these trees are harvested, replanting will not occur due to low yields from forests planted on blanket bog. These trees are due to be harvested in the near future and therefore there will be no conflict with present land use.

These statements appear to contradict each other. On the one hand, the nearest neighbour is to be shielded from noise by extensive coniferous forestry while, on the other hand, there is no conflict with forestry because the plantations will soon be removed and not replaced. Again, there is a sense that positive aspects are emphasised without being balanced by potentially negative and conflicting aspects elsewhere. In short, there is little evidence of integrated thinking in either report – aspects are addressed in isolation in a way that favours the development.

7.5 Impact assessment

As noted, the bulk of the reports addresses environmental issues with a description of the existing environment, the expected impacts and, finally, the proposed mitigation measures. Within any single topic, there is some opportunity for scoping – but only in a limited way. The discussion of impacts is (with the exception of the visual impact and noise) constrained first by a lack of adequate information and second by the apparently limited understanding of ecological processes. As a result, the mitigation proposals are often inappropriate, impossible to comply with or just inadequate.

The compartmentalised approach is a major issue the problems of emphasis are illustrated by noting that 17 pages (26%) of the EIS and 11 pages (22%) of the EA are concerned with the visual impact of the wind farm while three pages (5%) of the EIS and four (8%) of the EA are devoted to noise impacts: the EIS devotes 32 per cent of its content to visual and noise impacts and the EA 29 per cent. This contrasts with the space devoted to habitat impacts (essentially confined to the section on flora) which amounts in total to only three per cent of the EIS and four of the EA.

Within an EIA, habitat can be addressed as a singular entity within the general review of flora and fauna. Alternatively, or additionally, it can be regarded as a complex entity arising from interactions between lithosphere, atmosphere, biosphere and hydrosphere and can be addressed in the light of impact interactions. What is not in doubt is that the habitat must be addressed at some stage because it generally represents an entity that is greater than the sum of its constituent parts.

Every habitat has unique properties that must be addressed if a true picture of possible impact is to be obtained. 'Ecological quality' should be measured by much more than just the presence or absence of particular plant or animal assemblages. However, the focus of ecological attention for both reports is directed almost entirely towards the two separate questions (with no attempt at integration) of whether any significant botanical interest remains on the site and whether particular bird species use it. This absence of an integrated habitat assessment is another key failure of the reports.

From this point on, this review of the reports follows the sequence and titles of their headings.

7.5.1 *Visual impact*

The existing environment

> . . . These shale highlands occur through large parts of South Galway and Clare and are broad areas of gently rolling hills. There are few sharp [sic] or peaks or cliffs and poor drainage means that blanket bog is well developed . . .
>
> These hills are almost completely covered with blanket bog. In places this is several metres thick and is commonly harvested for turf. This bog gives the hills a bare and desolate aspect and contributes greatly to their character. Another factor is the relatively recent forestation of the blanket bogs. This has had a great effect on the landscape as the trees show great colour contrasts with the underlying bog. In addition, the planting of trees in blocks with abrupt boundaries and the monoculture nature of the plantations means that this effect is amplified . . .
>
> . . . The views from the site are very limited by both the very broad, almost flat nature of the hilltop and by the preponderance of forestry in the area.

It is clear that the developers recognise the presence of extensive blanket peat throughout the major part of the development area, that it is known to be at least two metres deep over most of the site and that there has been extensive afforestation on the peat.

The preponderance of blanket bog across this part of the Slieve Aughty Mountains is offered as an explanation for the open nature of the landscape. The forest blocks are described as providing sharp visual contrast with the blanket bog, particularly as these blocks have abrupt margins and consist of monocultures. It is therefore acknowledged that not only is forestry a feature of the site but that it reflects the typical practices of coniferous afforestation across deep blanket peat.

But there is no mention of the significance of the forestry for the condition and possible stability of these deep peat soils:

Measures to lessen adverse impacts

> The visual impact of tracks and roadways will be slight. This is because the roads will be excavated in areas already cleared for drainage, because the site is surrounded by convex slopes and because most if not all new access tracks will be of the floating type, constructed on geotextile mats laid directly on the bog surface. These floating tracks will be used if the bog is more than 2m deep as is the case in almost all of this site.

7.5.2 *Other possible impacts on humans*

Use of access roads

> The construction phase will involve the passage of equipment and materials for approximately six months. The operational phase thereafter will involve the weekly or monthly passage of a light van with the possibility of a truck or crane making very infrequent visits, perhaps once a year.
>
> During construction, access for heavy plant such as cranes and excavators will be required. Turbine components will also have to be transported to site by this route, necessitating the passage of some articulated trucks. The foundations for the turbines will require up to 345 [400][1] loads of readymix concrete in addition to other components such as reinforcing steel. The total number of truck loads is projected to be 443 [650] over the construction period of approximately 6 months. This heavy traffic would be spread over this construction time and would average approximately 3.5 [4.5] loads per day over this period. This traffic will peak when construction of foundations is at its maximum and will be correspondingly less than the average at other times during the six month construction period.

Despite acknowleding the depth of peat across the site and recognising the need for tracks that float on geotextile matting, no link is made either between the geo-mechanics of these roads and either the weight of machinery that will make use of them or the cumulative effect of frequent use. No

[1] The numbers in square brackets [123] were presented in the EA, the others in the EIS.

comparison is made with the construction methods employed by the forest industry; no literature is cited concerning the load-bearing capacities of floating roads and neither report attempts to review the evidence of their soil stability, their load-bearing capacity or their long-term maintenance issues.

This report has pointed out key issues associated with floating roads (section 5.1) but it appears that no actual or even possible geophysical impact from road construction was anticipated by the authors of the reports because neither the one nor the other is described in either paper.

7.5.3 *Effects on ecological quality (flora)*

Existing environment

> The habitat throughout is upland blanket bog . . . On the site in question, most has been planted with commercial forestry. In the short term, at least, this has substantially degraded the ecological quality of these areas by the associated drainage and replacement of blanket bog species with coniferous species. Lodgepole pine or Shore Pine (*Pinus contorta*) is the principal tree planted, while Sitka Spruce (*Picea sitchensis*) is also common. The canopy cover can be quite dense, sometimes over 90%, with the canopy height of up to 40 ft. The understorey often shows little growth, with occasional moss and ferns. In more open areas amid the trees, Purple Moor Grass (*Molinia caerulea*) and Ling Heather (*Calluna vulgaris*) become quite common, indicating the blanket bog nature of the original habitat.
>
> . . . less than 5 of the total [is] reasonable quality blanket bog habitat. However, most has been disturbed by nearby forestry and associated drainage and this has resulted in a reduction of the ecological quality.
>
> Overall, the coniferous forestry which covers most of the site is of little botanical interest. The blanket bog plant species have mostly been destroyed and the integrity of the blanket bog itself has been badly affected by drainage channels.

This is further acknowledgement that the habitat over most of the site is upland blanket bog and further recognition that plantation forestry has substantially degraded it as a result of drainage which has badly affected 'the integrity of the blanket bog'. The general scarcity of continuous bog vegetation cover is also highlighted, with the ground surface beneath the trees in particular being described as largely devoid of vegetation.

As sections 4.2 and 5 suggest, these conditions should have triggered concern about a number of potential problems in such an environment.

The lack of a literature review has already been discussed but the most striking feature of this section is the lack of any reference to the literature about peat bogs in general and blanket bogs in particular. A few references about the birds of blanket bogs appear in the EA but neither report mentions any of the literature about the habitat that dominates the site.

The excuse cannot be made that there is no such literature. Peatlands are found on all the continents except Antarctica and, globally, are the most extensive and widespread terrestrial wetland: there is considerable literature about the peatland environment (section 3).[2] The dynamics of Irish bogs have been described for at least 300 years (King 1685). To find no reference to any of this in either report suggests that no serious attempt was made to assess the likely impacts of wind farm development on this habitat – yet it was precisely this habitat that was to suffer dramatic and spectacular collapse.

It is not necessary to emphasise the important part that the peatland habitat should have played within the assessment process as the habitat has amply demonstrated the point.

The predicted impacts of the proposed development

As discussed in section 3, a blanket bog consists of a layer of living vegetation, an associated peat deposit and a characteristic hydrology – the three are inextricably linked (Ivanov 1981, Ingram 1983, Lindsay 1995, Charman 2002). Nowhere in either report is this composite view of the habitat adopted, rendering it impossible to make an adequate assessment of potential impact.

Various statements in the reports do identify potentially critical issues for the peatland habitat,

2 See www.ramsar.org.

particularly the impact of forestry, but they fail to recognise their significance. It is even claimed that the use of afforested land for turbine construction would be a positive environmental gain although it should be evident (section 3.2) that forestry may well be a key factor in rendering such areas *unsuitable* for development.

7.5.4 *The critical nature of hydrology*

> The major botanical impact of the siting of a wind farm in this area is the loss of habitat in the vicinity of the turbines. Owing to the already highly disturbed nature of the forested area, this ecological impact would not be significant.

Again, the reports consider the site in a compartmentalised rather than an integrated way. Excavations for 71 turbine towers do certainly represent wholesale vegetation destruction (and catotelm removal) but it is not the only, or even the major, likely impact on the bog ecosystem. The excavations, the long-term effects of the forestry on the peat and the impact of the roads should each be considered in terms of their particular effects on ecology and hydrology. The cumulative effect of these should then be considered on the ecosystem as a whole. It is important to recognise that intimate hydrological linkages maintain a functioning habitat complex that extends beyond the boundary of the proposal.

> . . . The planting of forestry on site has already allowed significant drainage and this would not be significantly increased by the construction of a wind farm. Compared to current forestry, the construction of a wind farm would involve minimal impacts on botanical quality and with time the absence of forestry will allow the regeneration of a representative blanket bog flora.

While this recognises that the peatland system has been affected by long-established forest plantations, no consideration is given to the detailed nature of the changes or their implications. Once again, there is no evidence of a review of the literature describing the long-term effects of forestry on peat and no systematic attempt to establish the condition of the peat soils beneath the plantations. There is no recognition that the wind farm would compound the effect of afforestation and give rise to a cumulative impact. Instead, the implication is that, in some way, it replaces the impact of the forestry with something more environmentally benign. This is not so (section 4.2).

It is one of the ironies of this case that the site was chosen in part because it was assumed that afforested blanket bog would have little wildlife interest and that the ecological impact of the development would be limited. It is true that removal of forest from areas of deep peat can provide opportunities for peatland restoration – major EU LIFE projects have in recent years assisted in achieving just this in parts of the UK and Ireland – but there is a world of difference between removing trees and blocking drainage system to encourage Sphagnum-rich communities to re-develop and removing trees to introduce industrial-scale development with significant additional construction and drainage works. In the first case, removal is associated with a reversion to more natural conditions, in the second, the removal of trees is a precursor to a new pattern of disruption applied over an existing pattern of disturbance.

> The construction of this project would also impact on the quality of the blanket bog plants species present if it resulted in significantly increased drainage in the area. However, two features of wind farm construction have a bearing on this possibility:
>
> a) If peat is more than 2m deep it is more economical to construct a floating road over the surface of the bog than it is to excavate the peat down to bedrock. Floating roads tend to subside in time to the level of the surrounding peat. This means that no channels then exist to enhance the local drainage. Probing the peat at Derrybrien has revealed that this is economically the best option for new roads on site. Other roads will be located by pre-existing drains. Therefore road construction will not result in significantly enhanced drainage and consequent degradation of the ecological quality of the site.

Although the motivation for creating floating roads is clearly financial rather than ecological, it is presented as a solution to an acknowledged environmental problem. As discussed (section 2.3), peat particularly the impact of forestry, but they fail to recognise their significance. It is even claimed that the use of afforested land for turbine construction would be a positive environmental gain although it should be evident (section 3.2) that forestry may well be a key factor in rendering such areas *unsuitable* for development.

7.5.4 *The critical nature of hydrology*

> The major botanical impact of the siting of a wind farm in this area is the loss of habitat in the vicinity of the turbines. Owing to the already highly disturbed nature of the forested area, this ecological impact would not be significant.

Again, the reports consider the site in a compartmentalised rather than an integrated way. Excavations for 71 turbine towers do certainly represent wholesale vegetation destruction (and catotelm removal) but it is not the only, or even the major, likely impact on the bog ecosystem. The excavations, the long-term effects of the forestry on the peat and the impact of the roads should each be considered in terms of their particular effects on ecology and hydrology. The cumulative effect of these should then be considered on the ecosystem as a whole. It is important to recognise that intimate hydrological linkages maintain a functioning habitat complex that extends beyond the boundary of the proposal.

> . . . The planting of forestry on site has already allowed significant drainage and this would not be significantly increased by the construction of a wind farm. Compared to current forestry, the construction of a wind farm would involve minimal impacts on botanical quality and with time the absence of forestry will allow the regeneration of a representative blanket bog flora.

While this recognises that the peatland system has been affected by long-established forest plantations, no consideration is given to the detailed nature of the changes or their implications. Once again, there is no evidence of a review of the literature describing the long-term effects of forestry on peat and no systematic attempt to establish the condition of the peat soils beneath the plantations. There is no recognition that the wind farm would compound the effect of afforestation and give rise to a cumulative impact. Instead, the implication is that, in some way, it replaces the impact of the forestry with something more environmentally benign. This is not so (section 4.2).

It is one of the ironies of this case that the site was chosen in part because it was assumed that afforested blanket bog would have little wildlife interest and that the ecological impact of the development would be limited. It is true that removal of forest from areas of deep peat can provide opportunities for peatland restoration – major EU LIFE projects have in recent years assisted in achieving just this in parts of the UK and Ireland – but there is a world of difference between removing trees and blocking drainage system to encourage Sphagnum-rich communities to re-develop and removing trees to introduce industrial-scale development with significant additional construction and drainage works. In the first case, removal is associated with a reversion to more natural conditions, in the second, the removal of trees is a precursor to a new pattern of disruption applied over an existing pattern of disturbance.

> The construction of this project would also impact on the quality of the blanket bog plants species present if it resulted in significantly increased drainage in the area. However, two features of wind farm construction have a bearing on this possibility:
>
> a) If peat is more than 2m deep it is more economical to construct a floating road over the surface of the bog than it is to excavate the peat down to bedrock. Floating roads tend to subside in time to the level of the surrounding peat. This means that no channels then exist to enhance the local drainage. Probing the peat at Derrybrien has revealed that this is economically the best option for new roads on site. Other roads will be located by pre-existing drains. Therefore road construction will not result in significantly enhanced drainage and consequent degradation of the ecological quality of the site.

Although the motivation for creating floating roads is clearly financial rather than ecological, it is presented as a solution to an acknowledged environmental problem. As discussed (section 2.3), peat can be regarded for many purposes as a liquid – which is why developers talk of 'floating' roads. It was made clear (section 5.1) that such roads (and railway lines) do not merely sink to the level of the surrounding peat but continue sinking for the simple reason that, for a floating road to be maintained in a functioning state, it requires as much drainage as an excavated road.

Discussion with site representatives made it clear that managers were already talking of the need for comprehensive drainage of the road network despite assurances in the reports that no additional drainage would be required. The developers now recognise that it is simply not realistic to propose undrained floating roads. The original assertion that 'road construction will not result in significantly enhanced drainage and consequent degradation of the ecological quality of the site' reveals a lack of understanding of peatland eco-hydrology and the necessary on-site practice.

Nor is there any reference to the extensive literature of road construction. There is also a significant body of literature on the physical properties of peat and its behaviour under differing forms of stress but none of it is cited in the reports either. Given what was to happen, this is a major failing. It is unfortunate that, while both reports acknowledge that 'the integrity of the blanket bog itself has been badly affected by drainage channels', no connection is made between this and a possible instability of the peat. The evidence was there but the reports failed to recognise its significance whereas even the briefest review of the published literature would have alerted the developers to potentially significant issues on the basis of what they themselves had already recorded.

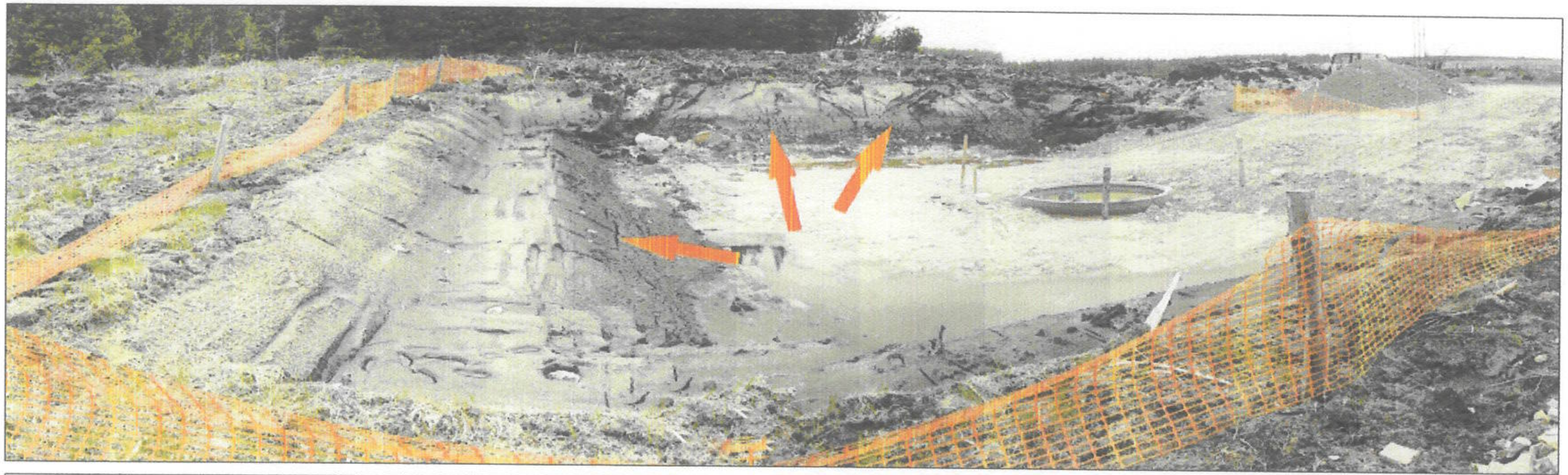
> b) Construction of turbine bases consists essentially of excavating a hole of approximately 15x15m down to competent bedrock and constructing the turbine base within this . . . The process does not result in long-term drainage of the surrounding peat.

Although acknowledging that habitat will be lost when turbine bases are constructed, the reports justify this by stating that it has already been damaged by forestry activities. Forestry has essentially a surface impact with much of the catotelm remaining undisturbed (section 3.2.1). With a turbine excavation, the entire acrotelm and catotelm are removed. If the peat is three metres deep, this will have taken around 3,000 years to accumulate and, as explained (section 5.2.2), it cannot be restored just by dumping new peat into the hole. Compared to forestry plantation, this is long-term damage.

Clearly of more concern is the possibility that the excavations might be thought to cause drainage from the surrounding peat and assurances are given that this will not happen – but they are not accompanied by any evidence. Given the issues associated with turbine-base construction, it is worth examining the reports more closely on this.

Their argument focuses on the relatively small footprint of the turbine bases and suggests that, although an area will suffer absolute loss, it only involves a hole 15 metres x 15 metres (i.e. 225 m^2) with the volume of material to be removed described as 175 m^3 of bedrock and overlying peat (equal to a concrete pad 15 metre square and approximately 0.8 metres thick. In reality, these figures give litle indication of the area required: they do not allow for the need for hard-standing for construction and maintenance machinery and they imply that a vertical-sided hole will be excavated whereas the side must be dug at or about the normal angle of repose for potentially unstable material. If the excavation is in deep peat, the margins of the excavation extend significantly further outwards (fig 5.3). In short, the total area of direct impact necessary for a securely installed turbine base with maintenance access is substantially larger is discussed in the reports. Plate 7.1 reveals the full extent of the impact of turbine-base.

Material removed from the excavations for the turbine bases (arisings) was reportedly heaped onto adjoining bog surface even when the excavation lay on a slope. In some cases, the peat mounds had failed and collapsed downslope (e.g. T34) while, in others, the underlying peat was showing signs of failure in the form of cracking, slumping or swelling. In the light of these, construction practices were altered and the arisings were spread out into much thinner layers across the surrounding bog surface, creating large areas of bare peat. As a result, the area of bog impacted by turbine installation is increased many times and these areas of sloping ground are now predisposed to erosion (section 4.1)



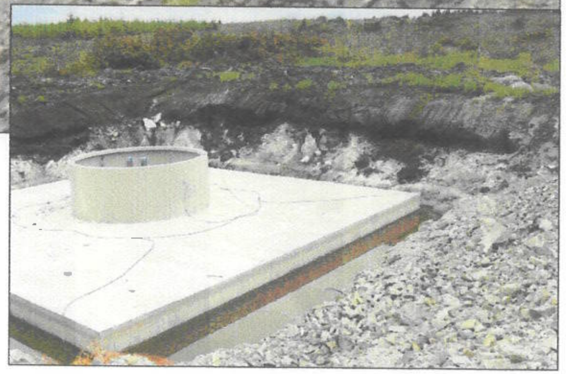


Plate 7.1. Top: T67, showing the base-can, the overburden burying its plinth and the exposed peat faces on the excavation sides. The area of peat removal is clearly much greater than the 15 metres x 15 metres claimed. Cracks in the catotelm peat are highlighted by arrows.

