URS

A890 Stromeferry Bypass

Constructing Roads Over Peat and Peat Management, Technical Note

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1. INTRODUCTION

1.1 Background

The A890 serves as the main link road down the west coast of Scotland and is also a significant transit for east-west traffic travelling between the Isle of Skye and Inverness. The A890 is mainly single carriageway but frequently reduces to single track with passing places along the stretch between Attadale and Ardnarff.

The road was opened in 1970 following the excavation of a number of rock slopes for the road alignment. There has been a long history of rockfall at the site since, resulting at times in a road closure and a 140 mile diversion and as such, various re-route options are currently under review, including a route to the north (requiring a bridge crossing), several online route options (such as a sidelong viaduct across Loch Carron, an inland tunnel, avalanche shelter extension, etc.) and a southern route option along Glen Udalain Valley.

1.2 Scope of Work

The scope of this Technical Note is to provide a summary of:-

- The geotechnical constraints peat can have on road construction;
- Current guidance / best practice for the construction of roads in areas of peatland to assist in the appraisal of the re-route options;
- Guidance on the management of peat; and
- Ground investigation works that may be required to investigate peat conditions within the selected road alignment corridors.

1.3 Objectives

The objectives of this Technical Note are to provide the following:-

- A brief summary of the realignment options with regards to location and peat conditions;
- A description of peat and the geotechnical constraints associated with this soil type;
- A summary of guidance on Scottish Environment Protection Agency's (SEPA's) regulatory position with regards to development on peat;
- Guidance on peat management before and during the construction phase;
- A list of guidance documents for road construction within peatlands; and
- Information on ground investigation works required to investigate peat.

While the Design Manual for Roads and Bridges (DMRB) does not contain specific information on constructing public highways through peat or on peat management, it is essential that potential impacts on peatlands are considered from an early design stage.

Development of upland areas and peat has increased in recent years, mainly due to the development of wind farms. Typically issues with peat are considered within the following design guidance documents generally used during the detailed design process:-

TABLE 1.1:- PEAT DOCUMENTS	
Document	**Description**
Peat Stability Assessment (PSA)	Assesses the risk of peat slides occurring at the site prior to and following construction and identifies areas within the site at a higher risk of peat instability, thus areas where development should be avoided. Peat probing and coring is required as a minimum to inform the assessment.
Geotechnical Risk Register (GRR)	Usually contained within the PSA as an appendix. A GRR is a tool used as a means of identifying and recording peat conditions and an aid to assessing the risk of peat failure at the specified site. It is a dynamic document, which should be created at an early project stage and updated throughout the GI / construction phase as more information relating to peat becomes available / is measured.
Peat Management Plan (PMP)	A PMP is a tool used to establish how peat excavated during construction will be managed to avoid or minimise disturbance to the peat and to maximise the re-use. It can also provide estimated calculations (based on ground investigation information) of the volume of peat required to be excavated and re-used. Recommended mitigation measures for use during construction are included.

The PSA and GRR may be required to assist in the finalised road alignment. A PMP should be produced once the proposed road alignment has been finalised, at DMRB Stage 3.

It should be noted that this document only discusses the Peat Management Plan appropriate for a Stage 2 Feasibility Study, and no detailed site investigation / peat probing has been carried out / is proposed at this stage. Dealing with peat has been included within the overall project Risk Register.

2. ROUTE LOCATIONS AND GEOLOGICAL CONDITIONS

2.1 Location

The potential realignment options which will allow a stretch of the A890 adjacent to Loch Carron in the Scottish Highlands to be bypassed, consist of three corridors which are generally 1km in width (locally wider).

The routes are centred on Loch Carron and generally connect the A890 at Achmore to the A890 at Strathcarron Junction. The approximate site centre is at National Grid Reference 190891, 838781.

