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National Parks and Wildlife Service

ASSESSMENT OF MAIN CONTRIBUTING FACTORS LEADING TO THREE MAJOR PEATLAND FAILURES IN LEITRIM, KERRY AND DONEGAL

IMPACT ASSESSMENT OF LAND USE CHANGES ON PEAT STABILITY ON BLANKET BOG/PEATLAND HABITATS

Prepared by Fehily Timoney and Company on behalf of Geological Survey Ireland (Department of the Environment, Climate and Communications and National Parks and Wildlife Service (Department of Housing, Local Government and Heritage).

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Overview: Task 6 of the project involves the assessment of potential impacts of land use changes on key blanket bog features and properties, and directly or indirectly on peat stability.

Table of Contents

1. Introduction

1.1 Fehily Timoney and Company

Fehily Timoney and Company (FT) is an Irish engineering, environmental science and planning consultancy with offices in Cork, Dublin and Carlow. The practice was established in 1990 and currently has c.100 members of staff, including engineers, scientists, planners and technical support staff. We deliver projects in Ireland and internationally in our core competency areas of Waste Management, Environment and Energy, Civils Infrastructure, Planning and GIS and Data Management.

FT have been involved in over 100 wind farm developments in both Ireland and the UK at various stages of development i.e. preliminary feasibility, planning, design, construction and operational stage and have established themselves as one of the leading engineering consultancies in peat stability assessment, geohazard mapping in peat land areas, investigation of peat failures and site assessment of peat.

1.2 Project Description

The Services that form this project comprise carrying out a detailed scientific assessment, using available data and data provided, along with appropriate site visits, to determine the main contributing factors that led to a series of peatland landslides located in Counties Donegal, Leitrim and Kerry. The project will seek to characterise the environmental setting of the landslides, determine the main contributing factors to the failures and further determine any shared conditions that may identify susceptibility in 3 additional areas of interest to GSI and NPWS.

The results of this assessment will be used to assess the potential to update Geological Survey Ireland's National Landslide Susceptibility Map and to produce technical notes for documentation(s) related to peatland land use and peat stability in Ireland.

This Technical Note covers Task 6 of the Specification of Requirements, namely *"Produce a technical advisory note that will be of assistance to planning authorities and government agencies for informing the assessments of potential impacts of proposed land use changes (e.g. infrastructural developments, peat extraction, forestry operations etc.) on key blanket bog features and properties including geology, geomorphology, stratigraphy, structure, ecology, ecohydrological functioning and directly or indirectly on peat stability."*

1.3 Contents of Technical Note

This technical note reviews current and draft Irish guidelines in terms of impact assessment with respect to proposed land use changes/developments.

Potential impacts from land use change are examined in relation to peat stability, hydrogeology, hydrology, geology and ecology. Both direct and indirect impacts on peat stability are considered.

1.4 Glossary of Terms

The following terms are used within this technical note, and an explanation of their meaning is included here for clarity.

- Acrotelm: The relatively thin upper layer of the peat, typically in aerobic conditions. Thickness can vary, from 0 to > c.40cm, depending on topography and hydrology. Near surface material is relatively undecomposed and more permeable than the underlying catotelm.
- Catotelm: Lower layer within a peat body, characterised by more humified plant remains in an anaerobic environment. Lower permeability than the acrotelm, although this depends on a number of factors.
- Blanket Bog: Peat deposited on upland areas where the number of rain days exceeds 200 days per year. Peat will accumulate wherever the drainage is impeded and where the slope is typically <20 degrees (Hobbs, 1986). Blanket bog is generally found on peat of over 0.5m thickness whereas heath is generally found on shallower peat.
- Undrained Shear Strength: Undrained shear strength (c_u) refers to the strength of soil in situations where the excess pore water pressures developed during shearing cannot dissipate and at which failure takes place. The undrained strength of a soil applies in the short-term, for example during construction and until construction induced pore water pressures dissipate.
- Drained Strength: The drained strength of a soil refers to the shear strength of a soil when the pore pressures generated by shearing dissipate rapidly or are not present at all. It is a measure of the long term strength of a soil, recorded as an effective friction angle (ø’) and effective cohesion (c’).
- Peat Pipes: An underground channel, typically at the base of a peat deposit, that water flows through. Note however that peat pipes also occur at other levels within a peat body. Not all mechanisms for their formation are understood.