Above: T34. The excavation is the pale surface on the right surrounded by orange netting. The excavation area is slightly smaller than that for T67. The grey material spreading down to the forestry in the distance is peat that had been excavated and piled up on the bog surface. It had subsequently either collapsed and flowed or had been deliberately spread to avoid further possibilities of instability, depending on who was describing it.

Right: The foundation for T23 showing the concrete pad and steel base can before the addition of hardcore overburden. Sited in an area of shallow peat, the top of the pad lies below the peat-mineral interface.

because the vegetation has been smothered with little left to bind the loose matrix of the surface peat together. The substantial additional area directly affected by the need to do something with the material is illustrated in plate 7.1.

While this was all very largely predictable, at least in principle if not in total extent, the picture does not give a sense of the extent of semi-direct impacts if the extensive areas of bare peat were to initiate an erosion complex.

Not only is the area directly impacted by the excavations much larger than the reports suggest, there is also an issue of indirect impacts resulting from drainage – despite the statement that the 'process does not result in long-term drainage of the surrounding peat'.

Under 'Effects on water' below, the reports recognise that turbine bases will fill with water and it is proposed that this be dealt with either by pumping it out or by displacing it with a backfill of hardcore and concrete. If it is pumped out, then the exposed peat faces will dry out – at several of the turbine excavations where pumping or drainage has been used, the resulting wall of catotelm peat has already become severely disrupted, is riven with cracks and is clearly undergoing oxidative change (plate 7.1).

The alternative solution, backfilling the excavation with hard core, is also inadequate as the picture shows. This backfill provides weight for the turbine base and hard-standing for machinery but it does not seem to be necessary to fill the excavation to the level of the cut peat faces.

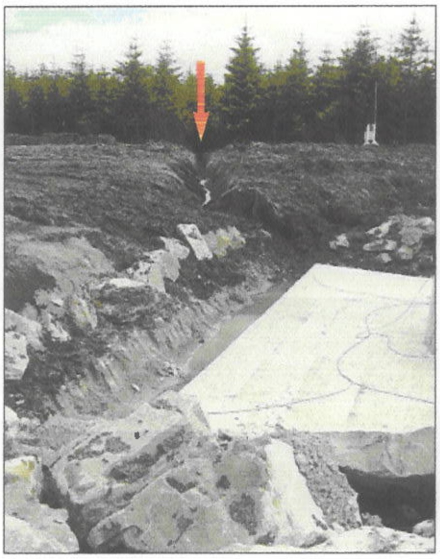
Backfill, excavations on slopes and peat drainage have already been discussed (section 5.2.2) – the evidence of on-site practice confirms that the excavations will result in long-term drainage of the peat.

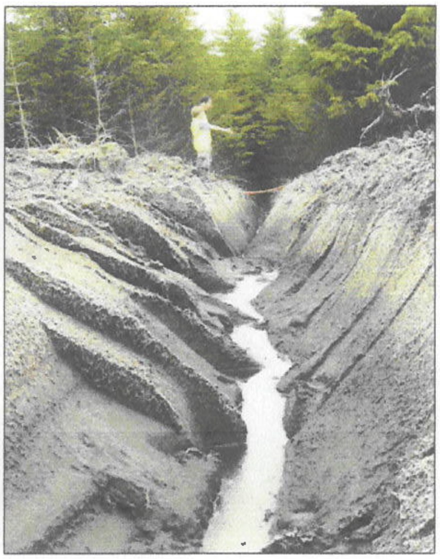
Not only do the approaches proposed for water management around turbine bases conflict with the practice at other (non-peat) wind farms, where adequate drainage is considered paramount to maintaining the functionality of the bases (sections 5.2.3 and 5.2.4) but the on-site practices are very different from their descriptions in the reports. Not only is it evident that substantial drainage has already been created to maintain a low water table in the excavations (plate 7.2) but geotechnical consultants have recommended that permanent drainage needs to be installed at all the excavations. This is being implemented through a series of ditches and culverts linked to a network of site drains. The claim that 'the process does not result in long-term drainage of the surrounding peat' is supported neither by any of the principles of peatland hydrology nor by evidence of on-site practice.

<u>Measures to lessen impacts</u>

Ecological impacts will be minimised by siting turbines predominantly in areas currently forested. Construction of roads will be carried out so as to minimise damage to undisturbed blanket bog habitat of which there is little in the site itself.

Plate 7.2: A drain dug to release water from the base of turbine T2. Note the rock reinforcement required to stabilise the sides of the excavation.





Blanket peat has a long history of instability, particularly when disrupted by human activity (section 5). Ironically, in an effort to reduce damage to upland blanket bog habitat, the development has been sited in an area where the bog is already highly disrupted and potentially unstable as a result of long-established forestry activities. It is, of course, correct that the reports should be concerned about, and propose ways of preventing, harm to undamaged blanket bog. However, just as with the administration of a dangerous medicine, if a proposal to minimise environmental impact poses its own significant risks, these should be acknowledged, measured, discussed and minimised. The adoption of solutions in a state of ignorance without following rigorous control procedures is likely to do more harm than good. Neither report acknowledges that the proposed 'measures to lessen impacts' pose any problems or dangers of their own.

7.5.5 *Effects on ecological quality (birds and other fauna)*

> Existing environment
>
> The bird species noted on the site visit include Meadow Pipet [sic], Skylark and Snipe. These are common on bogs and wetlands. Other species possibly frequenting the site include Merlin, Hen Harrier, Woodcock and Red Grouse. Merlin habituate open moorland and can nest in conifer plantations. Hen Harrier are found in similar habitats which have young forestry plantations. Woodcock can be found in forestry plantations and are not uncommon throughout country. Red Grouse, although currently scarce in the locality, can be found in open moorland with good Ling Heather growth.

It seems that assessment of the fauna of Derrybrien was based on a single site visit. Even if the wording is misleading and the evidence is based on more than one visit, it is of little value because no information is provided about the timing and duration of the visit(s) – i.e. dawn to dusk, morning, afternoon or some other period – or of the season in which the visit(s) took place, how many people were involved or what survey method was used – e.g. casual observation, timed transect, distance transect, fixed-point observations or repeated fixed-point counts. If more than one person was involved, how were the counts co-ordinated to avoid double counting? No numeric data are presented in either report, leaving the question open as to whether any counts were undertaken. Again, the reports present no data of possible relevance from the literature. The species list is most notable for its brevity: had the survey covered a full year, or even focused systematically on breeding and migration seasons only, it would surely have been substantially longer.

> One major limiting factor in the number of bird species found in the area is the extent of coniferous forestry plantation. This is such that the amount of open moorland is relatively small. The moorland is needed for hunting and food supply, while the forestry is mainly used for cover and nesting. Therefore, a dearth of open blanket bog would restrict the number of species frequenting the site.

The important question is whether there is, as implied, a 'dearth of open blanket bog'. If only the wind farm site is considered, then only a relatively small proportion of open blanket bog habitat still survives. However, even within the site, it is connected in a variety of directions with more extensive areas to the east, south west and north west. The point is made in the reports that a mosaic of habitats – forestry of various ages mixed with areas of open moorland – is required for successful feeding and nesting. No evidence is presented about the ratio of open ground to forestry that would either favour or discourage species such as hen harrier or merlin. It is implied that there is insufficient moorland for such species but no data are presented to support the implication.

It is worth noting that the first breeding survey of hen harriers in Ireland, carried out during 1998-2000, identified that a high proportion of the 102 hen harrier pairs recorded were found in young second-rotation conifer plantations (Norriss et al. 2002) whilst adult densities increase compared to open moorland in forests up to 10 years old. Following fire damage in the Derrybrien forest some years ago, a significant proportion of the forest on the southern slopes of Cashlaundrumlahan is now dominated by young plantations established after the fire (plate 3.3).

The survey by Norriss et al, undertaken between 1998-2000, raises another important planning issue. Its published results indicate that the Slieve Aughty Mountains represent the second most populated area for hen harriers in the country, with 15 to 23 pairs from a national population of 104 to 131 pairs. Awarding consent for the final 25 turbines on appeal, it appears that An Bord Pleanála did not request information from Norris's team about the survey (well-publicised through Dúchas, for example) but concluded instead that there were no data for the Slieve Aughty Mountains. The consent was subject to the developers undertaking a hen harrier survey concurrently with the development. Had An Bord Pleanála asked for summary results when considering the appeal, it is quite likely that at least provisional findings could have been supplied. The status of the hen harrier in the area would have been seen to be higher than the planning decision suggests.

It is difficult to reconcile good planning practice with the failure to embrace readily available information and even less so with the imposition of a planning condition that, in effect, postpones assessment of a potential impact until after the development. Such post-development assessment either gives a false impression of the impact because it occurred before the study begins or demonstrates impact when it may be too late to undo the harm identified.

To date, no detailed survey of Cashlaundrumlahan has been carried out for hen harriers though they are certainly present – a male was seen during our field visit. Furthermore, Coillte has established a Biodiversity Action Plan for the hen harrier under which forests will be managed to benefit the species (Coillte newsletter, www.coillte.ie). Harrier-friendly management of plantations seems to be feasible whether or not a wind farm is constructed.

All these factors raise questions, first about the suggestion that hen harriers are not significant components of the Derrybrien avifauna and, second, whether it is necessary to build a wind farm to create harrier-friendly conditions on the site. Would the biodiversity programmes now being established by Coillte have been better for hen harriers than the development of a wind farm, especially given concerns identified (section 6.3) about bird strike in poor visibility?

> <u>The predicted impacts of the proposed project</u>
>
> The impact of a wind farm on fauna present would not be major. The only species positively noted on site were Meadow Pipet [sic], Skylark, Snipe and Sika Deer. These species are quite robust and able to withstand some disturbance. With respect to other birds and mammals possibly present, the extent of coniferous forestry and relative dearth of good blanket bog habitat in the vicinity, would serve to restrict the numbers and variety of fauna present.
>
> <u>Measures to lessen impacts</u>
>
> If the wind turbines replaced some of the forestry, this may be in fact have a positive effect on the fauna present by increasing the diversity of habitats available and by an eventual improvement in the blanket bog habitat.

As research is only now being undertaken into the impacts of wind turbines on hen harriers in Ireland, it seems premature to state unambiguously that their impact on birds would not be significant. It would have been more correct to say that research was required. Notwithstanding the reports citing Briggs (1996), the RSPB's latest advice about wind farms and birds sets out guidance for developers wishing to be 'bird friendly'. The issues raised by the RSPB do not appear to have been considered in any depth by the reports.

7.5.6 *Effects on archaeological remains*

> <u>The existing environment</u>
>
> However, the coniferous plantation prevent archaeological investigation because the trees are planted close together and because the surface of the bog has been badly damaged in the process of forestation.

Here again is recognition that the bog surface is highly disrupted and has lost its structural integrity yet the implications again go unremarked and unrecognised.

7.5.7 *Effects on rocks and soil*

The existing environment

> Derrybrien is underlain by shales and sandstones of Upper Coniferous age. This bedrock is covered by blanket bog of up to 6 metres thick. There are no significant amounts of mineral soils present in the area. The peat cover is largely intact under the trees.

This section contains nothing about the behaviour and characteristics of and the impacts on the major, or indeed any, soil type found on the site. In the absence of a section describing impacts on the habitat, this would have been an appropriate place to discuss the possible behaviour of the peat in relation to the proposals. It represents the major component of the development in terms of where direct impacts will be felt – excavation of turbine bases, floating of roads and dumping of arisings, etc. Wherever there is an effect on the ground, peat is involved yet the reports devote only two brief sentences to the nature of the peat.

The guidance provided by the Essex Planning Officers' Association (1994) on the topic says:

> [Soil investigations] can be a fundamental aspect of an ES, since soil affects agriculture, water movement and land drainage, vegetation growth, ease and time frame for traffic movement over land . . . excavation . . . landfill and pipeline proposals.

It is also worth noting that An Bord Pleanála's 2004 assessment on appeal of PL.12.205751 concerning wind farm development in County Leitrim (the proposal was rejected) identifies the need for detailed geotechnical survey of that blanket bog area:

> A detailed geotechnical survey does not yet appear to have been undertaken . . . The applicant has not demonstrated that a bogslide would be unlikely to occur.

The legislative requirements for EIA did not change between 1999 and 2004 yet An Bord Pleanála made no request for a survey of Derrybrien even though it expects detailed assessments elsewhere.

As early as 2001, the difficulty of working with machinery at Derrybrien was highlighted by a consultant archaeologist appointed to the development as a condition of planning consent. His report (Wiggins 2001) highlighted that only eight of the 23 turbine sites in the eastern part of the site could be investigated using excavating machinery because 'the jelly-like movement of the ground under the weight of the machine rendered further digging unsafe'. One might have expected that such obviously unstable ground would not only have been identified in the early stages of assessment but would have led to a clear demand for stability analysis as part of the planning process. Neither occurred.

As well as issues of geotechnical stability, another topic not adequately addressed by the reports was the quarries or 'borrow pits' from which aggregate would be obtained for backfill of excavations or to surface the roadways. There is no mention of the use of explosives in the quarrying process. The shockwave from these can fracture the rock beneath the peat even at a distance from the quarry and can lead to creation of new routes for seepage at the peat/rock interface, which is a possible source of instability in blanket bog (section 5.2).

Blasting can also disrupt the pattern of natural peat-pipes – natural underground tubes formed in the peat, often close to the mineral base and themselves apparently responsible for peat-slope failures. It is also likely to have an impact on birdlife but this was not mentioned in the review of impacts on fauna. These are serious omissions.

The predicted impacts of the proposed project

> The only impacts on the soil and bedrock of the site will be in the construction stage. The foundations for each turbine will entail excavation of approximately 175 cubic metres of material comprising bedrock and overlying peat.

Not surprisingly, as there is no mention within the scoping paragraphs, no observations are provided about the potential impact of using explosives for quarrying nor is there recognition of the issues raised earlier concerning the excavation of the turbine bases, the pressure of floating roads, the need for drains, or the disruption of the hydrology by upslope ponding and downslope drying.

Measures to lessen adverse impacts

Few specific measures are proposed concerning impacts on the soils of the site. The one proposal for the peat is that it will be used for turf production, thereby ensuring that 'unsightly heaps of rubble do not have an adverse effect on the appearance of the site'. The extent to which reality contradicts this assurance can be seen in plate 7.1.

7.5.8 *Effects on water*

The existing environment

The surface drainage patterns at Derrybrien are largely natural despite drainage works associated with forestry. Apart from the acidifying effects of conifer leaf litter, ground and surface water are likely to be of high quality at Derrybrien. The high altitude location and a lack of development locally makes the likelihood of contamination of ground water from domestic, agricultural or industrial sources very unlikely.

Here, again, there is a chance to examine issues of peatland hydrology – drying, cracking, slumping, ponding – but these are not mentioned even though peatland erosion can give rise to substantial changes in water quality.

It was also an opportunity to consider wider questions relating to the geographical scope of the EIA because Cashlaundrumlahan forms the watershed summit for several river catchment systems. Impacts in the headwaters of these systems may have significant implications for conditions further downstream. It would have been reasonable to expect some acknowledgement of the watershed/catchment concept and its potential implications.

In addition, and clearly resulting from the lack of any proper scoping exercise, no review is provided of the potential for impact on a number of freshwater statutory conservation sites or sites of high conservation value. Had the literature concerning peatland stability been reviewed, it would have been obvious that there was a possibility of impacts to freshwater systems and that the potential effects of these impacts would need to be considered even if they were limited to increased sediment loading resulting directly from peatland drainage and erosion.

There are several SACs and SPAs and populations of several more Habitats Directive Annex I or Annex II species within the potential impact catchment (section 7.3). The SPA and Ramsar sites have been in place for some years and could have been so identified and SAC designation was ongoing during the planning phases of this development. Although the list of Habitats Directive sites for lamprey (all three recorded species are listed under Annex II of the Directive) was not identified until 2001 (Kelly & King 2001), the possibility that Lough Cutra, with its strong population of brook lamprey (*Lampetra planeri*), might well emerge as a candidate site was not identified.

The lower section of the Owendalulleegh River has been recognised as a reference site for high quality waters for the purposes of the Water Framework Directive, which came into force in December 2000. Some reference to the implications of this Directive could have been expected in the Environmental Assessment that accompanied the planning application submitted in October 2000, given that full implementation of the Directive would be completed within the lifetime of the development.

The potential impacts of the proposed project

The main potential impact to water from this project is during the construction phase if run-off from earth works brings large amounts of suspended solid matter into local streams. This risk is low as construction methods will not involve the large-scale movement of peat, soil or rock.

The construction of floating roads (see section on ecology above) means that the potential for excessive drainage and erosion along roads excavated to bedrock is eliminated. The excavation of turbine bases will result in water gathering in the resulting hole. This will be pumped out or displaced as the hole is back-filled with hardcore and concrete. This relatively small volume of water will be spread on the surface of the bog where it will be dissipated harmlessly.

After construction, the operation of the wind farm will have no significant effect on the site's water

> quality. The potential for spillage of turbine lubricants or vehicle fuel is low.

While the first sentence in this extract does make one accurate prediction of possible impacts, the second has, of course, been shown to be entirely incorrect. While there is a recognition that large-scale movement of peat is an issue, it is perceived only as physical transport of peat by construction machinery. No evidence is provided to demonstrate that the developer had investigated other forms, or causes, of peat movement or even of increases in sedimentation caused by construction activity.

Ponding associated with floating roads have been addressed (section 5.1) but the developers also identify that ponding may occur during the excavation of turbine bases. The hydrological and drainage issues associated with these excavations have also been discussed (section 5.2) but the explanation in the reports of how this water would be dealt with provides a revealing insight into the level of understanding that underpins them.

It is suggested that the water will either be displaced by infill or be pumped out. Any pumped water would then be 'spread on the surface of the bog where it will be dissipated harmlessly'.

Given the condition of the bog and observations about the dangers of pumping (section 6.1.5), it is difficult to think of a more dangerous proposal for this water. Such drainage cannot simply be achieved by 'over-pumping' the water onto the bog surface because concentrated discharge of water is one of the factors that triggers erosion and/or failure of the peat.

The other proposed solution is backfill, which was considered at some length (section 5.2.2). It has not been addressed by the developer; it is presented merely as the alternative solution but with no critical review of the implications in terms of the volumes involved, the need to obtain such quantities, the possible need for drainage or the potential for buoyancy effects if the excavation is not drained.

> <u>Measures to lessen adverse impacts</u>
>
> Earth-moving contractors will be required to ensure that their methods do not allow excessive soil run-off during the construction phase in the vicinity of streams (less than 50 metres). This may require temporarily blocking drains and watercourses feeding the stream so as to collect run off.

Having proposed pumping onto the peat as a solution to ponding within excavations, the mitigation measures for drainage of the site as a whole propose the ponding of drains and watercourses from time to time during construction to prevent excessive sediment release. This could cause significant volumes of water to be retained in drains followed by the release of the water on removal of temporary dams. Such sudden flows of water are just as likely to cause erosion as the pumping but the possible consequences are not considered.

7.5.9 *Effects on air and climate*

> <u>The predicted impacts of the proposed project</u>
>
> The project would also have a positive effect of global and local climate change. CO_2 and other greenhouse gas emissions emanating from fossil fuel power stations will tend to be reduced thereby lessening the effects of these gases on the enhanced greenhouse effect. There will be no impacts on local micro-climate.

The later of the two reports expands on this topic by presenting detailed information about the potential savings of greenhouse gas emissions:

> The following table shows the emissions saved by the Kilronan Wind Farm nearby during the year 1998. [Table of data provided.] The capacity of the Kilronan Wind Farm is 5MW and therefore approximately 10 times the shown environmental effects could be expected from the overall Derrybrien Wind Farm during the year 1998 had it existed. This shows the very significant avoidance of carbon emissions that can be achieved through the operation of large wind energy projects.
>
> The Derrybrien project would have positive effects on global and local climate change many times greater than those already taking place at Kilronan. CO_2 and other greenhouse gas emissions emanating from fossil fuel power stations will tend to be reduced thereby lessening the effects of

quality. The potential for spillage of turbine lubricants or vehicle fuel is low.

While the first sentence in this extract does make one accurate prediction of possible impacts, the second has, of course, been shown to be entirely incorrect. While there is a recognition that large-scale movement of peat is an issue, it is perceived only as physical transport of peat by construction machinery. No evidence is provided to demonstrate that the developer had investigated other forms, or causes, of peat movement or even of increases in sedimentation caused by construction activity.

Ponding associated with floating roads have been addressed (section 5.1) but the developers also identify that ponding may occur during the excavation of turbine bases. The hydrological and drainage issues associated with these excavations have also been discussed (section 5.2) but the explanation in the reports of how this water would be dealt with provides a revealing insight into the level of understanding that underpins them.

It is suggested that the water will either be displaced by infill or be pumped out. Any pumped water would then be 'spread on the surface of the bog where it will be dissipated harmlessly'.

Given the condition of the bog and observations about the dangers of pumping (section 6.1.5), it is difficult to think of a more dangerous proposal for this water. Such drainage cannot simply be achieved by 'over-pumping' the water onto the bog surface because concentrated discharge of water is one of the factors that triggers erosion and/or failure of the peat.