The northern corridor options follow the A890 from Achmore to Craeg Mhaol before crossing Loch Carron to Leacanasigh via a new bridge or tunnel, and then follow an existing road to Strome Wood. The route is then proposed either to continue along the existing road where it joins the A896 at Lochcarron to the Strathcarron Junction; or head northeast and off-line along a new section of road, crossing the A896 to the north of Lochcarron and then continue on the new road between the A896 crossing point and Kirkton, where it re-joins the A896 to the Strathcarron Junction.

The 'online' corridor follows the existing route along the A890 between Stromeferry and the Strathcarron Junction with a proposed upgrade of the existing route, with either an extended avalanche shelter, viaduct / embankment along Loch Carron, localised proposed tunnel or remediated rock slopes.

The southern corridor connects the A890 from Achmore / Braeintra to the A890 at Attadale via an inland diversion through the Glen Udalain, Glen Ling and River Attadale Valleys.

2.2 Geology

Information regarding the geological conditions at the site was obtained from available published geological sheets (Ref. 1) and a peat map (Ref. 2, included in Appendix B) and is summarised below for each of the corridor options:-

1 BGS 1:50,000 Solid and Drift Geological Sheet 81E, Loch Torridon and 82, Lochcarron.

2 URS (2013). *Stromeferry Walkover Survey, Appendix 3: Peat Locations* (Drawing Ref. 47065297 – JB1). Reproduced from BGS Data taken from *http://www.bgs.ac.uk/data/mapViewers/*

TABLE 2.1:- GEOLOGY	
Route Name	**Geological Description**
Northern Route Corridor	Where mapped, the superficial deposits along the majority of the northern corridor are recorded to comprise moraine and undifferentiated drift and some peat, with the exception of the stretch from Kirkton to Strathcarron Junction, which is recorded to be underlain by freshwater alluvia. No indication of the depth of the superficial deposits is given; however they are not consistently mapped across the site indicating that they may be thin or absent. Geological maps record peat in various areas along the route including to the west and northeast of Creag Mhaol in the southwest of the corridor; to the north of Lochcarron in the northern-central section of the corridor; and near the Strathcarron Junction in the northeast of the corridor. Around Stromeferry and Ardnarff the solid strata is changeable with massive and foliated pyroxenic hornblendic and micaceous gneiss affected by post-Cambrian movement; epidiorite and hornblende-schist affected by post-Cambrian movement; and flaggy quartz-feldspar granulite being recorded. Around Stromemore the routes were recorded to be underlain by massive and foliated pyroxenic hornblendic and micaceous gneiss affected by post-Cambrian movement and epidiorite and hornblende-schist affected by post-Cambrian movement. Beyond that, myolonite was recorded up to, and around, Slumbay Island, with the remainder of the routes being underlain by undifferentiated granulitic schists of the Moine Series. The solid strata were generally recorded to dip towards Loch Carron at an unspecified angle.
Online Route Corridor	Where superficial deposits are mapped they are generally recorded to comprise moraine and undifferentiated drift and some peat. Beneath the head of Loch Carron, the superficial deposits are recorded to comprise marine alluvia. No indication of the depth of the superficial deposits is given; however they are not consistently mapped across the site indicating that they may be thin or absent. Geological maps record peat between Stromeferry and Ardnarff in the southwest of the online corridor; surrounding the summit of Cnoc Nam Mult hill in the south of the central section of the site; and around Strathcarron Junction in the north of the corridor. It should be noted that the peat in the southwest and central areas of this corridor are shown on the hillside above the existing road and therefore are unlikely to be impacted on this option unless remediation of the rock slope profile results in rock cuttings up-slope. Peat around Strathcarron Junction may still be impacted on this option. The solid strata vary across the route. Around Stromeferry and Ardnarff in the southwest of the route the strata is particularly changeable with massive and foliated pyroxenic hornblendic and micaceous gneiss affected by post-Cambrian movement; epidiorite and hornblende-schist affected by post-Cambrian movement; and flaggy quartz-feldspar granulite being noted. Along the remainder of the route, granulitic schists of the Moine series are noted to underlie the route. However, the strata immediately to the south of the route along Loch Carron are recorded to comprise acid and hornblendic gneiss, amphibolite; and pelitic gneiss. The recorded dip direction varied from southeast, to east, to northeast. No angle of dip was recorded.