2. Impact Assessment for Blanket Bog/Peatland Habitats

2.1 Current and Draft Guidelines

2.1.1 Department of Housing, Planning and Local Government, Draft Wind Energy Development Guidelines (December 2019).

As this document is currently draft, any information within these guidelines is subject to change, and should be used as a general reference document rather than a specific guide to impact assessment.

The main potential impacts on habitats that can result in the reduction, or loss, of biodiversity are:

- Direct loss of habitat to the developments' infrastructure, including turbine foundations, buildings, roads, quarries and borrow pits;
- Degradation of habitats through alteration or disturbance, in particular arising from changes to hydrology that may alter the surface or groundwater flows and levels, and drainage patterns critical in peatlands and river headwaters;
- Fragmentation of habitats and increased edge effects; and
- Degradation and loss of habitats outside the development site, especially wetland habitats that may arise from pollution, siltation and erosion originating from within the development site.

In terms of Geology, the main requirements are:

- A landslide and slope stability risk assessment for the site for all stages of the project, with proposed mitigation measures where appropriate (this should also consider the possible effects of storage of excavated material);
- A thorough ground investigation, including hydrogeological investigations where appropriate, and a detailed evaluation of the nature of the peat, its geotechnical properties and the associated risk of instability and habitat loss or disturbance during construction and operation of the wind energy development, is to be carried out where the depth of peat is in excess of 0.5m.
- Location of the site in relation to any area or site that has been identified by Geological Survey Ireland as a geological Natural Heritage Area, a proposed Natural Heritage Area or as a County Geological Site. (If so, are there any impacts discussed, or mitigation measures proposed);
- Location of the site in relation to areas of significant mineral or aggregate potential.
- An assessment of any potential impacts of the development on groundwater, and
- Details of any borrow-pits proposed on site should be shown on the planning application and details given where blasting is proposed, such as on the avoidance and remediation of land slippage.

2.1.2 Institute of Geologists of Ireland (IGI)

The Guidelines for the preparation of Soils, Geology & Hydrogeology Chapters of Environmental Impact Statements (2013) provide the following recommended procedure.

- Initial Assessment – Establish the location, type, and scale of the development, including baseline conditions.
- Direct/Indirect Site Investigations & Studies – Select appropriate investigations and studies to categorise the impact of the proposed development on the receiving environment.
- Mitigation Measures, Residual Impacts and Final Impact Assessment – Identify mitigation measures to address potential impacts and assess the impact of any residual impacts.
- Completion of Chapter – Produce the Soils, Geology & Hydrogeology sections of the EIAR referring to the results of the preceding sections.

2.1.3 EPA

Guidelines on the information to be contained in Environmental Impact Assessment Report (EPA, 2022).

These guidelines currently set out a seven-stage approach (see Figure 3.1 of the Guidelines):

- Screening – is an EIAR required?
- Scoping – what information is required?
- Alternatives – a description of reasonable alternatives
- Project description/Baseline description– 'A description of the relevant aspects of the current state of the environment (baseline scenario) and an outline of the likely evolution thereof without implementation of the project as far as natural changes from the baseline scenario can be assessed with reasonable effort on the basis of the availability of environmental information and scientific knowledge.'
- Assessment of effects – Identify, describe, and present an assessment of the likely significant effects of a project on the environment.
- Mitigation & Monitoring – Explain the extent to which significant adverse effects on the environment are avoided, prevented, reduced, or offset, and should cover both the construction and operational phases.
- Residual Effects and Conclusions – Define the remaining environmental 'costs' of a project that could not be reasonably avoided.