The other proposed solution is backfill, which was considered at some length (section 5.2.2). It has not been addressed by the developer; it is presented merely as the alternative solution but with no critical review of the implications in terms of the volumes involved, the need to obtain such quantities, the possible need for drainage or the potential for buoyancy effects if the excavation is not drained.

Measures to lessen adverse impacts

> Earth-moving contractors will be required to ensure that their methods do not allow excessive soil run-off during the construction phase in the vicinity of streams (less than 50 metres). This may require temporarily blocking drains and watercourses feeding the stream so as to collect run off.

Having proposed pumping onto the peat as a solution to ponding within excavations, the mitigation measures for drainage of the site as a whole propose the ponding of drains and watercourses from time to time during construction to prevent excessive sediment release. This could cause significant volumes of water to be retained in drains followed by the release of the water on removal of temporary dams. Such sudden flows of water are just as likely to cause erosion as the pumping but the possible consequences are not considered.

7.5.9 *Effects on air and climate*

The predicted impacts of the proposed project

> The project would also have a positive effect of global and local climate change. CO_2 and other greenhouse gas emissions emanating from fossil fuel power stations will tend to be reduced thereby lessening the effects of these gases on the enhanced greenhouse effect. There will be no impacts on local micro-climate.

The later of the two reports expands on this topic by presenting detailed information about the potential savings of greenhouse gas emissions.

> The following table shows the emissions saved by the Kilronan Wind Farm nearby during the year 1998. [Table of data provided.] The capacity of the Kilronan Wind Farm is 5MW and therefore approximately 10 times the shown environmental effects could be expected from the overall Derrybrien Wind Farm during the year 1998 had it existed. This shows the very significant avoidance of carbon emissions that can be achieved through the operation of large wind energy projects.

> The Derrybrien project would have positive effects on global and local climate change many times greater than those already taking place at Kilronan. CO_2 and other greenhouse gas emissions emanating from fossil fuel power stations will tend to be reduced thereby lessening the effects of

these gasses on the enhanced greenhouse effect. There will be no effects on local microclimate.

Even without the events of October 2003, it is too simplistic to talk of a 60 MW wind farm representing such a total saving of carbon emissions. If a true carbon balance is to be calculated, it should include the carbon released from peat excavated for the turbine bases or drainage activities, carbon released during the manufacture of raw materials and turbines components, in the hundreds of truck loads, regular maintenance journeys and in decommissioning the wind farm.

The claimed CO_2 savings at the Kilronan wind farm for 1998 and 1999[3] are summarised in table 7.1. The factor used is 0.89 kg CO_2 kWh^{-1} (presumably derived from Irish power generation data) whereas the UK national emissions factor for grid electricity is currently quoted[4] as 0.43 $kgCO_2\,kWh^{-1}$.

Year	Month	Output (kWh)	CO_2 saved (kg)
1998	Jan	1,469,600	1,307,000
	Feb	1,658,360	1,474,000
	Mar	757,240	673,000
	Apr	1,113,200	990,000
	May	947,320	842,000
	Jun	817,080	726,000
	Jul	1,003,200	892,000
	Aug	1,141,694	1,015,000
	Sep	1,124,710	1,000,000
	Oct	1,410,650	1,254,000
	Nov	1,264,102	1,124,000
	Dec	1,531,633	1,362,000
1999	Jan	1,564,548	1,390,962
	Feb	1,401,578	1,246,073
	Mar	1,579,900	1,404,611
	Apr	1,575,646	1,400,829
	May	985,714	876,349
	Jun	685,560	609,497
	Jul	828,514	736,591
	Aug	685,658	609,584
	Sep	1,025,314	911,556
	Oct	1,474,326	1,310,750
	Nov	1,095,614	974,056
	Dec	1,504,970	1,337,994

Table 7.1: Summary of carbon dioxide savings claimed for wind power generation at Kilronan, 1998 and 1999.

Source: www.kilronanwindfarm.com.

The table indicates that the average power output of the Kilronan facility over two years was 1.635 MW, or around one-third of its full five MW capacity, presumably reflecting operational difficulties in addition to the availability of wind. Thus, the average power output to be anticipated from the 60.35 MW facility at Derrybrien is just under 20 MW. Table 7.2 shows annual carbon dioxide emission savings and equivalent peat volumes, calculated per turbine and for the whole Derrybrien facility, on the basis of both the Irish and the UK figures. On this basis, the CO_2 savings[5] associated with one year's operation of a single 850 kW turbine would be cancelled out by oxidation of 5,000 to 10,000 m^3 of peat and those achieved by operating the whole Derrybrien wind farm for one year by oxidation of 356,000-756,000 m^3 of peat.

The volume of peat estimated to have been released by the October 2003 bog slide is 450,000 m^3 (AGEC 2004). If completely oxidised, this is sufficient to cancel out the CO_2 savings from seven to 15 months of operation of the whole wind farm. If only half of this material were to oxidise, it would take the full projected lifetime (20 years) of one to two turbines to offset the associated release of CO_2 to the atmosphere. Thus, it seems that a 'do-nothing' option involving the omission of Turbine 68 would have given a more favourable outcome for atmospheric greenhouse gas loading.

7.5.10 *Interaction of impacts*

It is considered that there is little potential for special impacts caused by interaction of the environmental impacts described above or for significant exacerbation of these impacts.

Similarly, the other residual impacts are considered to be minor and show little potential for interactions leading to new negative impact. In addition it can be stressed that wind energy projects such as this do not pose worst-case scenario effects that lead to irreversible impacts of

3 www.kilronanwindfarm.com/kwh.htm.

4 www.dcarb-uk.org/pubs/phase1/udc/02.htm.

5 Based on peat bulk density 100 kg m^3 (0.1 g cm-3), carbon content 57 kg m^3 (57%) (Page et al 2002) and 1 kg of C equivalent to 3.664 kg CO_2.

	per 850 kW turbine		per 60,350 kW facility	
CO_2 saving/kWh of wind power (kg)	0.43	0.89	0.43	0.89
Anticipated annual generation (kWh)	2,434,921	2,434,921	172,879,401	172,879,401
Annual CO_2 saving (kg)	1,047,016	2,164,767	74,338,142	153,698,487
Equivalent peat volume (m^3)	5,013	10,365	355,944	735,935

Table 7.2: The potential annual CO_2 savings by wind generation at Derrybrien and equivalent peat volumes.

> an exceptionally severe nature such as contamination of an aquifer or destruction of a unique habitat.

These two paragraphs represent the sum total of assessment for impact interactions – arguably the most important phase in the EIA process. The conclusions expressed in the first paragraph reflect the selective and superficial nature of the information gathered. No attempt is made to examine potential interactions between different topic areas.

The second paragraph is an example of the belief that, if something is stated as being so, then it is so. No scientific argument is presented to justify the statements and actual events were later showed the degree to which they were both unfounded and unwise.

A genuine attempt to assess the indirect and cumulative impacts and potential impact interactions would have followed the detailed guidelines for such assessment produced by the European Commission (1999) and summarised above (section 6.1).

7.5.11 *Summary of likely overall positive and negative environmental impacts*

> Positive Environmental Benefits
>
> Wind power is one of the very cleanest ways of producing electricity. [There] are no emissions whatsoever.

This is misleading, indeed incorrect, for the reasons set out in the previous section.

7.5.12 *Non-technical summary*

> The site was chosen as the most suitable site for this venture owing to a number of factors.
>
> The ecological quality of a large proportion of the area has already been substantially damaged by the presence of monoculture forestry. The operation of the wind farm would not affect animals and plants and would tend instead to benefit the ecology of the area.

The claim that 'The operation of the wind farm would not affect animals and plants . . .' cannot be justified by the evidence presented in the reports, some of which even contradicts the statement. This is a case of 'hardening up' a statement into something more powerful than the evidence can support.

> The major impact of this development would be visual.

Clearly it was not.

> The effects on the ecological quality will be minor and mainly associated with road construction. These effects are primarily offset by the excavation of roads to bedrock where forestry work has already resulted in drainage and also by choice of floating roads in areas not already drained. These floating roads do to involve the excavation of peat in order to construct the road and so will not drain the bog.

The issues associated with floating roads have already been discussed.

> The potential impacts of the project on bird life are unknown but considered to be relatively minor due to the lack of known vulnerable bird species using or passing over the site.

It may be honest to admit that the potential impacts are unknown but it is difficult to see how the claim can be justified given the evidence that hen harriers (*Circus cyaneus*) and merlin (*Falco columbarius*), amongst other birds, possibly frequent the site. Evidence presented earlier is

transformed into a 'lack of known vulnerable bird species using or passing over the site.' This does not accurately reflect the evidence presented in the main body of the reports.

> The 'do-nothing' effect of not proceeding with the project is a continued and increasing reliance on fossil fuels to generate the power that the wind farm would have produced. .... In addition, the fact that Ireland has already exceeded the Kyoto limits on CO_2 production, which should not have been reached until 2010, means that there is an urgent need in Ireland to generate power without emissions.'

The implication, once again, is that wind farms generate power without greenhouse emissions. Even if the wind farm were to be built on mineral ground rather than peat, it cannot be claimed that wind farms are entirely without carbon emissions but the fact that the Derrybrien wind farm is built on peat further increases the carbon emission total for the development. This is not acknowledged or, perhaps, even recognised.

To end this section, and in the light of what actually happenned at Derrybrien, it is perhaps sobering to consider the confident concluding statement of both reports:

> No impacts of an exceptionally severe nature (e.g. contamination of an aquifer, destruction of a unique habitat) are possible through the construction and operation of this project.

Given that Fate demonstrated otherwise in the form of a considerable landslide and that this has both contaminated important aquifers and seriously damaged valued habitats, the issue of slope stability clearly is a key factor in the evaluation process. This should already be obvious from this report but the topic is patently absent from the Derrybrien reports.

The next section considers best practice in relation to the whole issue of slope stability.

7.6 *Planning and development on unstable ground*

A common thread running through much of this report is the issue of stability – perhaps not surprisingly, given the turn of events in October 2003. It is, or should be, a primary issue of concern whenever engineering work is to be carried out on a peatland. The number, geographical extent, regularity and, in some cases, scale of incidents where peat has become unstable – a mere sample of which was discussed above (section 5) – is a strong indication that any EIA concerned with development on a peatland system should consult all available guidance about development on unstable ground.

The EIS cites Policy Planning Guidance (PPG) Note 22, published in 1993 by the UK's Department of the Environment (DoE) in discussing issues of landscape and planning policy as adopted for parts of the UK. It could usefully have cited an earlier note, produced by the DoE in 1990: PPG14 – *Development on Unstable Land.*

This begins by observing that there are three broad causes of ground instability – underground cavities, unstable slopes or the ground compression of unconsolidated deposits such as peat, alluvium or landfill. All three are relevant to Derrybrien because, as established above, the peat contains cavities, it lies on a slope and it is subject to compression either from roads and traffic or from coniferous timber.

While PPG14 is a UK policy document, it is freely available. It gives an informed view of issues that could have been incorporated into the Derrybrien reports but were not, even though significant portions are directly relevant. Some of the more pertinent (from Annex 1, *Landslides and Planning*) are set out below.

7.6.1 *PPG14 – Development on Unstable Land*

> 4 The effects of ground instability vary in their nature, scale and extent. At their most extreme, they may threaten life and health or cause damage to buildings and structures, so generating public alarm. Whilst such alarm may or may not be justified, public perception of the risk is such that it cannot be ignored.

7 Damage due to instability may necessitate an expensive remedial action, or in the worst cases result in loss of buildings, structures or more productive land. If not foreseen before the commencement of development, problems arising from the instability may result in delays and in increased costs. At worst they may result in a development being abandoned and investment being wasted.

The relevance of this to Derrybrien is sufficiently obvious to require no further comment.

14 While in all cases instability may arise whether or not there is any development on the surface, it is important to recognise that the development itself or the intensification of development may be the triggering factor which initiates instability problems.

17 Where there are reasons for suspecting instability, the developer should determine by appropriate site investigations and geotechnical appraisal whether:

- the land is capable of supporting the loads to be imposed;
- the development will be threatened by unstable slopes on or adjacent to the site;
- the development will initiate slope instability which may threaten its neighbours;
- the site could be affected by ground movements due to natural cavities.

18 If this investigation and appraisal indicates that the ground is unstable or may become unstable due to the development proposed or for any other reason, the developer and/or his consultants should then assess the suitability and sufficiency of the proposed precautions to overcome the actual or potential instability.

There is no evidence that the reports considered any of the above in their investigations.

22 Where development is proposed on land which the planning authority knows is unstable or potentially unstable, it should ensure that the following issues are properly addressed by the development proposed:

- the physical capability of the land to be developed;
- possible adverse effects of instability on the development;
- possible adverse effects of the development on the stability of adjoining land; and
- possible effects on local amenities and conservation interests of the development and of any remedial or precautionary measures proposed.

31 The handling of individual applications for development on land which is known or suspected to be unstable or potentially unstable will need to take account of the potential hazard that such instability could create both to the development itself and to the neighbouring area. Whilst there is scope for flexibility and each application must be treated on its merits, it is important that a local planning authority should be satisfied by the developer that any instability has been taken into account.

Nor is there clear evidence that the planning authority considered any of the above issues when granting planning permission (on appeal) either for the initial application or for the extension.

46 The assessment of the significance of ground instability and of the associated risks requires careful professional judgment. In line with his responsibility for the safe development of any site, the developer should ensure that he has available the appropriate expertise to design and interpret the necessary site investigations and to design and execute any necessary remedial, preventive or precautionary measures.

47 . . . With regard to specific development, however, it must be emphasised that responsibility for assessment, as well as investigation, of ground conditions and the design and execution of any necessary remedial or precautionary measures, rests with the developer and not the local planning authority.

There is no evidence that the developer involved appropriate expertise to assess slope instability issues when carrying out the EIA investigations.

50 A realistic appreciation of the problems of ground instability and of the need to seek expert advice requires sound information. The importance of good accessible records of past events due to ground movement cannot be over-emphasised and any future events due to instability should be adequately recorded for the wider benefit of the community.

The extent to which the developer has recorded the events of the landslip and consequent/subsequent changes is unclear. The content of the EIA reports would seem to indicate that the developer did not consider the evidence of previous bog slides, nor their implications for the development.

7.6.2 *PPG14, Appendix A*

Causes of Instability

A3 Whatever the ultimate cause of instability, the triggering factor which initiates instability problems is very often human activity.

A43 Both natural and man-made slopes may be subject to instability due to land sliding or soil creep. Landslides are mass movements of soil and/or rock under the influence of gravity.

A46 Landslide movement may be initiated by natural processes or by human activities. ...
Slopes will only move if the forces contributing movement (e.g. gravity, water pressure, etc) exceed those resisting movement (e.g. strength of material, frictional resistance, etc).
Movement can be initiated by changes in any of these factors individually or in combination.
Loading of the top of slopes by natural deposition, tipping or by construction of buildings increases the weight (load) of the top of the slope, thus contributing to movement.
Increases in water content due to heavy rainfall or alteration of drainage may increase water pressures and thus decreases the resistance to ground movement.

A48 Whilst present-day natural processes can cause or contribute to land sliding, it is fairly clear that, at the present time, the main cause of landslide movement, both in terms of first-time movements and re-activation of ancient landslides, is human activity.

A51 Ground compression occurs when all ground materials are loaded or drained but in certain situations the ground deformation may be sudden or of such magnitude as to cause or to be considered examples of instability. Some natural materials (e.g. peat, soft silts and clays) and landfills and quarry backfill may compress significantly under load or when drained and full consolidation may take many years. The variable nature of such materials and of the bedrocks surface on which they occur often leads to a particular problems of differential settlement.

A55 Rising groundwater has been identified as a significant factor in causing instability due to ground compression... Other activities which may cause ground water level to rise include impoundment of water behind a dam, construction of a deep basement [or] underground barrier for pollution control, blockage of underground drainage channels.

All these paragraphs clearly have relevance to the conditions at Derrybrien and the proposed development. Anyone reading this guidance would have been unambiguously alerted to the potential for instability at Derrybrien and thus the need for more detailed investigations.

7.6.3 *PPG14, Annex 1 – Landslides and Planning*

3 [The guidelines] are intended to help to ensure that:

- the occurrence of and potential for slope instability is recognised at the earliest possible stage;
- appropriate strategies are adopted for dealing with the problems arising thus preventing the un-necessary sterilisation of land;
- due account is taken of the constraints imposed by slope instability at all stages of the planning process;
- development does not proceed in certain areas of instability or where treatment proposed is ineffectual;
- development is suitable and will not be threatened by landslides or cause instability of surroundings slopes;
- expensive protection or remedial works, which may be publicly funded, are not needed after a site has been developed;
- any necessary protection or remedial works will not lead to significant adverse environmental effects at the site or elsewhere.

Use of guidelines such as these would certainly have made a considerable difference to the assessment and planning process at Derrybrien.

6 In most cases, the potential for landsliding can be identified by appropriate investigations. Many of these costs [associated with landslides] are, therefore, avoidable. Generally, the costs of investigation and precautionary or remedial measures are greatly offset by the savings in terms of construction costs, damage, disruption or destruction that would otherwise arise.

A valuable piece of guidance, the wisdom of which would probably not now be lost on Saorgus Energy Ltd.

7 Landslides occur when the gravitational forces acting on the material comprising a slope exceed the resisting strength of those materials. Movement may be initiated by natural or human-induced changes in either of these controls. Once movement has occurred, the slope and geometry may change to a more stable configuration but the resisting strength is reduced permanently. Further movement may be more likely if there is any adverse change in conditions. Water is particularly important since it increases the weight and therefore the forces tending towards failure. Since the strength which is effective in resisting the landsliding is reduced by water pressure, water is also important from this point of view. As might be expected, the rapidity of landsliding and the mobility of debris is increased by the presence of water.

The significance of water in landslips is made very clear in the above paragraph. Of greater concern for the future of the Derrybrien development is the emphasis that the condition of instability becomes a permanent feature of the site.

8 [Figure 1] shows the distribution of the 8835 landslides recorded in the national landslide database. [This] gives a broad general picture of the widespread nature of landsliding in Great Britain. The picture is not complete, however . . . There are undoubtedly many more landslides than are recorded in the database.

The above paragraph simply serves to emphasise the widespread nature of landslides and thus highlight the fact that the potential for slope instability should really have been seen at Derrybrien – especially given the relationship between instability, slope and water described in earlier paragraphs.

9 Landslides involve the movement of large volumes of material in a relatively short time. Once movement has occurred, the normal erosion processes are slow and ineffective in removing the evidence. As a result, landslides accumulate in the landscape. The survival time of landslide form and deposits and the shear surface on which movement took place is very long. They thus remain in the landscape as a hazard for perhaps thousands of years.

10 Even landslides which occurred a long time ago, when environmental conditions may have been different than now, are still present as a potential hazard to development. Over time, the surface form may have all but disappeared due to erosion but the shear surface remains beneath the surface as a weak zone which may be reactivated easily by both natural and human interference.

The above paragraphs serve to emphasise, once again, that a slope which has demonstrably become unstable for all practical purposes remains in an unstable state indefinitely.

12 . . . the range of activities which may contribute to slope instability includes:-

- the placing of fills and others superimposed loads for construction purposes or the disposal of wastes;
- excavation, especially into old landslides but also into slopes previously unaffected by landsliding;
- mineral extraction beneath slopes;
- uncontrolled disposal of water, including soakaways and the diversion of a natural drainage courses; and
- changes in land use, such as deforestation or ploughing of grassland.

The effects of changing the distribution of loading on a slope and, especially of changing the water regime, are evident.

This list could, in effect, be a catalogue of activities carried out at Derrybrien.

18 It is the responsibility of the developers to ensure that their developments will not initiate

> instability or will not be affected by instability originating outside the area of a development. Developers should therefore seek appropriate technical and environmental expert advice about the likely consequences of proposed developments on sites where landsliding is known or may be reasonably foreseen. They should also procure any necessary investigations to ascertain that their sites are and will remain stable or can be made so as part of the development works.
>
> 19 . . . for these reasons, at least a preliminary assessment of slope stability should be carried out at the earliest possible stage before a detailed design is prepared. Only on the basis of such a geomorphological and engineering geological assessment, comprising a desk study of available information, including aerial photographs and a ground inspection, can the need for further investigations to ascertain the true extent of the hazard and any necessity for precautionary or remedial measures be determined.

There is no evidence that the developer sought out appropriate expertise for the EIA investigations. Indeed the reports do not even contain a preliminary assessment of slope stability.

> 28 Where there are grounds for believing that there is active or potential landsliding which would affect a proposed development, reservations can be overcome in an environmentally acceptable manner. This may require the application to be accompanied by a slope stability report prepared by a competent person, which demonstrates that the site is stable or can be made so and will not be affected by or trigger landsliding beyond the boundaries of the site. Guidance on the preparation, content and format of slope stability reports is contained in [Appendix 1B].

There is no clear evidence that the planning authorities requested any form of slope stability report before granting permission for this development.