TABLE 2.1:- GEOLOGY	
Route Name	**Geological Description**
Southern Route Corridor	Where mapped, the superficial deposits along the routes are recorded to comprise morainic deposits with some undifferentiated drift and peat. No indication of the depth of the superficial deposits is given; however they are not consistently mapped across the site indicating that they may be thin or absent. Geological maps record peat several extensive areas of peat in the southwest of this corridor. These are typically located around the hill Meall Ailein and to the north and south of Carn na Creige hill. A large area of peat is recorded to extend across the full width of the proposed development corridor to the north of Loch Innis nan Seangan in the south of the corridor. Peat is also recorded at Strathcarron Junction in the north of this corridor. The solid strata were recorded to comprise undifferentiated granulitic schists of the Moine Series, and were noted to dip to the south east at an unspecified angle.

It should be noted that peat is generally only identified on maps where the material is in excess of 1m thick and other areas of unrecorded peat may be present in the proposed route corridors.

3. DEFINITION OF PEAT AND GEOTECHNICAL CONSTRAINTS

3.1 Definition

Peat is a biogenic soil comprising partially decomposed plant remains and organic matter. It exhibits low bulk density and high carbon content which, when fully saturated, can comprise up to 90-95% water with 5-10% solid matter. It can be particularly sensitive to changes in rainfall and subsequent surface and groundwater changes.

Some properties of peat are similar to the behaviours of clay, but due to the extremely high water content of the peat, simple relations with material strength cannot be easily established.

Due to its high compressibility, low tensile strength and degenerative nature, the material is not considered to be a suitable medium for most developments, with some exceptions (such as floating roads constructed for forestry and wind farm developments).

3.2 Geotechnical Constraints Associated with Peat

The following geotechnical constraints are associated with construction within peat and may require consideration when designing the proposed route:-

TABLE 3.1:- GEOTECHNICAL CONSTRAINTS ASSOCIATED WITH PEAT

Constraint	Comments
High compressibility	Results in rapid and unacceptable settlement conditions.
Very low shear strength	The shear strength of peat is dependent on the moisture content and degree of humification (decomposition) of the soil. However, peat typically has a very low shear strength, which affects the stability of the deposits. Due to the variable nature of peat, the difficulties in obtaining acceptable representative samples and difficulties transporting back to a laboratory for analysis without deterioration of the structure of the peat, obtaining meaningful shear strength values is difficult. In addition, in situ field tests also have their limitations. Literature reports a great variation of shear strength for peat, however MacFarlane (Ref. 3) suggests the in-situ shear strength will generally be within the range of 4kPa to 20kPa.
pH & sulphate	pH and sulphate concentrations of the peat could be aggressive to concrete structures in contact with peat and the concrete class will therefore be required to be established throughout the vertical extent of the peat. Peat can be highly variable over relatively short distances (both vertically and laterally) and this should be taken into consideration when considering ground investigation design and testing in peat.
Gas generating potential	Peat can produce high concentrations of gas, which could be a risk to workers during the construction phase or sub-surface structures.
High water content / saturated peat	Deep excavations may require pumping / dewatering.

3 MacFarlane, I.C. (1969). *The Muskeg Engineering Handbook,* National Research Council of Canada.

TABLE 3.1:- GEOTECHNICAL CONSTRAINTS ASSOCIATED WITH PEAT	
Constraint	**Comments**
Stability	Due to the high moisture content and low shear strength, peat deposits can be unpredictable and may result in peat slides / bog bursts. Human activities can increase the risk of instability of peat deposits if not suitably managed and if relevant mitigation measures are not employed during construction.
Excavated peat	Peat can only be reused on-site if there is a specific purpose (e.g. turfs used for landscaping slopes). It may also be possible to re-use peat off-site on schemes where there is a deficit of landscaping material. However this would require to be approved by SEPA and the Local Authority. The remaining excavated peat is waste and requires to be taken to an offsite registered landfill.
Low internal angle of friction	The low friction angle of this material means that it can be unstable even at relatively shallow angles. This has to be taken into consideration when designing cut slopes through peat or using peat to dress cut / fill slopes.