3. Potential Impacts from Land Use Change

3.1 Introduction

For an EIAR, likely significant effects are based on a 'likelihood' or 'possibility' of significant effects on the environment occurring. Whether the effect is significant will depend on factors such as the type, extent, duration, intensity, timing, probability, and cumulative effects of the potential impact, as well as the sensitivity of the environment.

In relation to the development of wind farms, reference should be made to the guidance listed in Section 2, the Natural England Commissioned Report NECR032: Investigating the impacts of windfarm developments in England (2010), as well as Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments (Second Edition, 2017) (Scottish Government). While these documents are specifically related to wind farm developments, they both provide information useful to an assessment of any development or proposed land use change on blanket bog. Land use and land use change impacts blanket bog ecohydrology and the geotechnical properties of peat.

While each of the below aspects of a site (soils & geology, hydrogeology, hydrology, ecology) are typically considered individually, when considering peat stability all of the above also need to be considered in terms of their interaction with each other in order to accurately assess the potential impact of the change in land use on ecosystems such as blanket bogs. The Scottish Guidelines recommend that assessments of peat landslide risk should include input from at least three of the following disciplines – engineering geologist, geotechnical engineer, geomorphologist, hydrogeologist/hydrologist and ecologist. A non-exhaustive checklist is included in Appendix A containing items/reports to be considered when reviewing planning applications.

3.2 Peat Stability

In order to appropriately assess the potential impact of any land use change (including proposed developments) on peat stability, it is important that Impact Assessments consider both direct and indirect impacts of the development, as well as combinations of impacts of current land uses or land use changes that may reduce the stability of peat. These include:

- Loading of the peat (either temporary or permanent) – this could, for example, be from construction loading or stockpiling of materials, or excavation related to peat extraction. A relatively small additional load can, in certain conditions, lead to a large-scale peat failure, and this potential impact should be considered, and appropriate mitigation measures identified to reduce the risk of such a failure to an acceptably low level.

- Erosion from existing drainage or changes in drainage from a development.

- Uncontrolled discharges of water onto peat (both during the construction phase and in the long-term),

- Removal of surface vegetation that may be occurring for peat extraction purposes, or occurring as a result of other land use pressures such as from grazing stock,

- Maintenance requirements for artificial drainage that may be installed as part of a development to avoid water ponding in blocked drains.

- Excavations in peat, either temporary or permanent, during a development, must be appropriately designed and supported. Unsupported excavations that expose the more humified (decomposed) catotelm risk a large-scale peat failure and should be avoided. The presence of existing excavations, such as for peat extraction, can significantly reduce the stability of the peat, and the impact of these in combination with any development should be assessment and any significant impacts mitigated.

- A change in the water level within the peat (caused by changes in the drainage regime). Blocking of drains will lead to a rise in the water table, which may lead to a weakening of the peat through increased saturation. Drainage of peatlands can lead to desiccation within the peat layer and may lead to decomposition of the peat (this also occurs in areas adjacent to excavations). For stability assessments a worst case of groundwater at ground surface (fully saturated peat) should be assumed.

- Settlement and compaction of peat arising from a lowering of the groundwater level. Where forestry has been planted, studies have shown that settlement of peat deposits equal to 10% of the peat thickness can occur following drainage and planting when compared to unplanted areas. The majority of this settlement appears to occur in the initial 20 years post planting. The drainage installed artificially lowers the natural groundwater level within the peat, allowing compression/consolidation of the peat. This often leads to cracking of the peat, which allows the ingress of water to the weaker catotelm (a more humifies or decomposed peat) at the base of the peat layer, where it can increase the water pressure and reduce the stability of the peat.

- Impact Assessments should address not just the development footprint, but also any area downslope of the development that may be impacted from peat instability upslope, or any area upslope that has the potential to impact on peat stability. This requires the identification of any potential pre-failure indicators (see the Scottish Guidelines for details) and the gathering of information on the depth, strength, and condition of peat across a site, as well as on natural and artificial drainage systems and flow patterns and volumes in and around the development site catchment/sub-catchment and any available information on any historic failures in the vicinity.