> 34 The considered assessment of landslides and their consideration when determining planning applications will help to reduce the impact of undesirable consequences such as risks to public safety, property damage, avoidable costs to development, personal distress to those affected, degradation of the physical environment and loss of environmental resources.
>
> 35 The investigation and evaluation of slope stability here recommended is consistent with current good practice. It will thus not lead to additional costs to responsible developers and is likely to enable savings in avoiding costs which might arise if investigation falls short of this standard.

7.6.4 *PPG14, Annex 1B – The Slope Stability Report*

Annex 1B of PPG14 provides a detailed account of what a Slope Stability Report should contain. It is also emphasised that such a report should be prepared by a competent person, that is:

> . . . someone who is a Corporate Member of a relevant professional institution such as the Institution of Civil Engineers or the Geological Society. In this context, a competent person would be a geotechnical specialist as defined by the Site Investigation Steering Group of the Institution of Civil Engineers.

The purpose of the Slope Stability Report is set out clearly in 1B2:

> In order to satisfy a local planning authority, slope stability reports should demonstrate:
>
> - an adequate appreciation of ground and groundwater conditions and any other relevant factors influencing stability based on desk studies, aerial photographic interpretation, geomorphological and engineering geological mapping of the site and appropriate subsurface investigation, laboratory testing and monitoring where necessary; this appreciation must include a statement on whether or not the site or surrounding areas are affected by earlier landsliding or periglacial deposits and, if so, a definition of their extent in plan and section;
> - that the site is stable and has an adequate margin of stability, or can be made so as part of the development works, for the foreseeable conditions that will operate at the site;

instability or will not be affected by instability originating outside the area of a development. Developers should therefore seek appropriate technical and environmental expert advice about the likely consequences of proposed developments on sites where landsliding is known or may be reasonably foreseen. They should also procure any necessary investigations to ascertain that their sites are and will remain stable or can be made so as part of the development works.

19 . . . for these reasons, at least a preliminary assessment of slope stability should be carried out at the earliest possible stage before a detailed design is prepared. Only on the basis of such a geomorphological and engineering geological assessment, comprising a desk study of available information, including aerial photographs and a ground inspection, can the need for further investigations to ascertain the true extent of the hazard and any necessity for precautionary or remedial measures be determined.

There is no evidence that the developer sought out appropriate expertise for the EIA investigations. Indeed the reports do not even contain a preliminary assessment of slope stability.

28 Where there are grounds for believing that there is active or potential landsliding which would affect a proposed development, reservations can be overcome in an environmentally acceptable manner. This may require the application to be accompanied by a slope stability report prepared by a competent person, which demonstrates that the site is stable or can be made so and will not be affected by or trigger landsliding beyond the boundaries of the site. Guidance on the preparation, content and format of slope stability reports is contained in [Appendix 1B].

There is no clear evidence that the planning authorities requested any form of slope stability report before granting permission for this development.

34 The considered assessment of landslides and their consideration when determining planning applications will help to reduce the impact of undesirable consequences such as risks to public safety, property damage, avoidable costs to development, personal distress to those affected, degradation of the physical environment and loss of environmental resources.

35 The investigation and evaluation of slope stability here recommended is consistent with current good practice. It will thus not lead to additional costs to responsible developers and is likely to enable savings in avoiding costs which might arise if investigation falls short of this standard.

7.6.4 *PPG14, Annex 1B – The Slope Stability Report*

Annex 1B of PPG14 provides a detailed account of what a Slope Stability Report should contain. It is also emphasised that such a report should be prepared by a competent person, that is:

. . . someone who is a Corporate Member of a relevant professional institution such as the Institution of Civil Engineers or the Geological Society. In this context, a competent person would be a geotechnical specialist as defined by the Site Investigation Steering Group of the Institution of Civil Engineers.

The purpose of the Slope Stability Report is set out clearly in 1B2:

In order to satisfy a local planning authority, slope stability reports should demonstrate:

- an adequate appreciation of ground and groundwater conditions and any other relevant factors influencing stability based on desk studies, aerial photographic interpretation, geomorphological and engineering geological mapping of the site and appropriate subsurface investigation, laboratory testing and monitoring where necessary; this appreciation must include a statement on whether or not the site or surrounding areas are affected by earlier landsliding or periglacial deposits and, if so, a definition of their extent in plan and section;
- that the site is stable and has an adequate margin of stability, or can be made so as part of the development works, for the foreseeable conditions that will operate at the site;

- that the site is not likely to be threatened or affected by reasonably foreseeable slope instability originating outside the boundaries and
- that the development is not likely to result in slope instability which will affect either the development or nearby property.99

The key elements of a Slope Stability Report can be summarised as desk and field investigations that provide information concerning:

- relevant published and available unpublished information;
- the morphology of the area; the geological sequence and structure; landslide features; seepage lines and wet areas; vegetation types indicative of high water table or changes in soil type; evidence of movement in existing structures and trees; evidence of past movement; evidence of movement due to mining or natural underground cavities; evidence of previous changes to the structure of site by human activity;

Other issues include:

- the location of any features indicative of slope instability in the site and surrounding area; the consequences of failure; understanding of ground water conditions; water pressures within the slope and likely fluctuations in adverse conditions; the engineering parameters of the materials in the slope for use in stability calculations; engineering interpretation of ground and ground water conditions; details of stability calculations.

It is clear that the level of investigation of stability issues described in the reports falls a long way short of the standard set by PPG14. Had suitable studies been undertaken or been insisted on by the planning authority, it is possible that the Derrybrien development could have avoided giving rise to:

> . . . undesirable consequences such as risks to public safety, property damage, avoidable costs to development, personal distress to those affected, degradation of the physical environment and loss of environmental resources.

Summary of Chapter 7

1 The project proposal for Derrybrien appears to have been prepared in the form of three smaller proposals that would form one large development – i.e. using the 'salami-slicing' approach to gain incremental approval for a single large development.

2 The developer claims not to need an EIA for the third development but this is incorrect. It is not clear that the screening process corrected this misapprehension.

3 The developer states that the two EIA documents have been produced on a voluntary basis to demonstrate the environmentally benign nature of wind farm development. The documents are not, therefore, dispassionate reviews of possible impacts.

4 Part of the development appears not to have been subject to specific EIA procedures, although the development as a whole represents one of the largest wind farms in Europe.

5 There is no real attempt at scoping in either of the documents.

6 There is no attempt to consider indirect or cumulative impacts, or impact interactions in either of the documents.

7 Detailed impact assessment is restricted to visual and noise impacts alone.

8 Little consideration given to blanket mire and its associated soils as an ecosystem or to the possible effect of forestry on these soils.

9 No credible assessment is made of avifauna using the site. Species are mentioned merely to be dismissed as significant factors. It appears that no request was made either by the developer or the planning authority for sight of recent survey data concerning hen harriers in the Slieve Aughty Mountains. The planning authority instead imposed a planning condition concerning survey of the hen harrier that can provide no safeguards for the population.

10 There is no mention of bog-slide potential within the consideration of either rocks and soil or water; there is no evidence that the developers have considered issues of stability at all nor did the planning authority require a stability assessment, despite the evidently unstable nature of the ground in many areas of the site.

11 Claims are made for the emission levels of wind energy that are quite simply not true and the fact that peat excavation and drainage causes CO_2 release does not seem to be recognised.

12 The authors of the present report point to PPG14 produced by the UK Government for development on unstable ground and in particular to the Slope Stability Report detailed in Appendix 1B. The level of detail required for such a report are in stark contrast to the details provided by the two Derrybrien EIA documents.

PART 2
The events of October 16 and subsequent issues

Chapter 8
The bogslide at Derrybrien

8.1 *Description*

MASS MOVEMENT OF PEAT commenced at about 16:00 hrs on Thursday 16 October 2003 and stopped around Saturday 18 October but was re-activated ten days later[1] following heavy, continuous rain.

The authors of this report visited the site eight months after these events, on 8 June 2004. By this time significant sections of the debris had been washed away and various works to stabilise the hillside had been completed. This account is necessarily based on records made by others within a few days of the initial slide as well as on our own observations. The principal sources are the account of a site inspection carried out on 17 October 2003 by consultants to the developer (AGEC 2004) and photographs provided by Martin Collins of Derrybrien. A video recording of an aerial inspection on 18 October (BMA 2004) by engineering staff at Galway County Council has also been viewed.

The route of the first slide can be traced on fig 8.1. Its upper limit lies close to the southern side of an excavation made by the developer to accommodate the base of Turbine 68 (T68). Its track passes through mature forestry, covering a second turbine site (T70) some 300 metres downslope. From here, it continued in a south-easterly direction along a natural drainage line to the stream-head and then followed the course of the stream, its toe initially coming to rest just north of the Black Road (M614036), 2,450 metres from T68. Failure of peat was apparently restricted to the upper 1,200 to 1,300 metres of this track, from the T68 site to the point where the stream turns eastwards into a narrow bedrock channel near M603038. The width of the failure scar on 18 October ranged from c. 45 metres at the head to a maximum of c. 270 metres some 750 metres downslope.

The later-re-activation of the bog slide led to a rapid flow of peat down into the Owendalulleegh River and then onwards for a further 20 km to enter Lough Cutra. The fate of the material after that is still the subject of environmental monitoring and investigation – the total geographical and ecological impact has yet to be established.

Observation on 18 October indicated that the original basal failure surface was within the lower part of the peat layer, typically 200 to 400 mm above mineral soil. The ground appeared initially to have separated into distinct rafts along forest plough/drainage channels, the rafts breaking down as they moved leading to flow-type movement of peat (AGEC 2004). This description suggests that the event should be termed a bog slide rather than a bog burst or peat slide (section 4.2).

Plates 8.2 to 8.5 give a photographic record of the section of the failure scar that lies within the wind farm boundary. The excavation at T68 was reported not to have failed and indeed appeared still to be more or less intact in June 2004 (plate 8.4a). The head of the failure was coincident with the upslope edge of a site access road a few metres downslope of the excavation. Photographs taken

[1] Dates vary but Fire Services & Emergency Planning, Galway County Council reports it as Tuesday 28 October

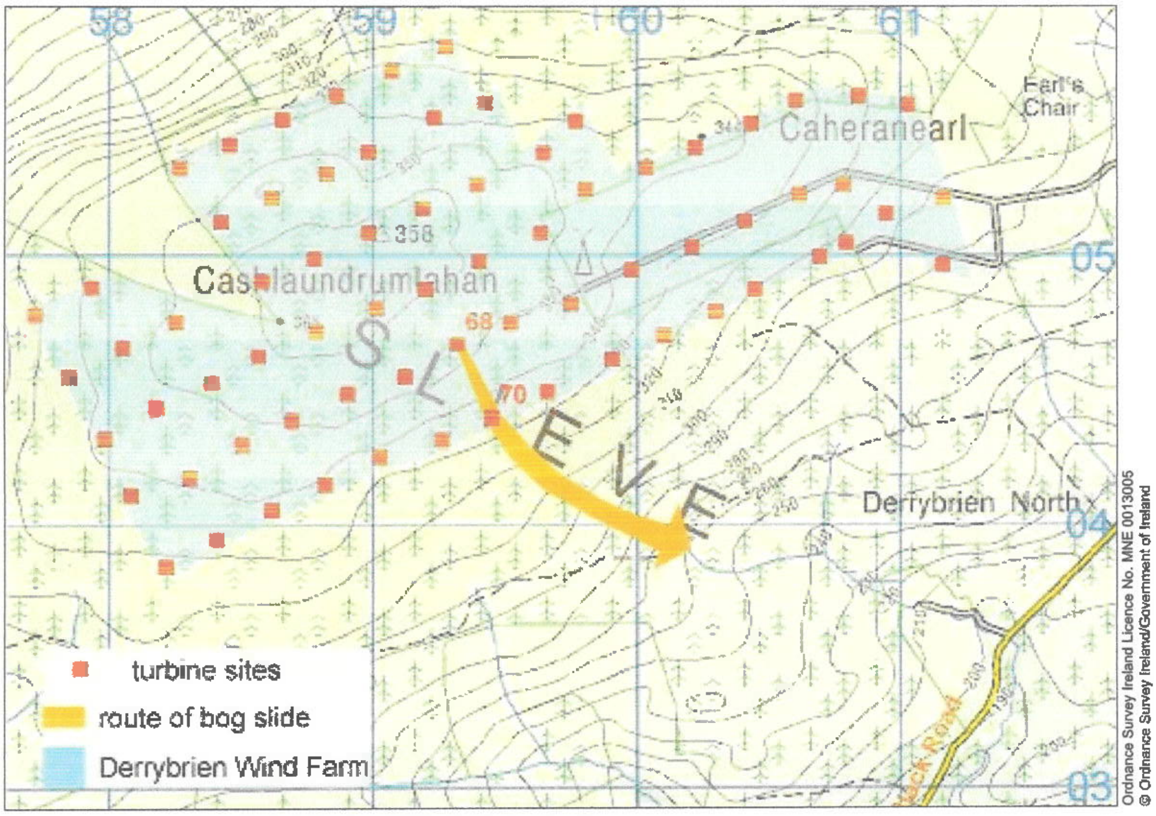


Figure 8.1: Route of the Derrybrien bog slide, indicated by the orange arrow.

within days of the slide indicate that the southern wall of the excavation remained in place, supporting a precariously perched excavator. The road had bowed southwards by 10-20 metres (plates 8.2b, c and d). Plate 8.3, taken in June 2004, gives two views looking southwards from the reconstructed road at T68. The pattern of detachment of rafts of vegetation along plough lines was still evident in mature lodgepole pine plantation at the eastern side of the scar. South of T70, a small exposure of bedrock was found at this time (plate 8.4c) but appeared to be the result of water erosion subsequent to the landslide. The trees in this area were smaller than those upslope and included some Sitka spruce understood to have been planted to repair fire damage (plate 8.4a). A crack in apparently intact surface was found at the eastern edge

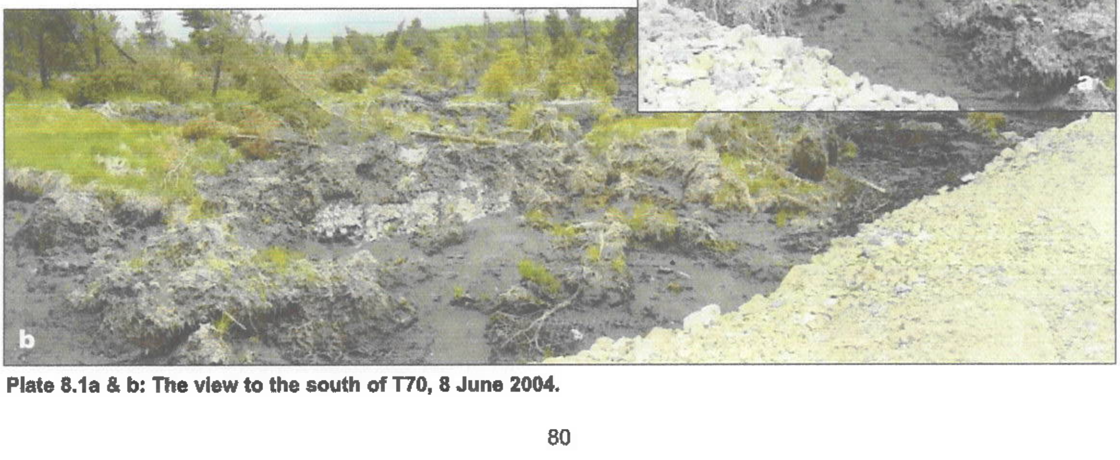


Plate 8.1a & b: The view to the south of T70, 8 June 2004.

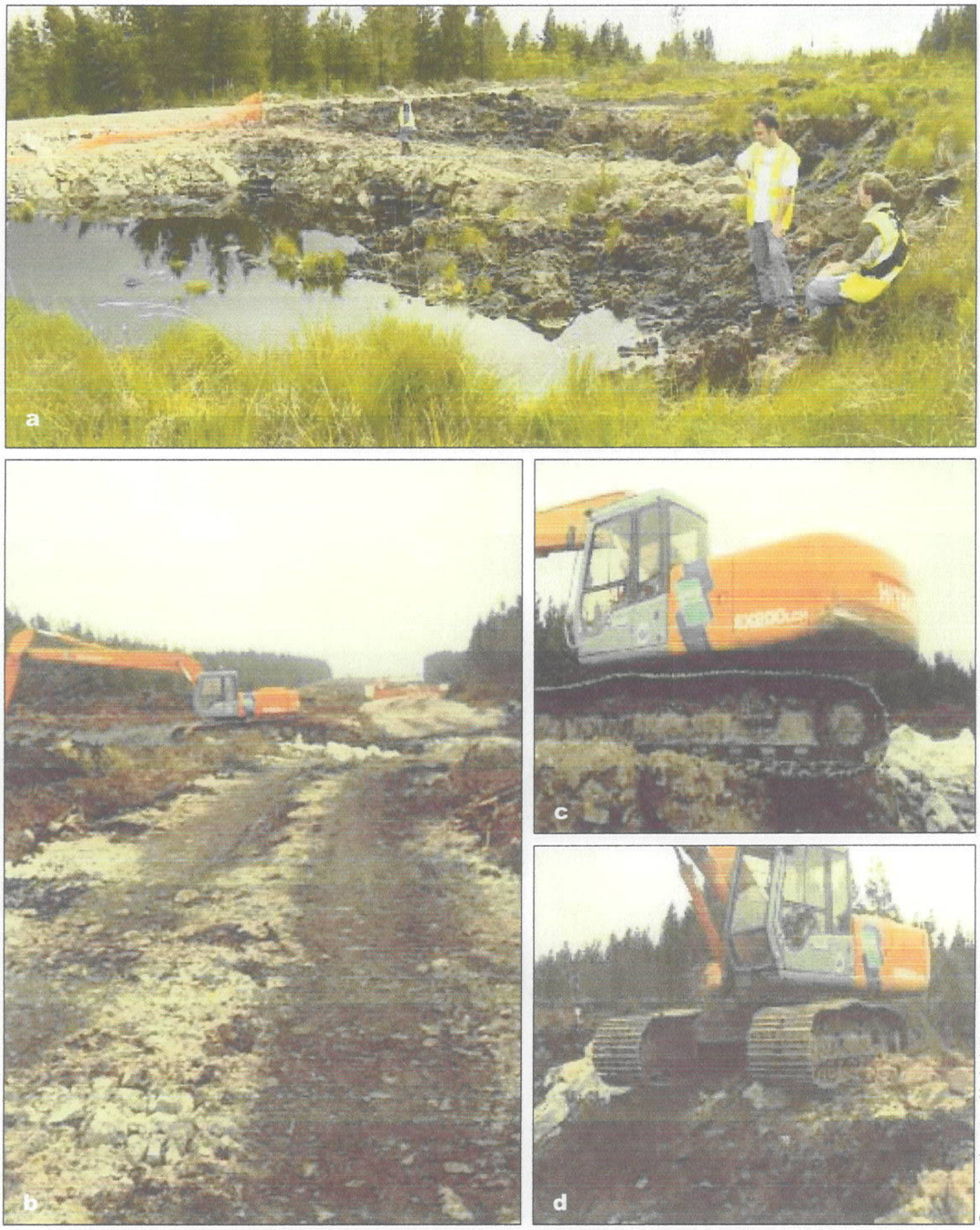


Plate 8.2: The head of the peat slide at T68. a: turbine base excavation in June 2004; b: deformation of floating road October 2003; c, d: an excavator after the bog slide.

of the scar (plate 8.1a). Probing indicated that the peat thickness here was 2.14 metres and the crack 0.7 metres deep.

8.2 *The contribution of the weather*

The weather is an important factor to consider because many bog slides are associated with heavy rainfall. In this case, there was no rainfall either on the day or on the days leading up to the incident.

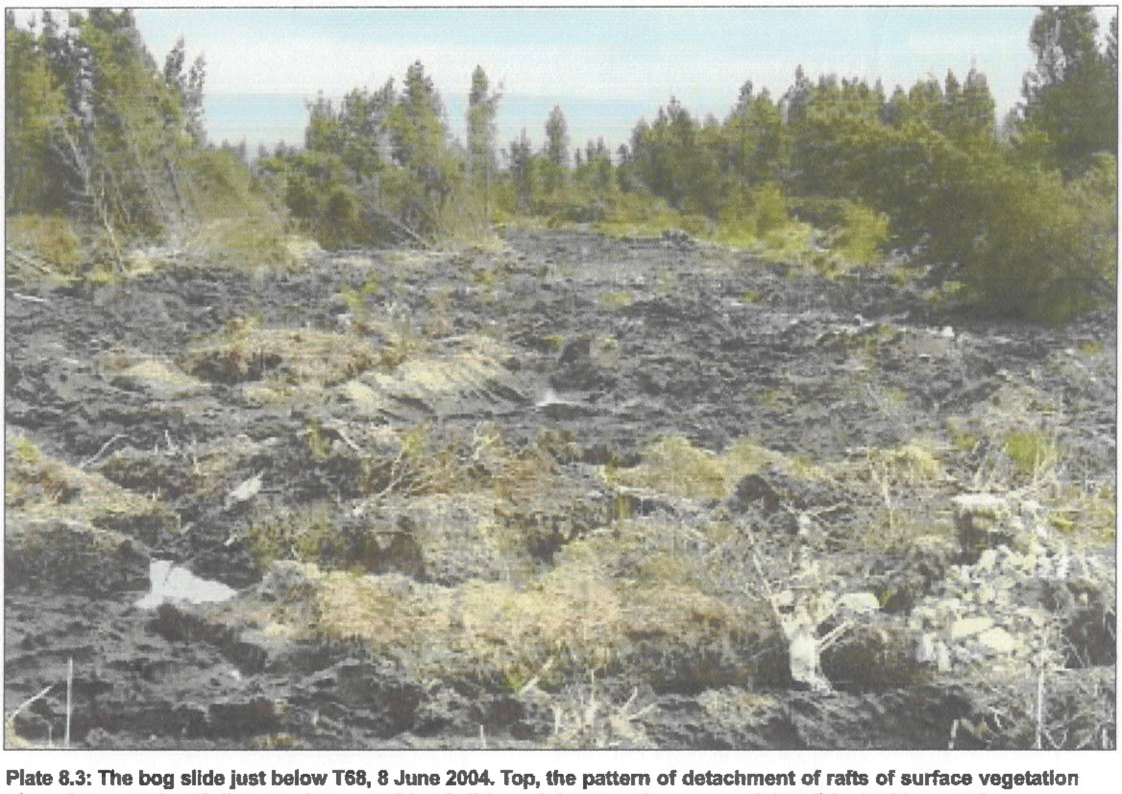


Plate 8.3: The bog slide just below T68, 8 June 2004. Top, the pattern of detachment of rafts of surface vegetation along forestry plough lines at the west side of slide and, bottom, the centre of the slide, looking south.