4. AVAILABLE GUIDANCE DOCUMENTS

4.1 Available Guidance Documents

The Design Manual for Roads and Bridges (DMRB) does not contain specific information on constructing public highways through peat.

A number of sources of information relating to best practice construction methods and peatland surveys for forestry roads and wind farms are available. Although these may not be directly related to the construction of public roads, following the relevant methodologies, procedures and employing mitigation measures relevant to the development and construction activities should reduce risks to the environment and human health and reduce costs during the construction phase, subject to acceptance by the overseeing highways authority. These sources are as follows:-

- *Guidelines for the Risk Management of Peat Slips on the Construction of Low Volume / Low Cost Roads Over Peat* (Ref. 4);
- *SEPA Regulatory Position Statement – Developments on Peat* (Ref. 5);
- *Floating Roads on Peat* (Ref. 6);
- *Good Practice During Wind Farm Construction* (Ref. 7);
- *Guidance – Developments on Peatland: Site Surveys* (Ref. 8).
- *Developments on peatland: guidance on the assessment of peat volumes, reuse of excavated peat and the minimisation of waste* (Ref. 9).
- ROADEX Network website (Ref. 10).

4 Forestry Civil Engineering (January 2006). *Guidance for the Risk Management of Peat Slips on the Construction of Low Volume / Low Cost Roads Over Peat.*

5 SEPA (February 2010). *SEPA Regulatory Position Statement – Developments on Peat.*

6 SNH and Forestry Commission Scotland (FCS) (August 2010). *Floating Roads on Peat.*

7 Scottish Renewables, Scottish Natural Heritage (SNH), Scottish Environment Protection Agency (SEPA) and FCS (October 2010). *Good Practice During Windfarm Construction.*

8 SNH, SEPA, Scottish Government and James Hutton Institute (August 2011). *Guidance – Developments on Peatland: Site Surveys.*

9 Scottish Renewables and SEPA (2012). *Developments on peatland: guidance on the assessment of peat volumes, reuse of excavated peat and the minimisation of waste.*

10 http://www.roadex.org/

5. OPTIONS FOR ROAD CONSTUCTION

Section 3 of this document demonstrates that peat is not generally considered a suitable medium for the construction of foundations and roads either within, or above, due to its highly compressible and degenerative nature. The DMRB (which provides official standards, advice notes and other documents relating to the design, assessment and operation of roads in the UK) does not contain specific guidance on constructing public highways through peat.

There is support for the construction of floating roads over peat for 'low volume' roads, typically consisting of temporary private roads constructed on forestry and wind farm sites (Ref. 4, 6, 7 & 10), largely due to the reduction of the carbon off-set for these environmentally sensitive projects. However this is generally not considered to be a suitable option for the construction of public highways as the variable, unpredictable loadings could result in floating sections sinking, cracking or failing completely and therefore require regular inspection of the condition and repair of sections susceptible to settlement.

Furthermore, this could result in unacceptable and dangerous driving surfaces and for these reasons is generally not considered an appropriate option for the construction of public roads.