A methodology for undertaking peat stability assessment is included in "Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments (Second Edition, 2017)". In accordance with the Draft Wind Energy Guidelines (2019), a peat stability assessment should be undertaken where the thickness of peat exceeds 0.5m. Justification should be provided for sites where a peat stability assessment is not undertaken.

3.3 Hydrogeology

Groundwater quality is under increased pressures due to land use intensification and industrial actions (Burri et al, 2019). Land use change that involves artificial drainage (such as infrastructure developments) can reduce the capacity of the peat land to store water, resulting in greater volumes of run-off and the potential for erosion and silt release into nearby receptors. Drainage can also lead to desiccation of the peatland and changes in peat structure with potential implications for peat stability.
The main hydrogeological features in peatland systems to be considered:

- Peat Thickness: The depth and thickness of the peat layer play an important role in hydrogeology. Thicker peat layers may retain water and affect drainage differently than thin layers.

- Water Table: The position of the water table, or the level at which the ground is saturated with water, should be determined. Typically, the water table in intact peatlands is close to the ground surface.

- Groundwater Flow: Assessing the direction and flow of groundwater within and around the peatland is important when determining the impact of any proposed changes to the natural drainage regime. Groundwater flow in peatlands is considered to follow topography. Groundwater movement can impact drainage, erosion, and flooding.

- Soil Permeability: Humified peat has low permeability, which affects water movement. Understanding how water moves through peat is important for drainage and water management. However, peat permeability can vary significantly, and gathering usable data can be very difficult.

- Vegetation Cover: The type and density of vegetation can influence hydrogeology and ecological and hydrological functioning. Vegetation also stabilises peat by absorbing moisture and reinforcing the surface though not everywhere as moss lawns can grow over very wet, weak peat.

Should a change in land use or proposed development require the installation of new drainage or modification of existing drainage, new drainage should seek to minimise and mitigate the following:

- Water level drawdown, shrinkage, and decomposition of in-situ peat.
- Creation of preferential pathways and unidentified cracking of the peat mass
- Compaction of the in-situ peat
- Excessive drying out/desiccation of the peat mass
- Movement or change to existing peat workings that could destabilise the peat

3.4 Hydrology

An assessment of the impact to a change in land use on the hydrology of a blanket or raised bog should include an accurate conceptual model of the site, which includes any potential impact on the existing peat hydrology. Factors to consider include surface and sub-surface topography, water table position, water inflow and outflow, natural and artificial drainage features and flow directions, rainfall and climate, groundwater flow, surface water flow patterns, vegetation, permeability, human activities, peat thickness, climate change and erosion control. Many peatland systems are ombrotrophic, meaning they are fed by rainwater precipitation; there may be a dependency on rainfall, surface water and ground water dynamics depending on the site.

Hydrological factors to be considered include:

- Impact of Drainage Pattern Changes: Alterations in drainage patterns, whether transitioning from natural to artificial or vice versa, can have negative consequences for peat stability. These drainage pattern changes are often associated with forestry plantations and the construction of drainage outfalls, including in upland developments such as wind farm projects.

- Alteration of Hydrological System: Construction in peatland, particularly the artificial drainage of peat, disrupts the hydrology of both the sub-surface peat body and its surface. Drainage channels should seek to mimic the natural system and alter the natural system as little as possible in order to avoid drying of the near surface peat or other effects that disrupt bog ecosystem functioning so as not to negatively impact on peat stability.

- Forestry Plantations: The impact of drainage is not limited to infrastructure but also affects areas where new forestry plantations are established. Such drainage artificially lowers the water table in the peat, eventually altering the type of vegetation growing on the peat and preventing the formation of new peat.

- Ploughed Drainage Channels: In the context of afforestation, ploughed drainage channels play a significant role in altering peat hydrology, lowering water tables, changing vegetation types, and preventing peat accumulation.