Plate 8.3: The bog slide just below T68, 8 June 2004. Top, the pattern of detachment of rafts of surface vegetation along forestry plough lines at the west side of slide and, bottom, the centre of the slide, looking south.

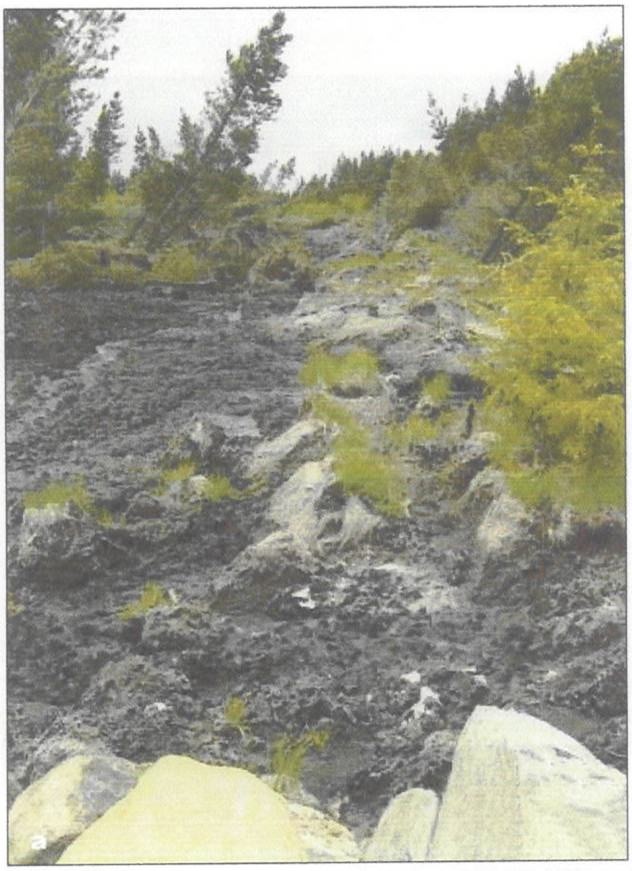
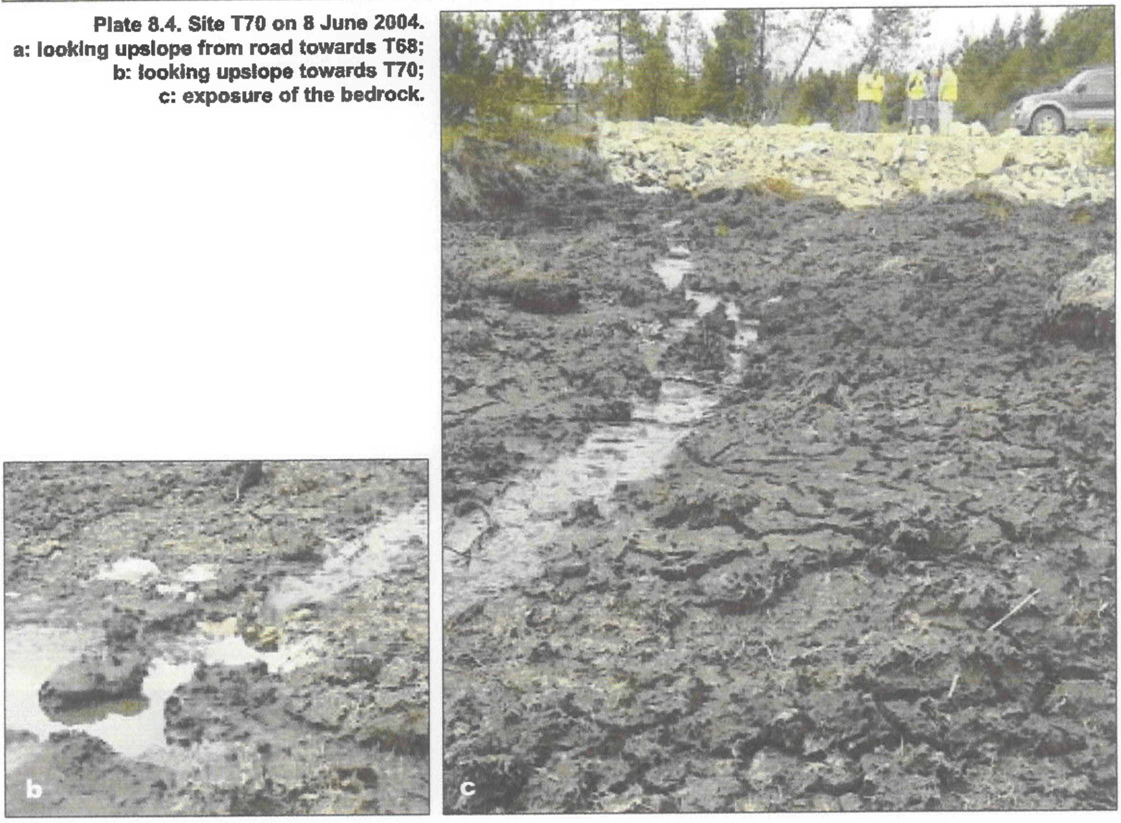


Plate 8.4. Site T70 on 8 June 2004.
a: looking upslope from road towards T68;
b: looking upslope towards T70;
c: exposure of the bedrock.



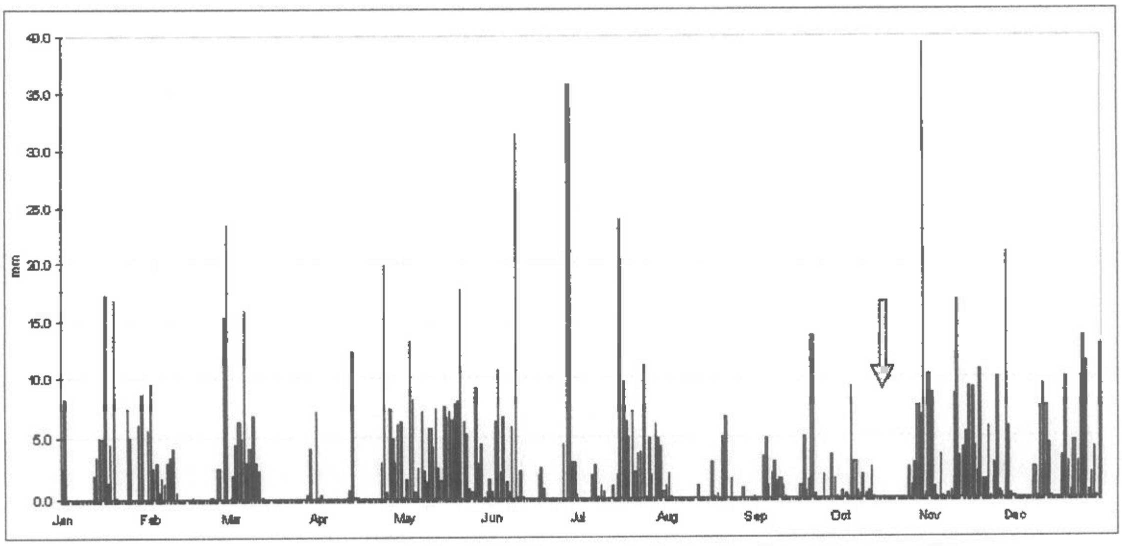


Figure 8.2: Daily rainfall for Derrybrien during 2003. The arrow indicates the date of the bog slide.

However, another factor may have played a key part in predisposing the site to what happened – the effect of prolonged dry spells on cracking in the peat. The usual examination of weather events immediately surrounding such incidents must replaced with a more extensive consideration of weather patterns extending over the whole year, and over previous years, to determine whether the weather pattern for the whole of 2003 provides to the causes of failure.

8.2.1 *The rainfall record*

Daily rainfall data for Derrybrien for period 17 January 1990 to 21 June 2004 were provided by the Irish Meteorological Service for a location three km to the south of and 220 metres below the summit of Cashlaundrumlahan.[2]

Many accounts associate mass movements of peat with heavy rainfall events (section 4) but the records in this case (fig 8.2 and table 8.1) indicates that there was no rainfall in Derrybrien during the period 14 to 24 October. Prior to this, the last three days with more than five mm rainfall were 5 October (9.1 mm), 21 September (13.6 mm) and 22 August (6.5 mm). The bog slide occurred after two dry days and the weather remained dry throughout the slide's initial advance towards the Black Road. The possibility of a localised storm on the mountain is ruled out by the accounts of people on site on the day of the slide,

Date	Rainfall (mm)	Progress of bog slide
1	0.0	
2	0.6	
3	0.4	
4	0.2	
5	9.1	
6	2.9	
7	0.5	
8	0.4	
9	1.8	
10	0.4	
11	0.6	
12	2.5	
13	0.1	
14	0.0	
15	0.0	
16	0.0	Bog slide initiated
17	0.0	
18	0.0	
19	0.0	Initial advance halted
20	0.0	
21	0.0	
22	0.0	
23	0.0	
24	0.0	
25	2.6	
26	1.0	
27	2.8	
28	7.5	
29	6.7	Slide re-mobilised
30	39.3	
31	0.3	

Table 8.1: The daily rainfall record for Derrybrien, in October 2003 and the progress of the bog slide.

[2] The data processing was carried out by Ms Hannah Stockwell and Ms Louise Francis. It is understood that the rain-gauge is located in Derrybrien near grid reference M598019 at an altitude of c. 140 metres above OSI datum, near the home of the observer, Mrs Sarah Slattery.

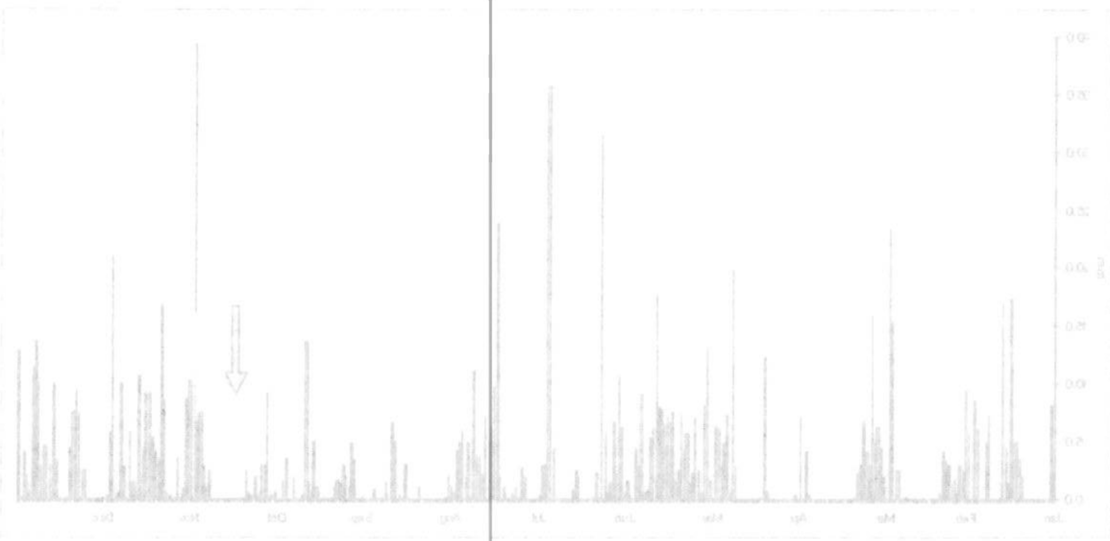


Figure 8.2: Daily rainfall for Derrybrien during 2003. The arrow indicates the date of the bog slide.

However, another factor may have played a key part in predisposing the site to what happened – the effect of prolonged dry spells on cracking in the peat. The usual examination of weather events immediately surrounding such incidents must replaced with a more extensive consideration of weather patterns extending over the whole year, and over previous years, to determine whether the weather pattern for the whole of 2003 provides to the causes of failure.

8.2.1 The rainfall record

Daily rainfall data for Derrybrien for period 17 January 1990 to 21 June 2004 were provided by the Irish Meteorological Service for a location three km to the south of and 220 metres below the summit of Cashlaundrumlahan.[2]

Many accounts associate mass movements of peat with heavy rainfall events (section 4) but the records in this case (fig 8.2 and table 8.1) indicates that there was no rainfall in Derrybrien during the period 14 to 24 October. Prior to this, the last three days with more than five mm rainfall were 5 October (9.1 mm), 21 September (13.6 mm) and 22 August (6.5 mm). The bog slide occurred after two dry days and the weather remained dry throughout the slide's initial advance towards the Black Road. The possibility of a localised storm on the mountain is ruled out by the accounts of people on site on the day of the slide,

Date	Rainfall (mm)	Progress of bog slide
1	0.0	
2	0.6	
3	0.4	
4	0.2	
5	9.1	
6	2.9	
7	0.5	
8	0.4	
9	1.3	
10	0.4	
11	0.6	
12	2.5	
13	0.1	
14	0.0	
15	0.0	
16	0.0	Bog slide initiated
17	0.0	
18	0.0	
19	0.0	Initial advance halted
20	0.0	
21	0.0	
22	0.0	
23	0.0	
24	0.0	
25	2.6	
26	1.0	
27	2.8	
28	7.5	
29	6.7	Slide re-mobilised
30	39.3	
31	0.3	

Table 8.1: The daily rainfall record for Derrybrien, in October 2003 and the progress of the bog slide.

[2] The data processing was carried out by Ms Hannah Stockwell and Ms Louise Francis. It is understood that the rain-gauge is located in Derrybrien near grid reference M598019 at an altitude of c. 140 metres above OSI datum, near the home of the observer, Mrs Sarah Slattery

Year	Rainfall (mm)
1990	1587.2
1991	1252.0
1992	1412.5
1993	1422.7
1994	1587.8
1995	1374.8
1996	1194.9
1997	1258.8
1998	1551.4
1999	1569.7
2000	1348.7
2001	1083.9
2002	1620.4
2003	1075.4
Mean	1381.4

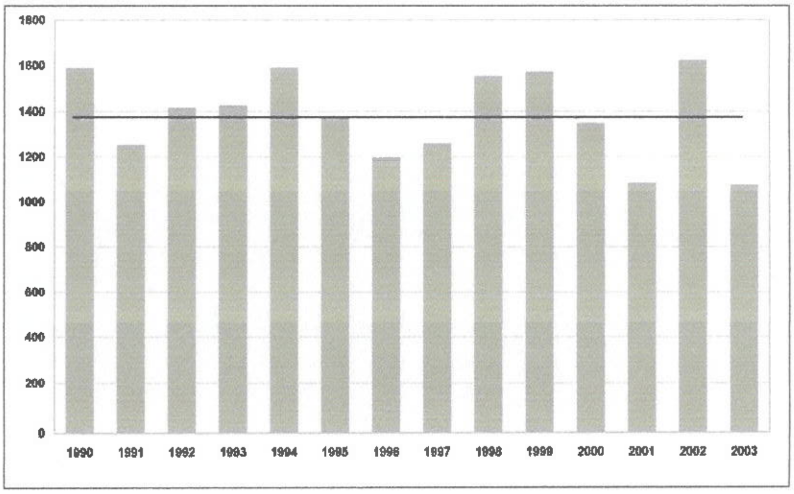


Figure 8.3: Annual (vertical bars) and 14-year annual mean (horizontal line) rainfall for Derrybrien, 1990 to 2003.

who report that the weather was fine. The displaced peat was re-mobilised only after four days of continuous rain, presumably accelerating during a storm on 30 October. Thus, although much of the downstream damage can be associated with a heavy rainfall event, the initial peat failure cannot.

8.2.2 *Rainfall averages: 1990 to 2003*

Annual rainfall totals for the 14-year period January 1990[2] to December 2003 are shown in fig 8.3. The record indicates that high-rainfall years were distributed fairly evenly throughout this period. The highest annual rainfall was recorded in 2002 (1620.4 mm) but annual totals for 1990, 1994, 1998 and 1999 were within 40 mm of the this value. Totals for 1992, 1993, 1995 and 2000 were close to average, whilst 1991, 1996 and 1997 were low-rainfall years. The two lowest rainfall totals occur near the end of the record, in 2001 and 2003.

2 The total for 1990 is slightly under-estimated as no correction was made for an absence of measurements for the first 16 days of January. This introduces a slight inaccuracy into the calculations.

		Month											
		Jan	Feb	Mar	Apr	May	Jun	Jly	Aug	Sep	Oct	Nov	Dec
year	1990	202.2	286.5	56.1	103.1	40.0	124.6	79.4	125.3	38.4	206.2	121.6	203.8
	1991	127.8	117.7	114.7	148.1	17.6	123.1	101	74.0	80.1	102.3	168.2	77.4
	1992	142.2	95.2	148.1	147.8	77.5	55.9	82.3	189.2	112.6	77.4	167.6	116.7
	1993	174.2	34.5	65.5	151.8	132.5	113.4	100.5	72.5	101.7	73.5	82.4	320.2
	1994	184.0	149.5	203.4	149.6	82.5	59.9	70.4	103.5	102.3	76.3	120.1	286.3
	1995	244.1	183.1	156.6	41.1	84.3	53.5	124.8	13.2	68.4	216.1	118.9	70.7
	1996	90.6	156.9	108.4	73.7	67.3	35.6	87.1	112.4	68.2	195.9	152.4	46.4
	1997	41.0	214.9	44.8	42.5	114.1	106	105	153.7	82.5	129.5	110.1	114.7
	1998	159.9	60.2	144.5	115.4	44.0	196.1	98.8	104.6	95.6	190.8	172.4	169.1
	1999	169.4	99.0	75.0	94.5	102.1	71.0	71.7	85.4	238.4	104.5	169.3	289.4
	2000	122.6	162.4	51.3	53.3	12.8	70.1	92.4	95.5	142.4	219.5	175.1	148.3
	2001	66.7	66.6	108.6	100.5	42.5	85.4	97.1	113.1	58.5	131.6	136.3	77.0
	2002	197.4	235.3	95.9	104.6	138.6	134.3	63.7	145.2	42.2	172.6	178.7	111.9
	2003	97.8	70.6	63.9	64.7	149.3	118.9	104.2	21.6	47.3	79.7	147.2	110.2
	Mean	144.3	138.0	102.8	99.3	78.9	96.3	91.3	100.7	91.3	141.1	144.3	153.0
	SD	56.8	73.8	46.9	40.1	44.3	42.7	16.6	47.4	51.5	56.9	29.8	89.1

Table 8.2: Monthly rainfall totals for Derrybrien, 1990 to 2003. Unusually wet months are shown in blue and unusually dry months in red. See also fig 8.4.

Figure 8.3: Annual (vertical bars) and 14-year annual mean (horizontal line) rainfall for Derrybrien, 1990 to 2003.

Year	Rainfall (mm)
1990	1587.2
1991	1252.0
1992	1412.5
1993	1422.7
1994	1587.8
1995	1374.8
1996	1194.9
1997	1258.8
1998	1561.4
1999	1569.7
2000	1348.7
2001	1083.9
2002	1620.4
2003	1075.4
Mean	1381.4

who report that the weather was fine. The displaced peat was re-mobilised only after four days of continuous rain, presumably accelerating during a storm on 30 October. Thus, although much of the downstream damage can be associated with a heavy rainfall event, the initial peat failure cannot.

8.2.2 *Rainfall averages: 1990 to 2003*

Annual rainfall totals for the 14-year period January 1990[2] to December 2003 are shown in fig 8.3. The record indicates that high-rainfall years were distributed fairly evenly throughout this period. The highest annual rainfall was recorded in 2002 (1620.4 mm) but annual totals for 1990, 1994, 1998 and 1999 were within 40 mm of the this value. Totals for 1992, 1993, 1995 and 2000 were close to average, whilst 1991, 1996 and 1997 were low-rainfall years. The two lowest rainfall totals occur near the end of the record, in 2001 and 2003.