The method of construction is typically site specific and selected following the detailed design stage. The method of construction may also depend on Contractor design and approach to risk. However, potential options for the construction of roads, along with an assessment of the suitability of the option are provided in Table 5.1 below:-

TABLE 5.1:- CONSTRUCTION TECHNIQUE		
Technique	**Options**	**Comment / Considerations**
Avoid areas of peat	The most favourable (and possibly cheapest) approach would be to obtain sufficient ground investigation information to design the road alignment to avoid areas of peat (where possible). Total avoidance may not be possible, but robust GI information should help to avoid the deepest peat and therefore minimise disturbance to the peat.	Robust GI required to delineate the extent of peat (both vertically and laterally across the routes) to assist in the design of the best route. See Section 9 for more details. **Avoidance of peat / avoidance of deepest areas of peat (where possible) is considered the best option. It is advised that this is considered in the design of the road at the detailed design stage. It is understood, however, that other considerations (such as ecological, ornithological, visual impact, etc.) will also be required to be taken into account when considering the proposed route.**

TABLE 5.1:- CONSTRUCTION TECHNIQUE		
Technique	**Options**	**Comment / Considerations**
Excavate peat	Remove all peat and any other organic, soft or otherwise unsuitable material from beneath the proposed road and embankments and replace with suitably compacted granular fill up to the proposed road level.	The total volume of peat to be excavated will require consideration. Cognisance will also be required of the possibility of other organic, soft or otherwise unsuitable material beneath the peat, the extent of the embankments and excavation carried out at an angle such that instability of the peat is not an issue. Drainage design may require approval from SEPA and should demonstrate that the use of free draining material shall not cause excessive drainage of some areas and oversaturation of other areas. It may also need to demonstrate that it will not affect the hydrology of raised bogs / blanket bogs / wetlands. Proposals for the on-site re-use of peat will require approval from SEPA (See Section 6.3). Waste peat shall require to be disposed of. SEPA should be contacted in this regard (See Section 6.5). On-site management of excavated peat is detailed in Section 7.4. Gas generation of the peat may be an issue for personnel working within excavations. Gas monitoring will be necessary before and during construction. Although Contractors views may differ, and site specific conditions will likely be of influence, an arbitrary depth of 5m for initial costing purposes can be considered as the maximum depth to which a Contractor will excavate. **Excavation of peat and founding the road directly on top of suitable underlying or imported material is considered to be an option. However, consideration of the re-use of excavated peat on-site will be required to minimise waste peat being taken to an off-site landfill and therefore minimise the environmental impact of the proposed scheme.**

TABLE 5.1:- CONSTRUCTION TECHNIQUE		
Technique	**Options**	**Comment / Considerations**
Piling	Piles are used to transmit loads through soil strata of low bearing capacity to deeper soil or rock strata having a high bearing capacity.	Piles are commonly used for road projects. They will reduce the volume waste peat produced during construction and minimise the disturbance to the peat. **Piles are considered to be a suitable option for constructing peat over deeper areas of peat (generally where peat is in excess of 5m), where avoidance of deeper peat is not possible. The requirement for piling can be specific to the ground conditions and Contractor methodologies.**
Floating	Floating roads over the peat using geotextiles to spread the load of the road and traffic.	Typically used in low volume traffic, private or temporary roads. Highly compressible peat along with variable loadings of the proposed road are likely to result in settlement / cracking / failing of the road and therefore unsafe driving conditions. On-going inspections and maintenance works would be required. **Floating roads method of construction has generally not considered to be suitable for public roads given these limitations.**

TABLE 5.1:- CONSTRUCTION TECHNIQUE		
Technique	**Options**	**Comment / Considerations**
Vibro-replacement	*Vibro-stone columns:-* Vertical boreholes drilled into the ground and filled upwards with gravel compacted by means of a vibrator.	For soft soil layers of less than 4m or in excess of 20m, other techniques are likely to be more effective. In very soft soils (c_u <15kPa) stone columns are not applicable due to the lack of lateral support of the soil. As stated in Section 3.2, the shear strength of peat is generally between 4kPa and 20kPa and can vary considerably over short distanced both vertically and horizontally. Vibro-replacement is therefore not likely to be achievable through peat. Because of the high compressibility of peat and organic soils, little lateral support may be developed and large vertical deflections of the columns may result. When the thickness of the organic layer is greater than 1 to 2 stone column diameters, vibro-replacement should not be used. The lack of lateral resistance associated with the very soft soils may result in the column displacing into the peat and therefore be rendered unsuitable for use. **Vibro-replacement methods are generally not considered to be a suitable option for ground improvement through peat.**
	Vibro-concrete columns:- Using a special auger, grout is added to the gravel of the columns. Thus, the column stiffness and resistance is higher.	