- Peat Failures: There is a risk of peat instability, especially near the headwaters of streams, which can be triggered by man-made drainage that increases surface water flow in these areas.

- Impact of Constructed Tracks: Tracks, such as 'floating roads' as built across peatlands, may lead to peat compaction, peat subsidence, altered surface water flows, water ponding, local desiccation, peat erosion, destruction of the bog vegetation and compaction and reduced permeability of the acrotelm (more permeable upper peat layer).

- Peat Cracking: Artificial drainage can lead to the cracking of peat, which provides pathways for rainfall to flow into the base of the peat layer, potentially resulting in peat failures due to porewater pressure buildup.

The change in drainage patterns from natural to artificial, and from artificial to natural, has the potential to adversely impact on peat stability. These changes are often associated with the edges of forestry plantations, and where drainage outfalls are constructed as part of the development of upland sites e.g. wind farm developments. This can occur through erosion of the surface of the peat following intense rainfall events which may overwhelm artificial drainage networks. Once erosion of the peat surface has commenced, the vegetation in the area may not re-establish, which will leave bare peat exposed and lead to further erosion, increasing the ecological and hydrological impact of a proposed development. This is because surface water creates channels in the surface that gradually deepen and get wider, rather than flow on a broad front through a porous acrotelm. These areas require careful assessment for any proposed land use changes, and appropriate mitigation measures should be provided to reduce the potential for a change in erosion rates. Discharge points from artificial drainage should seek to mimic the natural drainage patterns on a particular site.

Construction in peatland can alter the hydrological system of blanket peat at either surface (floating roads) or sub-surface (founded roads) level. Constructed tracks (in the form of floating roads) can result in the compaction and subsidence of peat and changes to the sub-surface flow through the peat because of the consolidation process. Compression of the peat through track construction may lead to accumulations of surface runoff water (ponding), which may lead to erosion and/or instability of the track and adjacent peat, as well as reducing the permeability of the acrotelm. As such, any proposed drainage associated with road construction should seek to minimise the impact of this alteration to the natural hydrological system and provide suitable mitigation measures where significant impacts are likely.

The above applies to infrastructure developments, but also to forestry plantations in areas where no forestry is currently present. Any such plantation will have drains associated with the planting, and these drains will alter the hydrology of the site. This may lead to some of the issues listed above, and any impact assessment should include an assessment of this and include mitigation measures to address any potentially significant impacts.

In terms of peat stability, peat failures have been associated with the headwaters of streams. This refers to the specific source of a stream rather than the general headwater location. These areas are also often characterised by the presence of flushes. Should man-made drainage increase the surface water flow to a specific headwater, it may lead to peat instability. As such, any proposed outfalls should avoid headwaters.

As with hydrogeology, should a change in land use or proposed development require the installation of new drainage or modification of existing drainage, new drainage should seek to minimise and mitigate the following:

- Water level drawdown, shrinkage, and decomposition of in-situ peat.
- Creation of preferential pathways and unidentified cracking of the peat mass
- Discharge in the headwaters of streams or flush zones
- Compaction of the in-situ peat
- Excessive drying out/desiccation of the peat mass

3.5 Geology/Geomorphology

Any Impact from a proposed land use change on geology is dependent on the sensitivity of the site, as per the IGI Guidelines (2013). Forestry operations typically have minimal impact on the geology or geomorphology of a site, however removal of vegetation by machinery can lead to excessive erosion of soils and subsoils, if not properly mitigated. Infrastructure developments result in the excavation of soil/subsoil which involves the permanent loss of a potential resource.

Excavation of peat will expose the underlying geology, which may lead to erosion of material. Excavations for borrow pits may lead to a temporary lowering of the groundwater table (or permanent lowering if the borrow pit is not backfilled), which may increase drying and erosion of adjacent peatlands. Both of these processes will result in a permanent loss of materials, which in the case of bedrock may involve the loss of a material asset, although this isn't relevant to peat stability. This loss of material is unlikely to be a significant impact on the geology and is unlikely to require any mitigation measures. Where possible, mitigation measures should be provided in order to minimise the impact of any localised lowering of the groundwater table.