2 The total for 1990 is slightly under-estimated as no correction was made for an absence of measurements for the first 16 days of January. This introduces a slight inaccuracy into the calculations.

Year	Jan	Feb	Mar	Apr	May	Jun	Jly	Aug	Sep	Oct	Nov	Dec
1990	[illegible]	[illegible]	56.1	103.1	40.0	124.6	79.4	125.3	[illegible]	[illegible]	121.6	203.8
1991	127.6	117.7	114.7	[illegible]		123.1	101	74.0	80.1	102.3	168.2	77.4
1992	142.2	95.2	148.1	[illegible]	77.5	55.9	82.3	[illegible]	112.6	[illegible]	167.8	116.7
1993	174.2	[illegible]	65.6	[illegible]	[illegible]	113.4	100.5	72.5	101.7	[illegible]	[illegible]	[illegible]
1994	184.0	149.5	[illegible]	[illegible]	52.5	59.9	[illegible]	103.5	102.3	[illegible]	120.1	[illegible]
1995	[illegible]	183.1	[illegible]	41.1	84.3	53.5	[illegible]	[illegible]	68.4	[illegible]	118.9	70.7
1996	90.6	156.9	108.4	73.7	67.3	[illegible]	87.1	112.4	68.2	195.9	152.4	[illegible]
1997	[illegible]	[illegible]	[illegible]	[illegible]	114.1	106	105	[illegible]	82.5	129.5	[illegible]	114.7
1998	159.9	[illegible]	144.5	115.4	44.0	[illegible]	98.8	104.5	95.6	190.8	172.4	169.1
1999	169.4	99.0	75.0	84.5	102.1	71.0	[illegible]	85.4	[illegible]	104.5	169.3	[illegible]
2000	122.6	162.4	[illegible]			70.1	92.4	95.5	142.4	[illegible]	[illegible]	148.3
2001	[illegible]	66.6	108.6	100.5	42.5	85.4	97.1	113.1	58.5	131.6	136.3	77.0
2002	197.4	[illegible]	95.9	104.6	[illegible]	134.3	[illegible]	145.2	42.2	172.6	[illegible]	111.9
2003	97.8	70.6	63.9	64.7	[illegible]	118.9	104.2	[illegible]	47.3	[illegible]	147.2	110.2
Mean	144.3	138.0	102.8	99.3	78.9	96.3	91.3	100.7	91.3	141.1	144.3	153.0
SD	56.8	73.8	46.9	40.1	44.3	42.7	16.8	47.4	51.5	56.9	29.8	89.1

Table 8.2: Monthly rainfall totals for Derrybrien, 1990 to 2003. Unusually wet months are shown in blue and unusually dry months in red. See also fig 8.4.

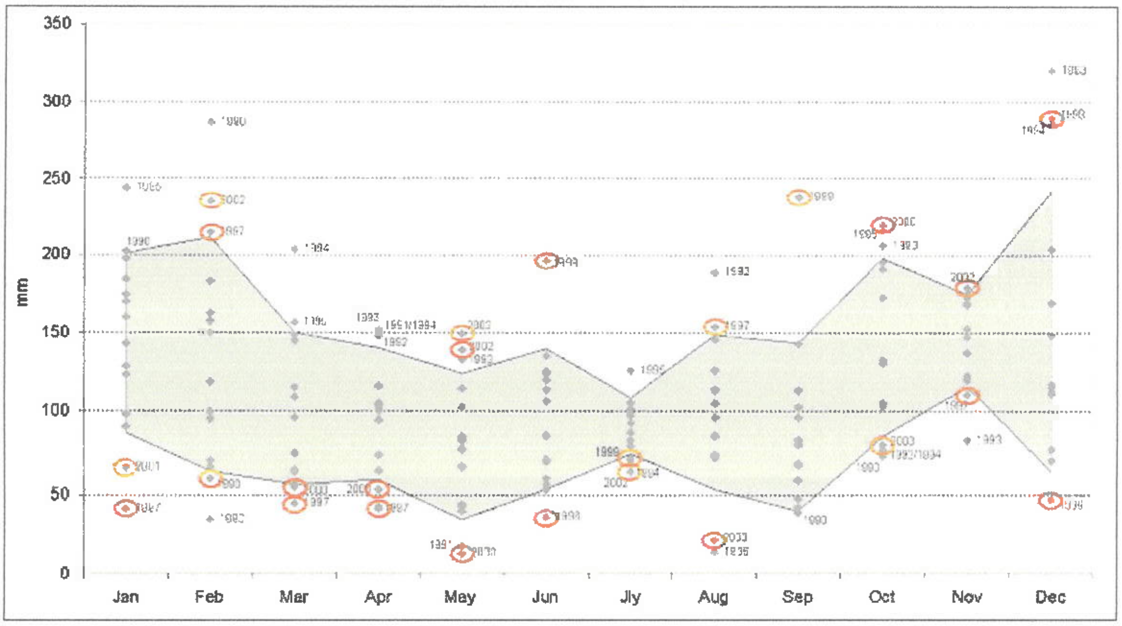


Figure 8.4: The range of monthly rainfall totals at Derrybrien, 1990 to 2003. The labelled values lie more than one standard deviation above or below the monthly mean (the shaded envelope) and are taken to indicate 'high-' and 'low-rainfall' months respectively. Values for 1996 to 2003 are circled in red and the full dataset is given in table 8.2.

Table 8.2 gives monthly rainfall totals for the same period. For each month, the 14-year mean and standard deviation is shown at the bottom of the table. Monthly totals that exceed the mean plus one standard deviation are shown in blue italics (high-rainfall months) and monthly totals that are less than the mean by more than one standard deviation (low-rainfall months) are shown in red italics.

These data are also plotted in fi 8.4. For each month, only the outlier values – those years when the rainfall total fell outside the boundaries defined by the monthly mean ± one standard deviation (i.e. years of relatively low or relatively high rainfall) are labelled. Outlier values occurred throughout the whole period of records and at least one high-rainfall and one low-rainfall month occurred during every year except 1996 (two high-rainfall months, no low-rainfall months) and 2001 (no high-rainfall months, one low-rainfall month). In the first six years (1990 – 1995), there were 16 high-rainfall and nine low-rainfall months. In the remaining seven years (1996 – 2003), nine high-rainfall and 15 low-rainfall months were recorded. The monthly data therefore indicate that low-rainfall months occurred far more frequently between 1996 and 2003 than in the period 1990 to 1995.

8.2.3 *Pattern of rainfall*

Clearly, slope failure is not directly linked to any particular high-rainfall incident and attention may be turned to the issue of dry conditions and exacerbation of peat cracking. The fact that there appears to have been a substantially higher number of dry months in the last eight years than in the six year period 1990 to 1995 suggests that steady exacerbation of drying out caused by the forest plantation is a possibility. However, of far greater significance is the possibility of long sequences of dry months, creating an extended period of relative drought. It is therefore important to look for such sequences.

Fig 8.5 compares monthly rainfall totals for 2003 with the 14-year monthly means. The May rainfall total was the highest during the period of records considered. Although only August and October qualify as low-rainfall months on the basis of the criterion adopted above, the record in fact consists of two sequences of relatively dry months (January to April and August to October) and two sequences of wetter-than-average months (May to July and November-December), giving a bimodal distribution of rainfall through the year.

Comparison with data for other years (figs 8.6 and 8.7) shows that this is an unusual pattern. Sequences of more than two wetter-than-average or drier-than-average months are rare throughout

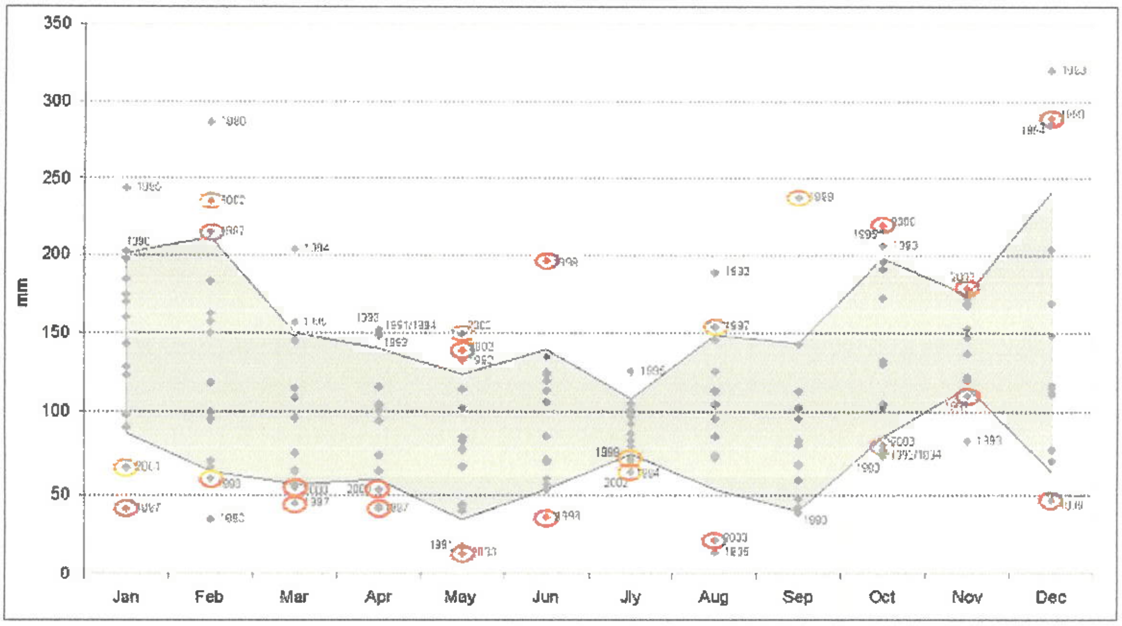


Figure 8.4: The range of monthly rainfall totals at Derrybrien, 1990 to 2003. The labelled values lie more than one standard deviation above or below the monthly mean (the shaded envelope) and are taken to indicate 'high-' and 'low-rainfall' months respectively. Values for 1996 to 2003 are circled in red and the full dataset is given in table 8.2.

Table 8.2 gives monthly rainfall totals for the same period. For each month, the 14-year mean and standard deviation is shown at the bottom of the table. Monthly totals that exceed the mean plus one standard deviation are shown in blue italics (high-rainfall months) and monthly totals that are less than the mean by more than one standard deviation (low-rainfall months) are shown in red italics.

These data are also plotted in fi 8.4. For each month, only the outlier values – those years when the rainfall total fell outside the boundaries defined by the monthly mean ± one standard deviation (i.e. years of relatively low or relatively high rainfall) are labelled. Outlier values occurred throughout the whole period of records and at least one high-rainfall and one low-rainfall month occurred during every year except 1996 (two high-rainfall months, no low-rainfall months) and 2001 (no high-rainfall months, one low-rainfall month). In the first six years (1990 – 1995), there were 16 high-rainfall and nine low-rainfall months. In the remaining seven years (1996 – 2003), nine high-rainfall and 15 low-rainfall months were recorded. The monthly data therefore indicate that low-rainfall months occurred far more frequently between 1996 and 2003 than in the period 1990 to 1995.

8.2.3 *Pattern of rainfall*

Clearly, slope failure is not directly linked to any particular high-rainfall incident and attention may be turned to the issue of dry conditions and exacerbation of peat cracking. The fact that there appears to have been a substantially higher number of dry months in the last eight years than in the six year period 1990 to 1995 suggests that steady exacerbation of drying out caused by the forest plantation is a possibility. However, of far greater significance is the possibility of long sequences of dry months, creating an extended period of relative drought. It is therefore important to look for such sequences.

Fig 8.5 compares monthly rainfall totals for 2003 with the 14-year monthly means. The May rainfall total was the highest during the period of records considered. Although only August and October qualify as low-rainfall months on the basis of the criterion adopted above, the record in fact consists of two sequences of relatively dry months (January to April and August to October) and two sequences of wetter-than-average months (May to July and November-December), giving a bimodal distribution of rainfall through the year.

Comparison with data for other years (figs 8.6 and 8.7) shows that this is an unusual pattern. Sequences of more than two wetter-than-average or drier-than-average months are rare throughout

Figure 8.4: The range of monthly rainfall totals at Derrybrien, 1990 to 2003. The labelled values lie more than one standard deviation above or below the monthly mean (the shaded envelope) and are taken to indicate 'high-' and 'low-rainfall' months respectively. Values for 1996 to 2003 are circled in red and the full dataset is given in table 8.2.

Table 8.2 gives monthly rainfall totals for the same period. For each month, the 14-year mean and standard deviation is shown at the bottom of the table. Monthly totals that exceed the mean plus one standard deviation are shown in blue italics (high-rainfall months) and monthly totals that are less than the mean by more than one standard deviation (low-rainfall months) are shown in red italics.

These data are also plotted in fi 8.4. For each month, only the outlier values – those years when the rainfall total fell outside the boundaries defined by the monthly mean ± one standard deviation (i.e. years of relatively low or relatively high rainfall) are labelled. Outlier values occurred throughout the whole period of records and at least one high-rainfall and one low-rainfall month occurred during every year except 1996 (two high-rainfall months, no low-rainfall months) and 2001 (no high-rainfall months, one low-rainfall month). In the first six years (1990 – 1995), there were 16 high-rainfall and nine low-rainfall months. In the remaining seven years (1996 – 2003), nine high-rainfall and 15 low-rainfall months were recorded. The monthly data therefore indicate that low-rainfall months occurred far more frequently between 1996 and 2003 than in the period 1990 to 1995.

8.2.3 Pattern of rainfall

Clearly, slope failure is not directly linked to any particular high-rainfall incident and attention may be turned to the issue of dry conditions and exacerbation of peat cracking. The fact that there appears to have been a substantially higher number of dry months in the last eight years than in the six year period 1990 to 1995 suggests that steady exacerbation of drying out caused by the forest plantation is a possibility. However, of far greater significance is the possibility of long sequences of dry months, creating an extended period of relative drought. It is therefore important to look for such sequences.

Fig 8.5 compares monthly rainfall totals for 2003 with the 14-year monthly means. The May rainfall total was the highest during the period of records considered. Although only August and October qualify as low-rainfall months on the basis of the criterion adopted above, the record in fact consists of two sequences of relatively dry months (January to April and August to October) and two sequences of wetter-than-average months (May to July and November-December), giving a bimodal distribution of rainfall through the year.

Comparison with data for other years (figs 8.6 and 8.7) shows that this is an unusual pattern. Sequences of more than two wetter-than-average or drier-than-average months are rare throughout

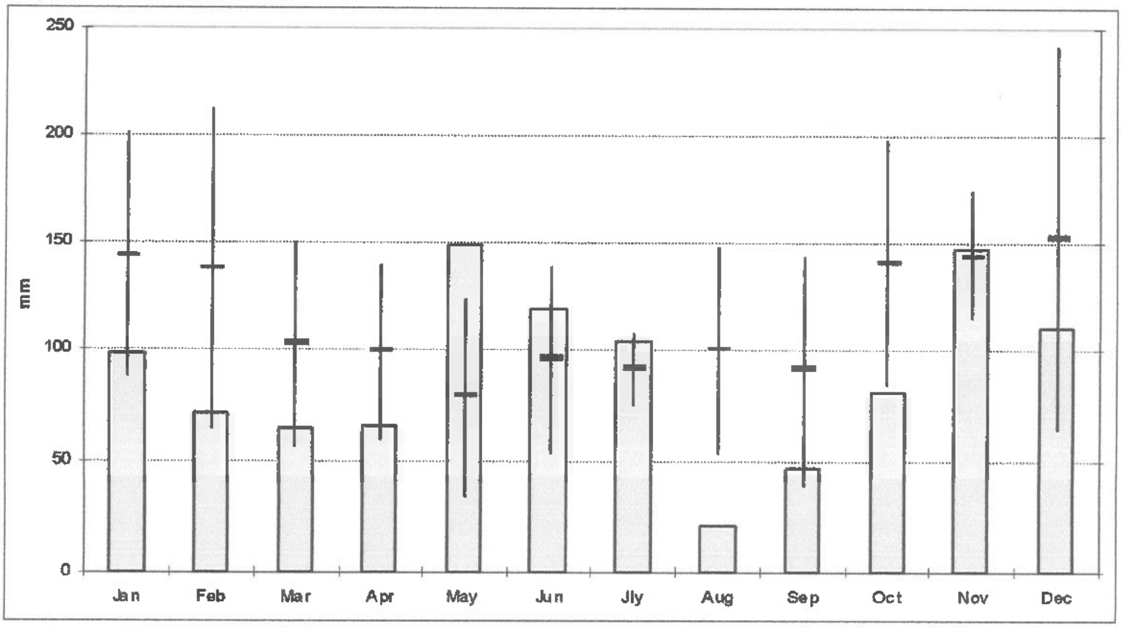


Figure 8.5: Comparison of Derrybrien monthly rainfall totals for 2003 (grey bars) with 14-year monthly means (black horizontal bars) and standard deviations (black vertical bars).

the 14-year record but a pattern involving sequences of four drier-than-average months (March to June), two close-to-average months (July and August) and three wetter-than-average months (September to November) did occur in 2000. Thus, the Derrybrien bog slide occurred during a low-rainfall year, towards the end of an apparently atypical weather sequence involving three low-rainfall months in late summer following three high-rainfall months in early summer and a dry spring.

The possibility that the cumulative effect of part or all of this sequence reflected a clear departure from the normal range of water availability at the time of the bog slide is explored in fig 8.8. The vertical bars at the bottom of the diagram represent rainfall totals for individual months throughout the 14-year period January 1990 to December 2003. The variation in antecedent rainfall is explored by calculating total accumulated rainfall during, respectively, the three, six and 12 months prior to the last day of each month. These values are indicated above each monthly rainfall total.

The graphic reveals that October 2003 came at the end of the second-driest three-month period in the 14 years of records. The average monthly rainfall for the preceding three months was 49.5 mm. The only drier three-month period ended in May 2000, for which the corresponding average was 40.1 mm. The wet weather in the early summer of 2003 meant that the rainfall total for the six-month period prior to the bog slide was within the range of figures obtained for several other years. On the other hand, the preceding 12-month period was again one of the driest on record (mean monthly rainfall November 2002 to October 2003 was 92.4 mm). A similar 12-month total was calculated for April 1997 and lower 12-month totals were obtained for July 1996 (average monthly rainfall 92.2 mm) and December 2001 (average monthly rainfall 90.3 mm).

A full assessment of the effect of dry weather on the moisture status of the peat blanket requires calculation of potential soil moisture deficit (the accumulated excess of potential evapotranspiration over rainfall). This would take into account the effect of any seasonal pattern in evapotranspiration, which would be expected to promote more intense drying of peat during low-rainfall periods in summer than during similar periods in winter. This calculation has not been performed because evapotranspiration data were not available. However, on the basis of the rainfall record alone, it appears that, although somewhat similar weather conditions had arisen on a few other occasions during the previous 14 years, the Derrybrien bog slide occurred at the end of a low-rainfall autumn in a low-rainfall year.

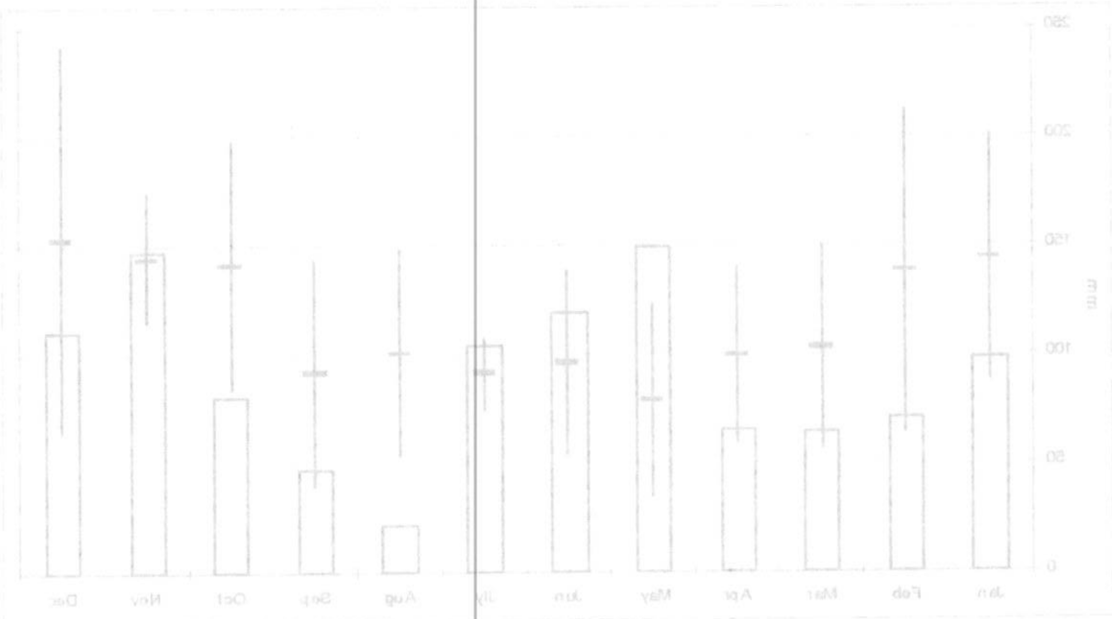


Figure 8.5: Comparison of Derrybrien monthly rainfall totals for 2003 (grey bars) with 14-year monthly means (black horizontal bars) and standard deviations (black vertical bars).

the 14-year record but a pattern involving sequences of four drier-than-average months (March to June), two close-to-average months (July and August) and three wetter-than-average months (September to November) did occur in 2000. Thus, the Derrybrien bog slide occurred during a low-rainfall year, towards the end of an apparently atypical weather sequence involving three low-rainfall months in late summer following three high-rainfall months in early summer and a dry spring.