The impacts on geomorphology from a change in land use are likely to be relatively small and localised in nature.

3.6 Ecology/Ecosystem Functioning/Biodiversity

Impacts from land use change are often indirect as well as direct. For example, a change in hydrology may lead to a change in vegetation downslope of areas where artificial drainage, such as for a wind farm or forestry, is installed. This can lead to a change in the existing habitat, and in peatlands, the loss of peat forming vegetation and consequent changes in ecological and hydrological functioning which may, in turn, impact peat stability. Factors to consider include:

- Change in Hydrology: Alterations in the hydrology of peatlands, such as changes in water table levels due to drainage, can directly affect the vegetation and habitats in these ecosystems. Specific details about how these changes impact water-dependent plant species and the overall ecosystem are needed for a site-specific assessment.

- Habitat Fragmentation: Construction activities, including tracks and infrastructure development, can lead to habitat fragmentation, isolating plant, and animal populations, which should be minimised and mitigated against as part of any proposed change of land use. This fragmentation can impact surface water flow pattern and ecological and hydrological functioning and thereby also peat stability

- Conversion to Plantation Forest: The conversion of natural peatlands into plantation forests can have significant impacts on ecosystem functioning and biodiversity. Details on how this impacts the composition of plant and animal communities, as well as the hydrological changes caused by dewatering and peat oxidation, should be assessed, minimised and mitigated as part of any impact assessment.

- Erosion and Peat Subsidence: The processes of erosion and peat subsidence are crucial for understanding peatland instability. Specifics about the impact on vegetation, soil structure, and overall ecosystem functioning should be provided.

- Recovery and Restoration: Information about the potential for recovery and restoration of peatlands after various disturbances, such as forestry or peat extraction, is important. This includes details on the success of restoration efforts and the ability to regain the original peat state. Any potential effects of restoration works or methods of working on peats stability should also be assessed.

- Edge Effects: The influence of edge effects in modified habitats on the biodiversity and ecology of peatlands should be explained. Specify how this affects breeding birds or other wildlife populations.

- Peat Extraction: The loss of active bog vegetation due to peat extraction and the resulting changes in hydrology, along with the resultant impact on ecosystem function, should be assessed and mitigated.

- Grazing and Trampling: The specific effects of grazing and trampling on different types of blanket bogs and wet heaths, including the damage caused, rate of recovery, and potential for restoration, should be assessed, and where necessary mitigated.

The conversion of a previously undisturbed blanket peatland to plantation forest initiates a process of change that alters the ecosystem and can also impact on neighbouring ecosystems. The natural vegetation may be eliminated, some species for much of the rotation, others permanently. Peat subsidence occurs as a result of dewatering and peat oxidation which can have ecological implications (Regan et al, 2019). The consequence of this is a change in vegetation type, subsidence and shrinkage of the peat, and change in soil structure (Stroud et al, 1987), all of which can have an impact on peat stability. There is generally no blanket bog vegetation remaining at mature forestry sites, unless small areas of open bog have been left unplanted. Active peat formation may re-commence after felling if suitable restoration measures are implemented. However, the original state of the peat is unlikely to be regained, due to the widespread drainage measures implemented during forestry, which will have impacted the fabric of the peat (NECR, 2010), and will have changed both the hydrological and hydrogeological regime, altering the type of vegetation that can recolonise the area post felling.

It is important to point out that, although the nature and quality of the plant communities is dependent on maintaining the structure and hydrology of the peat, a peat body bearing degraded vegetation is still as vulnerable locally to additional physical damage (shrinkage, erosion, mass movement) as is an undamaged deposit (NECR, 2010).

The damage caused by grazing/trampling by stock is nearly always a long-term (decades) process. However, relatively rapid degradation and extensive erosion of blanket bogs and wet heaths resulted from the increases in sheep stock densities that resulted from the introduction, in c. 1980, of ewe headage payments. Recovery from erosion is slow and some of these areas have not recovered despite reduction in stock numbers. Ultimately overstocking of peatlands results in loss of peat forming vegetation. In sensitive locations the endresult of persistent high stocking levels is that the acrotelm is lost completely, the drier surface is colonised by non-peat forming species, patches of bare peat appear, and erosion is initiated as a consequence. Where damage of various kinds mean that sites have lost a degree of their natural resilience, the additional factor of grazing, even at low intensities, can both stretch this resilience, sometimes to breaking point (IUCN, 2010), which can also negatively impact on peat stability.

3.7 Peat Management

An EIAR should demonstrate that any excavated materials (specifically peat) can be managed appropriately on site as part of any development without impacting on peatland stability. This should include the following:

- Assessment of peat volumes and potential for reuse of peat to be included in EIAR.
- Inclusion of a Peat Management Plan where excavation of peat is proposed.
- Ensure layout is optimised to reduce excavation volumes.
- Include details of how peat disturbance will be minimised or prevented.
- Include details of peat monitoring where considered relevant, such as in areas of deep peat or adjacent to watercourses.
- Identify areas where peat can be reused on site, local to area of excavation where feasible and appropriate.
- Provide a stability assessment of any proposed peat storage areas, particularly where excavated peat will be placed on in-situ peat.
- Ensure measures are taken to revegetate areas of exposed peat (where present) with site characteristic peatland vegetation.

Reference can be made to Scottish Renewables and Scottish Environmental Protection Agency Guidance on the Assessment of Peat Volumes, Reuse of Excavated Peat and the Minimisation of Waste (SEPA 2012).

3.8 Interfaces

While each of the above aspects of a site (soils & geology, hydrogeology, hydrology, ecology) are typically analysed individually, when considering the impact on peat stability all of the above need to be considered in terms of their interaction with each other in order to accurately assess the potential impact of the change in land use on areas such as blanket bogs and on peat stability. This process is typically an iterative one, as changes to a development to mitigate impacts on hydrology may have an adverse impact on peat stability or ecology, for example.

4. Summary

This technical note was produced to provide information on the assessment of potential impacts of land uses and land use changes on peatland stability, specifically with reference to blanket bog areas and where such changes may impact (directly or indirectly) on peat stability. The technical note focuses on land uses and land use changes that may directly or indirectly impact on key blanket bog features and properties including geology, geomorphology, stratigraphy, structure, ecology, ecohydrological functioning and directly or indirectly on peat stability, and on improving the assessment of these impacts in order to reduce peat stability risks. An assessment of peat stability should be undertaken where the depth of peat exceeds 0.5m, or justification provided for sites where a peat stability assessment is not undertaken.

Peatland stability is influenced by various factors, such as changes in drainage patterns, land use practices, and alterations in hydrology. These changes, often associated with activities such as forestry, infrastructure development, and peat extraction, can lead to drying, erosion, and alterations in vegetation. Land use changes, particularly the conversion of undisturbed peatlands to plantation forests, can result in the loss of natural vegetation and peat subsidence, affecting peat stability and ecosystem structure. Habitat fragmentation due to construction and grazing also plays a role in biodiversity impacts. Site specific information is required for a comprehensive understanding of how these factors affect peatland ecology, ecosystem functioning, and biodiversity. Site specific mitigation measures are required where any impacts are deemed to be significant.

While each of the above aspects of a site (soils & geology, hydrogeology, hydrology, ecology) are typically analysed individually, all of the above need to be considered in terms of their interaction with each other in order to accurately assess the potential impact of a change in land use on areas such as blanket bogs. Land use and land use change impacts blanket bog echohydrology and the geotechnical properties of peat.