The possibility that the cumulative effect of part or all of this sequence reflected a clear departure from the normal range of water availability at the time of the bog slide is explored in fig 8.8. The vertical bars at the bottom of the diagram represent rainfall totals for individual months throughout the 14-year period January 1990 to December 2003. The variation in antecedent rainfall is explored by calculating total accumulated rainfall during, respectively, the three, six and 12 months prior to the last day of each month. These values are indicated above each monthly rainfall total.

The graphic reveals that October 2003 came at the end of the second-driest three-month period in the 14 years of records. The average monthly rainfall for the preceding three months was 49.5 mm. The only drier three-month period ended in May 2000, for which the corresponding average was 40.1 mm. The wet weather in the early summer of 2003 meant that the rainfall total for the six-month period prior to the bog slide was within the range of figures obtained for several other years. On the other hand, the preceding 12-month period was again one of the driest on record (mean monthly rainfall November 2002 to October 2003 was 92.4 mm). A similar 12-month total was calculated for April 1997 and lower 12-month totals were obtained for July 1996 (average monthly rainfall 92.2 mm) and December 2001 (average monthly rainfall 90.3 mm).

A full assessment of the effect of dry weather on the moisture status of the peat blanket requires calculation of potential soil moisture deficit (the accumulated excess of potential evapotranspiration over rainfall). This would take into account the effect of any seasonal pattern in evapotranspiration, which would be expected to promote more intense drying of peat during low-rainfall periods in summer than during similar periods in winter. This calculation has not been performed because evapotranspiration data were not available. However, on the basis of the rainfall record alone, it appears that, although somewhat similar weather conditions had arisen on a few other occasions during the previous 14 years, the Derrybrien bog slide occurred at the end of a low-rainfall autumn in a low-rainfall year.

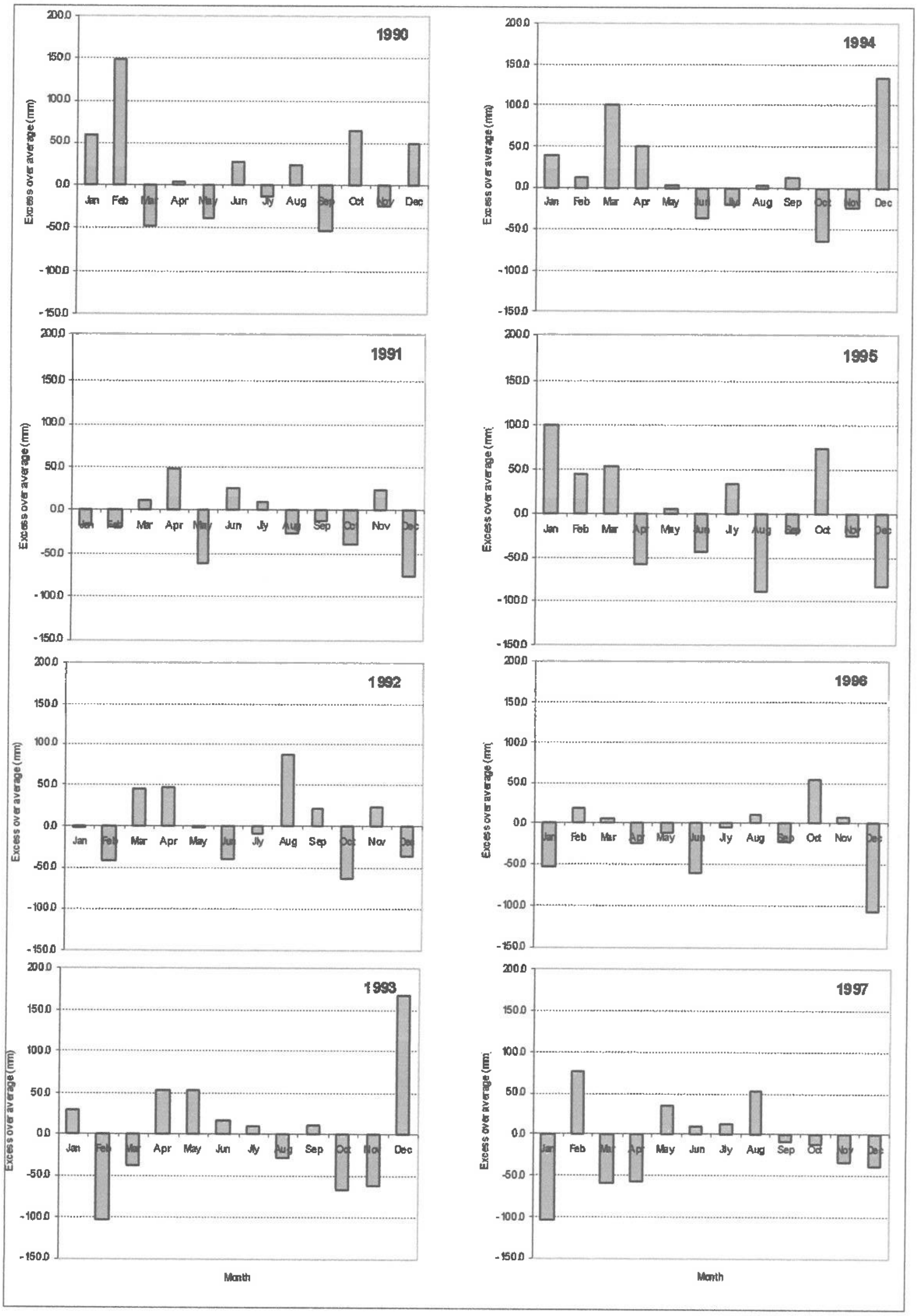


Figure 8.6: Monthly rainfall data for Derrybrien, 1990 to 1997. Each bar indicates the deviation of the month's rainfall total from the appropriate 14-year monthly mean.

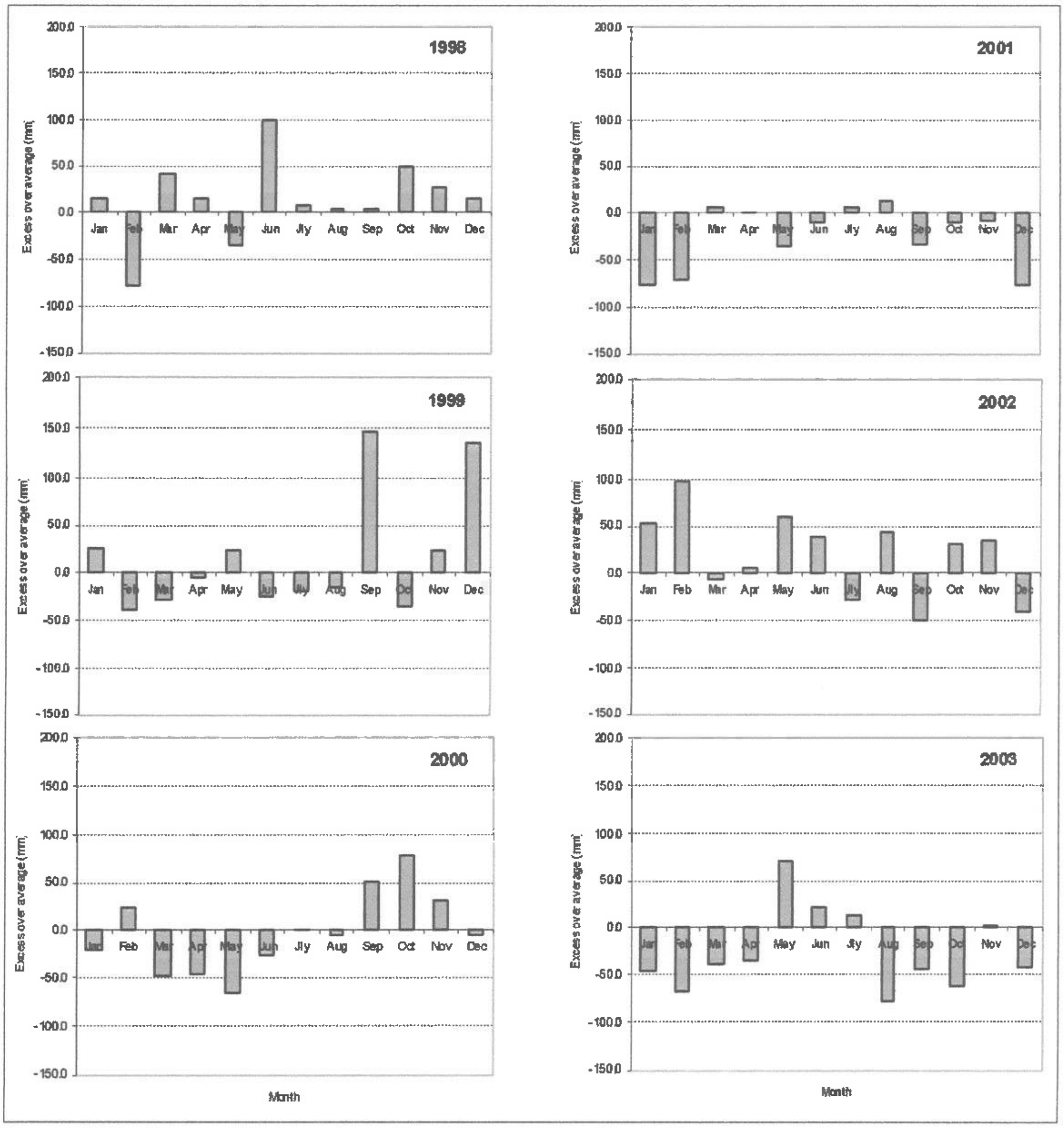


Figure 8.7: Monthly rainfall data for Derrybrien, 1998 to 2003. Each bar indicates the deviation of the month's rainfall total from the appropriate 14-year monthly mean.

8.3 *Influence of topography and hydrology*

The T68 bog slide occurred in a shallow valley or natural flush, where seepage flow lines in the peat begin to converge to form one of the streams that drain southwards from the peat blanket on Cashlaundrumlahan (fig 8.1). The catotelm in this area should be fairly resistant to drying out even in a drained site, because seepage is focused into it from a sector of bog stretching to the summit of the mountain. This is also the type of location where underground peat pipes develop, although they tend to be active in conducting water only during wet weather.

Nonetheless, we would expect that the surface layer of the bog in this area would be dry. The acrotelm was subdivided by forestry ploughing and drainage around 30 years ago and the living bog vegetation would have been lost at canopy closure some ten years ago. The area is also at the edge of a fire scar which may have further damaged the natural bog surface. The rate of evapotranspiration from mature trees is much higher than from natural bog vegetation. All these effects mean that the

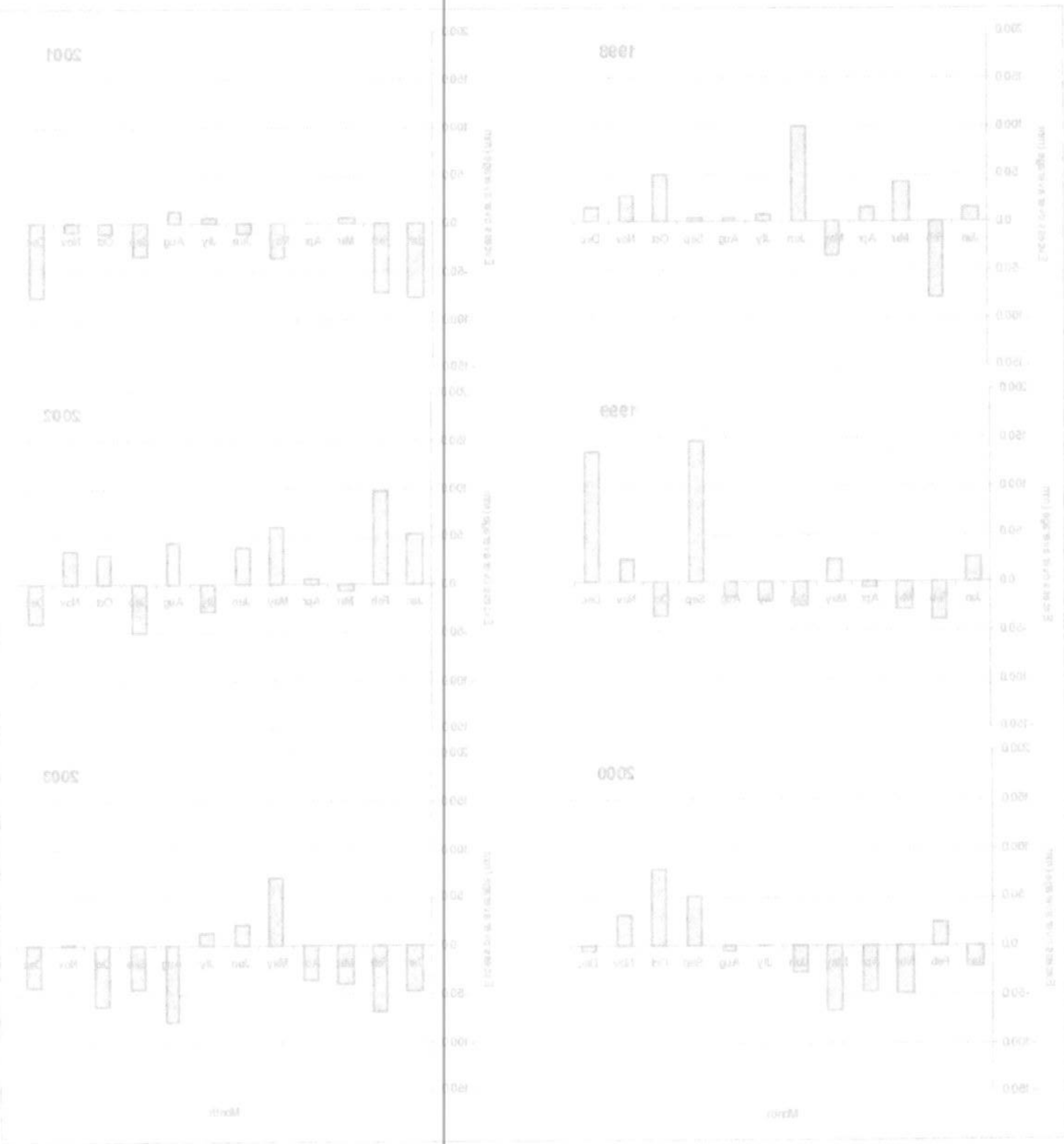


Figure 8.7: Monthly rainfall data for Derrybrien, 1998 to 2003. Each bar indicates the deviation of the month's rainfall total from the appropriate 14-year monthly mean.

8.3 *Influence of topography and hydrology*

The To8 bog slide occurred in a shallow valley or natural flush, where seepage flow lines in the peat begin to converge to form one of the streams that drain southwards from the peat blanket on Cashlaundrumlahan (fig 8.1). The catotelm in this area should be fairly resistant to drying out even in a drained site, because seepage is focused into it from a sector of bog stretching to the summit of the mountain. This is also the type of location where underground peat pipes develop, although they tend to be active in conducting water only during wet weather.

Nonetheless, we would expect that the surface layer of the bog in this area would be dry. The acrotelm was subdivided by forestry ploughing and drainage around 30 years ago and the living bog vegetation would have been lost at canopy closure some ten years ago. The area is also at the edge of a fire scar which may have further damaged the natural bog surface. The rate of evapotranspiration from mature trees is much higher than from natural bog vegetation. All these effects mean that the

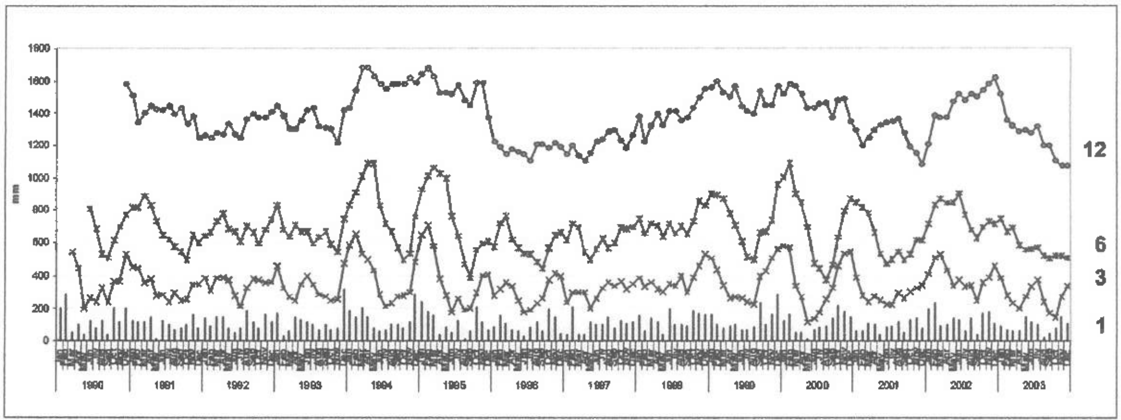


Figure 8.8: Monthly rainfall totals for Derrybrien, January 1990 to December 2003. The vertical bars at the bottom of the diagram (labelled 1) indicate monthly rainfall totals. The continuous lines indicate the total accumulated rainfall for the three, six and twelve months respectively preceding the last day of each month.

fibrous surface layer would dry out more rapidly than an intact mire surface during a spell of prolonged dry weather.

The conditions thus appear to be of a type that predispose the peat to slippage by one of the surface rupture mechanisms, described by Warburton et al. (2004),[3] involving the relative swelling of basal peat and the contraction of surface peat. Any water shed locally onto the mire surface in the vicinity would be focused into the centre of the flush and routed through surface cracks directly to the bases of cracks and any connecting peat pipes in the catotelm. This is capable of triggering the type of buoyancy failure where plates of dry peat were lifted from the ground (section 4.2).

8.4 *Predisposition by forestry*

Plates 8.3 to 8.5 clearly show that the area of the bog slide was afforested. T68 and T70 were located in a mature lodgepole pine (*Pinus contorta*) plantation and, below T70, there is mature lodgepole pine to the east and an area with sparse lodgepole pine scattered amongst Sitka spruce to the west. The Sitka spruce is a second-rotation crop planted after a fire destroyed part of the first.

A feature of the forestry worthy of note in this context is that the plough furrows run downhill, perpendicular to the contours. This is just the configuration of drains highlighted as being likely to allow water moving along them to attain scouring velocities that can initiate erosion (section 4).

A related and very striking feature of the bog slide is the way in which long ribbons of peat appear to have almost 'delaminated' from the rest of the peat body in successive layers, progressing outwards from the centre of the slide. Examples can be seen in plates 8.5 to 8.8. The ribbons, like the forest ploughing furrows, run straight down the slope. In fact they are sections of peat that have separated along the lines of the ploughing furrows so that they all tend to be the same width. It can be seen from plates 8.5 to 8.8 that each one supports a separate line of trees, reflecting the original planting lines with each successive line of trees now lying at a different angle and the different distances moved as the ribbons progressively peeled away from the lateral margins of the slip.

Closer examination of the delaminated ribbons reveals that the faces of the peat tend to be somewhere between 1-2m in height and generally display an upper pale fibrous layer while the lower parts are dark, amorphous and more obviously catotelm peat. Another striking feature of the ribbons, given that many support extensive tree growth, is their remarkably smooth faces. It is possible to see roots extending through this surface zone lengthways along the ribbon (plates 8.6 and 8.7) but there are few major roots extending sideways outwards from the ribbon as part of a circular root-mat. This is because (section 4.2), cracks in the furrows tend to inhibit sideways extension of new roots. The significance of this for Derrybrien is that the plough lines running down the hill are not bound together across the plough furrows by the sort of tight root mat that would be typical of a natural

[3] See table 4.3.

forest formed on such a slope. Each planting ridge, with its load of timber, is bound reasonably tightly along its length by the tree roots but remains largely separate from its neighbours. The connecting material that joins two adjacent ribbons together is largely amorphous peat lacking coherence because of the extensive cracks that also run parallel with the planting furrows.

This separation into ribbons would be enhanced by the cracking along drain and plough lines. Since the plantation between T68 and T70 is around 30 years old and obviously mature, whilst that below T70 results from two plantings separated by a fire over the same period, we might well expect to find cracking in the vicinity of the slide. Plate 8.8 shows a peat ribbon just beginning to separate along what appears to be a plough-furrow crack just above the eastern side of the area that was most severely disturbed by the slide.

It appears that the dissection of the acrotelm caused by forestry ploughing, carried out around 30 years ago, at least predisposed it to fragmentation once the underlying peat had begun to fail. Furthermore, the plough furrows and forestry drains are arranged to run directly downslope, this pattern continuing uninterrupted across the natural drainage line that connects T68 and T70 before the slide. Such a pattern would encourage any water arriving at the surface in this vicinity to move rapidly downslope within the furrows and drains. The possibility that cracking has converted the shallow furrows into vertical slits penetrating from the surface to a depth of 70 cm or more provides a direct route into the catotelm for any such water. It is also possible that cracking could affect the strength of the peat matrix.