Depending on the general site characteristics, the following may require more detailed studies:

- Water Table Position;
- Natural and artificial drainage systems
- Rainfall and Climate;
- Groundwater Flow;
- Surface water flow pattern and impacts on these
- Habitat Vegetation and patterns of variation;
- Topography
- Substrate topography
- Areas such as wet or quaking bog area, pool systems etc
- Ecosystem functioning including hydrological functioning, connectivity/fragmentation;
- Peat Permeability;
- Compression and Subsidence;
- Human Activities (past and recent/current);
- Peat Thickness and condition;
- Climate Change factors;
- Erosion Control.

Impact Assessments should cover not just the development footprint, but also any areas downslope of the development that may be impacted from peat instability, or any area upslope that may be impacted by peat failure (such as occurred at Shass, Meenbog and Mount Eagle) and/or has the potential to impact on a proposed development.

It is also important that Impact Assessments consider direct and indirect impacts, or combinations of impacts that may reduce the stability of peat through any changes in land uses that have occurred on the peatland whether they are historical or recent.

Impacts on peat stability can result from several factors including: effects of land uses/land use changes that can alter peat structure and properties and impair the ecohydrological functioning of the peatland such as loading of peat (construction loading or stockpiling or loading from timber weight of plantation trees); erosion due to changes in the vegetation cover or the natural drainage regime; changes in the peatland's surface water flow patterns; excavations in peat (temporary or permanent); and the impacts of changes in the water levels in peat from artificial drainage or the blocking of existing drains and many more factors.

In relation to hydrogeology/hydrology, should a change in land use or proposed development require the installation of new drainage or modification of existing drainage, new drainage should seek to minimise and mitigate the following to an appropriate level:

- Water level drawdown, shrinkage, and decomposition of in-situ peat.
- Creation of preferential pathways and unidentified cracking of the peat mass
- Compaction of the in-situ peat
- Excessive drying out/desiccation of the peat mass
- Movement or change to existing peat workings

For ecosystem functioning, developments on peatlands can lead to a fragmentation of the ecosystem, reducing the natural functioning of the habitat. Artificial drainage may lead to changes in the dominant vegetation types with multiple impacts including changes to the natural hydrological regime, e.g. changes to surface water patterns and to run-off, prevention of peat formation and degradation of the ecosystem with resulting consequences including peat failure/instability.

A non-exhaustive checklist is included in Appendix A containing tasks/reports to be considered when reviewing planning applications.

5. References/Bibliography

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APPENDIX A

Checklist of Information

Considerations when Reviewing the Potential Impacts of Land Use and Land Use Changes on Peat Stability/Peat Failure Susceptibility			
	Task	**Yes**	**No**
1	Has an appropriate desk study been undertaken for each relevant discipline utilising the relevant publicly available datasets.		
2	Have site visits been undertaken and site-specific data gathered by the relevant specialists including on habitats and vegetation types occurring in all zones of hydrological relevance to the sites (see Sections 3.4 and 3.6 for details).		
3	Have the interactions between soils & geology, ecology and hydrology been considered, documented, and assessed as part of the Impact Assessment process?		
4	Has a site specific and appropriately detailed Peat Stability Assessment been provided (see Section 3.2 for details).		
5	Has a site-specific Peat Management Plan been provided (see Section 3.7 for details).		
6	Are peat storage areas proposed? If so, has a stability analysis (both short and long term) been undertaken for these (see Section 3.2 for details).		
7	Has an appropriate hydrological and hydrogeological survey been undertaken and has existing drainage (natural and artificial) been identified, both within the site and drainage into the site from surrounding catchments (see Section 3.3 and 3.4 for details).		
8	Has the interaction between proposed artificial drainage and the natural site drainage been assessed and any significant impacts avoided or appropriately mitigated (see Section 3.3 and 3.4 for details).		
9	Has appropriately detailed habitat and vegetation mapping been undertaken as part of the EIAR and does this identify all sensitive and susceptible areas of bog; areas of undisturbed bog; degraded bog; fens / flushes etc. (see Section 3.7 for details).		