8.5 *Contribution of wind farm construction work*

The uppermost extent of the bog slide extended to just below turbine site 68 (T68) and obliterated site 70 (T70), approximately 300 metres downslope. At the time of the slide, the excavation for T68

Plate 8.5: Looking southwards from T68 on 8 June 2004, the peat appeared to have separated from the plantation along plough furrows to form long ribbons that were progressively drawn into the slide.

Plate 8.6: Face of delaminated ribbon of peat. Note the depth of delamination and the tendency of tree roots to run along the line of the ribbon with few roots extending laterally at right angles to the ribbon. This suggests that there is relatively limited root growth across lines of the cracks that form under plantation conditions.

was being dug. A ramp had been constructed at its western side and one excavator was positioned on this. There was a second excavator on the road edge at its southern side. Apparently, it was the job of the first excavator to dig peat (arisings) out of the site and that of the second to pile the arisings on the south side of the road.

According to the AGEC (2004) account, the excavation had reached mineral soil and had 'several drains feeding into it and appeared to have been water-filled . . . site representatives (have) indicated that they (were) unaware of any over-pumping at this location'. Photographs taken within days (plates 8.8 and 8.9) show the positions of the excavators. At that time there was a small quantity of water in the base of the excavation.

There was also a disconnected water pump at the southern edge of the road. It has not been possible to clarify whether this was being used on the day of the slide, or whether it had been brought in later. However, its position suggests that it could have been used at some time to pump water from the excavation to a point close to the centre of the failed area. The fact that it appears to have slid or been pushed off the edge of the surfaced part of the road onto the timber rafting may be consistent with its having been present when the road moved downslope.

Evidence that water does tend to pond in this location is provided by the fact that the T68 excavation was water-filled in June 2004 (plates 8.2 and 8.11). Such ponding would certainly render excavation more difficult and thus the presence of a pump at this location might not be unexpected. What is not clear, however, is whether this pump was in operation on the day of the peat failure. The T70 site was located to the north of a floating access road 300 metres downslope of T70. It is not clear whether or not the excavation for T70 had been completed at the time of the slide. All of the other sites planned for the southernmost row of turbines had been excavated except the one (T71) immediately to the east of T70, which had been partially excavated. The AGEC mapping sheet states that the T70 'base was not constructed'. Therefore it seems likely that T70 had been excavated but possible that it had not. If the former was the case, the excavation was certainly full of water (see below).

Plate 8.6: Face of delaminated ribbon of peat. Note the depth of delamination and the tendency of tree roots to run along the line of the ribbon with few roots extending laterally at right angles to the ribbon. This suggests that there is relatively limited root growth across lines of the cracks that form under plantation conditions.

was being dug. A ramp had been constructed at its western side and one excavator was positioned on this. There was a second excavator on the road edge at its southern side. Apparently, it was the job of the first excavator to dig peat (arisings) out of the site and that of the second to pile the arisings on the south side of the road.

According to the AGEC (2004) account, the excavation had reached mineral soil and had 'several drains feeding into it and appeared to have been water filled . . . site representatives (have) indicated that they (were) unaware of any over-pumping at this location'. Photographs taken within days (plates 8.8 and 8.9) show the positions of the excavators. At that time there was a small quantity of water in the base of the excavation.

There was also a disconnected water pump at the southern edge of the road. It has not been possible to clarify whether this was being used on the day of the slide, or whether it had been brought in later. However, its position suggests that it could have been used at some time to pump water from the excavation to a point close to the centre of the failed area. The fact that it appears to have slid or been pushed off the edge of the surfaced part of the road onto the timber rafting may be consistent with its having been present when the road moved downslope.

Evidence that water does tend to pond in this location is provided by the fact that the T68 excavation was water-filled in June 2004 (plates 8.2 and 8.11). Such ponding would certainly render excavation more difficult and thus the presence of a pump at this location might not be unexpected. What is not clear, however, is whether this pump was in operation on the day of the peat failure. The T70 site was located to the north of a floating access road 300 metres downslope of T70. It is not clear whether or not the excavation for T70 had been completed at the time of the slide. All of the other sites planned for the southernmost row of turbines had been excavated except the one (T71) immediately to the east of T70, which had been partially excavated. The AGEC mapping sheet states that the T70 'base was not constructed'. Therefore it seems likely that T70 had been excavated but possible that it had not. If the former was the case, the excavation was certainly full of water (see below).

Plate 8.7: Delaminated ribbons of peat at the edge of the failed area near T70. The two-layered structure of the peat profile is obvious on the faces of the ribbons but there are few protruding tree roots. Some cracking of catotelm peat is evident in the upper picture.

Plate 8.8: A peat ribbon just beginning to separate along what appears to be a plough-furrow crack adjacent to the failed area.

On 16 October 2003, an excavator began working to release water that had become ponded at the northern side of the road. A channel had been cut through the road before a machinery fault developed and work was halted. The driver was still waiting for assistance to arrive when, some time later, the failure occurred.

In summary, the possible causes of, and contributory factors to, the slide appear to be the dry weather in combination with local factors at each of the turbine sites (fig 8.9), as follows:

at T68:

1 possible cracked peat south of the road due to forestry (the excavation being in a ride where cracks are reported not to propagate) giving direct access for surface water to the catotelm approximately 0.7 metres below the surface and to any underground pipe system;

2 possible standing water in T68 excavation with steep hydraulic gradient downslope due to the presence of the road, tending to push the road sideways;

3 loading of the peat surface by forestry, the road, the weight of machinery and piled arisings;

4 over-pumping of water from the flooded excavation onto cracked peat in an area where it will be focused into the centre of the natural seepage line after dry weather, raising the subsurface hydraulic pressure towards a point where either the peat mass begins to act like a liquid or dry peat is lifted in plates and transported downslope.

at T70:

1 possible cracked peat due to forestry, with additional disturbance due to fire and re-planting;

2 possible weight of machinery, although it is understood that this was some tens of metres

Reproduced courtesy of Martin Collins

Plate 8.9: T68 shortly after the bog slide. The head of the failure was marked by a tension crack which can be seen beneath the perched excavator and the access road bowed downslope (to the right of the lower picture, which was taken from the west side of the slide).

away from the centre of the drainage line at the time of the slide;

3 removal of support to the upslope wall of possible T70 excavation due to release of water through the line of the road;

4 discharge of water onto degraded peat downslope of T70, causing loss of strength as described for over-pumping at T68.

The cause of the failure could not be specifically identified even by the geotechnical experts who visited the site within days and so viewed all the evidence in a 'fresh' state. However, whilst the weather and condition of the site due to forestry could be predisposing factors, it seems probable that the slide was actually triggered at either T68 or at T70 or by a combination of the factors at both sites

Plate 8.10: Photographs taken at T68 shortly after the bog slide. A disconnected water pump features prominently in these frames, which were taken from south and east of the slide.

simultaneously and acting on the slope as a whole. Possible triggers for the slide appear to be:

- a failure due to loading at T68 which was propagated downslope;
- this process possibly being promoted by over-pumping which reduced the strength of the peat below T68;
- the collapse of the northern face of the putative excavation at T70 due to removal of the water that had been supporting it, this failure being propagated upslope as described by Proctor for the event at Wingecarribee Swamp (section 4.2).

Thus it appears that the most likely triggers are various activities directed towards wind turbine installation.

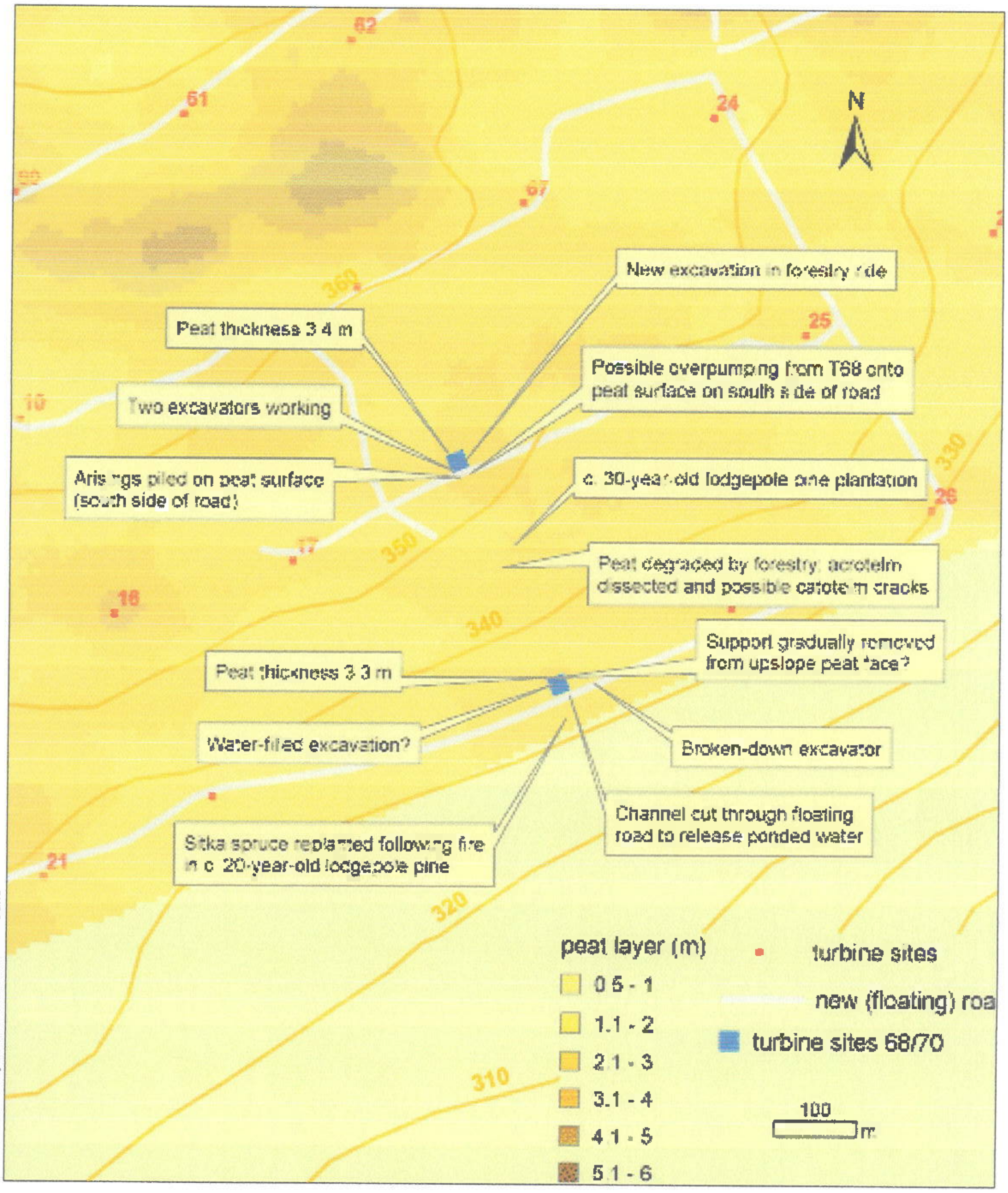


Figure 8.9: Factors that may have contributed to the bog slide at T68.

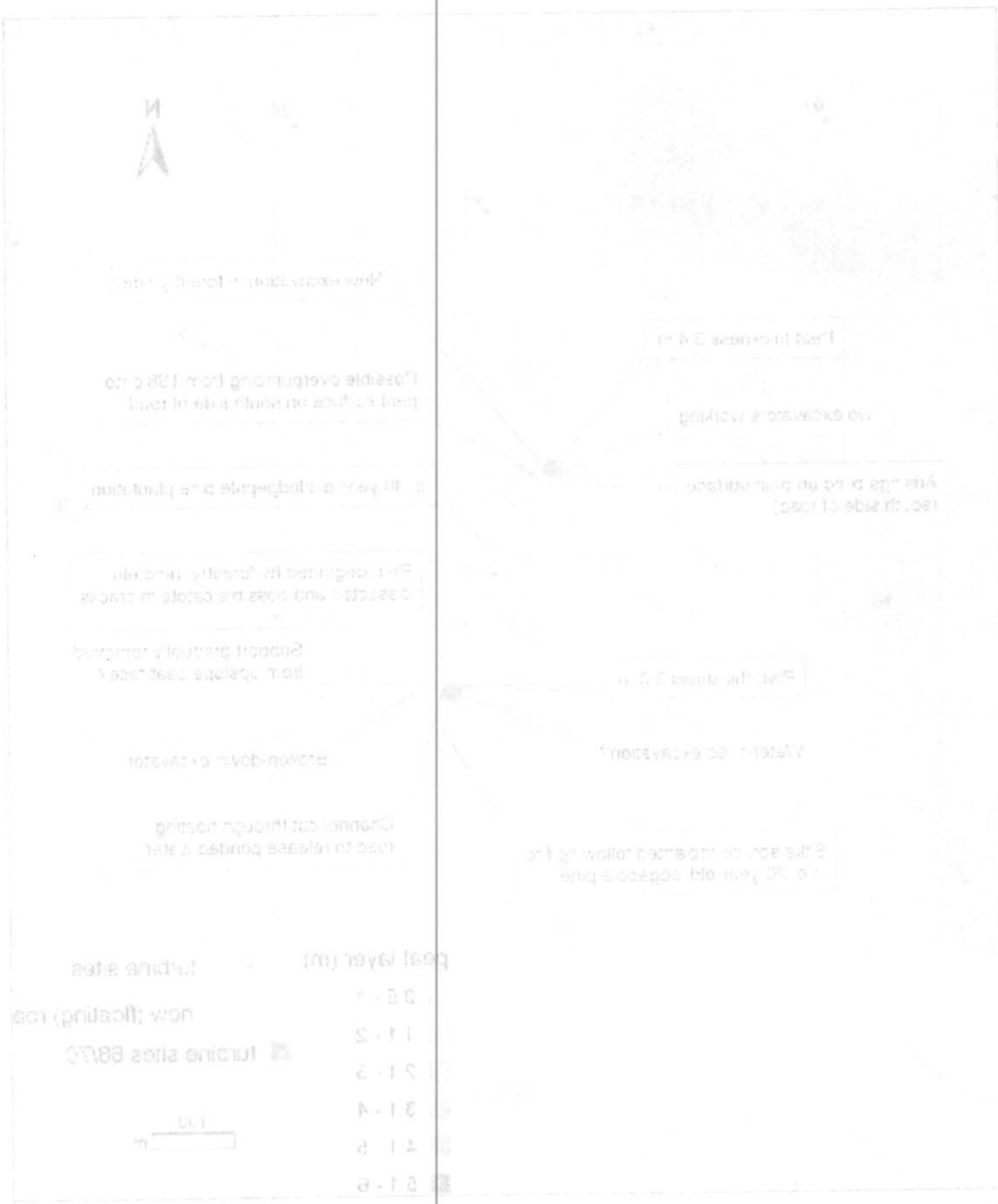


Figure 8.9. Factors that may have contributed to the bog slide at T68.

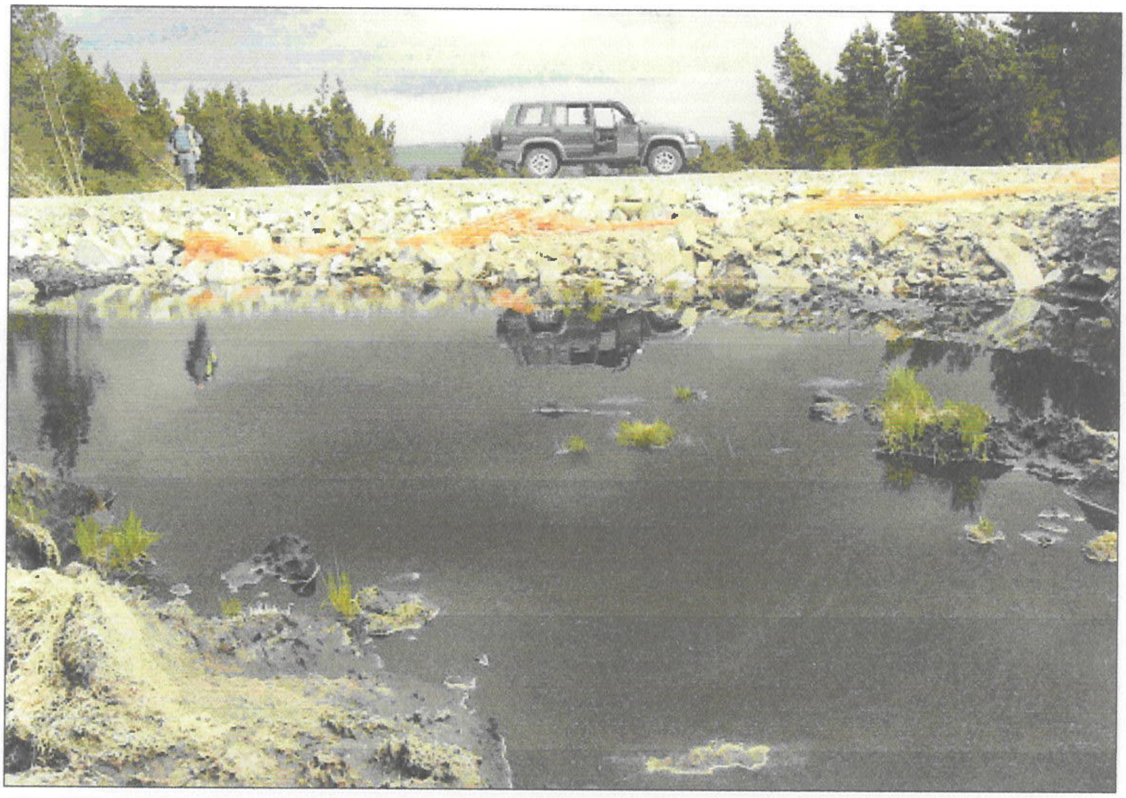


Plate 8.11: A damaged floating road just by T68. By June 2004, when this photograph was taken, it had been top-loaded with some decimetres of rock and aggregate, presumably rendering it rather less permeable to water than previously. A considerable depth of water had accumulated upslope, as the picture shows.

Summary of Chapter 8

1 The bog slide on 16 October 2003 involved failure of peat over an area 1.25 km long and 0.27 km wide, the uppermost point of which lay by the site of Turbine 68 (T68). The material travelled 1.25 km, affecting a total expanse stretching for some 2.5 km downslope. The peat flowed down a natural drainage line which led to a stream-course.

2 At the end of the month there was heavy continuous rain and the bog slide became re-activated, moving much faster in the form of a liquid stream and travelling a further 20 km along the Owendalulleegh River into Lough Cutra.

3 There was no rain at the time of the original event: the preceding few weeks had been exceptionally dry.

4 The failure appears to have been in the peat layer, thus pointing to issues affecting the peat rather than the sub-soil as the cause of the failure.

5 During the original event, the peat appears to have separated into long linear rafts each supporting a line of plantation trees. Even some eight months later, these rafts give the appearance of having delaminated from each other during the event.

6 The rainfall record for the 14 years up to and including the event give an annual average rainfall of almost 1,400 mm: 2002 was a very wet year compared to the 14-year average but both 2001 and 2003 were exceptionally dry years compared to the average.

7 Looking at the spread of rainfall throughout each year by comparing monthly rainfall with the 14-year average for each month, 2000 had very low rainfall for the first six months of the year, 2001 was generally below average for eight months scattered through the year and 2003 had prolonged periods of low rainfall in the spring and in the three months immediately before the bog slide. The 12 months preceding the bog slide produced one of the lowest cumulative rainfall totals in the record.

8 The rainfall record, rather than highlighting a high-rainfall incident as the trigger to failure, instead points to low rainfall conditions that exacerbated cracking of the peat initially caused by plantation forest cover.

9 The area of failure was covered with plantation forest and the surface of the peat was thus dry and extensively fissured, probably more so as a result of recent weather patterns. There was a considerable weight of timber sitting on the peat.

10 The bog slide occurred in a shallow valley forming a natural seepage line. The lower catotelm peat was probably thus fully saturated, whereas drainage and forest cover would have dried out the surface layers and caused extensive cracking. Peat slippage in these circumstances can be caused by swelling of the peat base and contraction of the surface, resulting in surface rupture.

11 Alternatively, if quantities of surface water are introduced to the system through pumping or by breaching structures holding ponded water, this flow of water can enter the cracked surface and cause buoyancy in the surface layers of peat, leading to buoyancy failure.

12 Loading failure from the weight of timber may have contributed further to both mechanisms described in Points 9 and 10.

13 Construction work at the time consisted of excavation for the base of T68 and drainage work on the road beside T70. The T68 excavation had filled with water and a pump was photographed close to the excavation a few days later. If there had been pumping out of released quantities of water onto the downslope surface, this may have initiated the slide.

14 If culvert construction at T70 involved the sudden release of ponded water onto the downslope surface, this may have initiated the slide.

15 The mechanisms in Points 12 and 13 would both be encouraged by extensive fissuring of the peat, the weight of construction machinery and the weight of plantation timber