In summary, the avoidance of peat is considered to be the best option where this is possible. Where it cannot be avoided, excavation of peat and founding the road on suitable underlying / imported material may be considered. The depth of excavation will depend on a number of factors (such as the design of the road and the Contractor) however an arbitrary maximum depth of 5m excavation may be considered appropriate at this stage. Beyond a depth of 5m, a piled solution may be considered.

It should be noted that a combination of suitable construction methods may be required across the length of the development for all options.

6. THE WASTE HIERARCHY

6.1 General

The definition of waste given in the Waste Framework Directive (75/442/EEC) is: *'any substance or object in the categories set out in Annex 1 which the holder discards or intends or is required to discard'*.

Where potential re-use options for peat have been identified at a site, the excavated peat is not always suitable for the proposed uses (for example due to instability / slide risk; peat may be too liquid for re-use; re-use option may not demonstrate an ecological benefit to the area; etc.). In such cases, peat may be regarded as a waste in law, meaning regulatory controls must be applied to its storage, treatment recovery and / or disposal.

Article 4 of the Revised Waste Framework Directive introduces the waste hierarchy which is to be applied as a priority order in waste prevention and management legislation and policy.

The waste hierarchy is as follows:-

1. Prevention;
2. Preparing for re-use;
3. Recycling;
4. Other recovery e.g. energy recovery; and
5. Disposal.

Where peat does not have a genuine, identified and legitimate re-use, it is likely that the peat will be classified as a waste material. Decisions on whether a particular substance, object or material is a waste must be considered on a case by case basis.

6.2 Prevention

Preventing the disturbance to peat can be managed by designing the proposed road alignment adequately. Following the *'Guidance – Developments on Peatland: Site Surveys'* guidance note (Ref. 8), this may involve a phased ground investigation approach, usually carried out at DMRB Stage 3, once the preferred route corridor is identified, as follows:-

Phase 1

Peat probing across the corridor on a 100m grid. This will allow a peat contour plan to be created, which will help to identify thicker areas of peat to avoid and assist the development of a preliminary route alignment.

Phase 2

Additional targeted peat probing and coring along the proposed road alignment at 50m centres along the preliminary route alignment and either side within a micro-siting corridor. This more targeted probing / coring will help to micro-site the route alignment. The phase 2 peat survey can be carried out at the same time as the detailed ground investigation for design, but should be noted that any micro-siting of the road alignment may require further ground investigation to be carried out.

A phased approach as outlined above should provide comprehensive information on the peat conditions at the site.

Compilation and use of a site specific Site Waste Management Plan (SWMP) can also help to reduce peat disturbance, as well as the production of a Peat Management Plan (PMP).

Where thick peat deposits are unavoidable, suitable construction techniques (such as piling) may be an option to minimise peat disturbance.

6.3 Re-use

Developers should attempt to re-use as much peat as is possible. Re-use strategies for excavated peat should be identified and SEPA should be consulted on any proposed re-use activities to determine whether these should be classified as waste activities and what regulatory requirements are associated with the proposals (e.g. exemptions, permits, etc.).

SEPA will seek to ensure that there are no risks to the environment or human health associated with the proposed activities.

The fact that materials have a potential re-use within the site boundary is not sufficient in itself to say that they are not waste. For example, where there is no justified requirement or demonstrable need for the peat to be used or it is clearly not suitable for the intended use, it will likely be classed as a disposal operation and the proposed activity will require authorisation from SEPA accordingly.

Examples of where peat may be re-used on a site include (following approval from SEPA, SNH, Local Authority, etc. as required):-

- Restoration of road edges, embankments and cut slopes (to reduce the visual impact of the construction works). This will generally be limited to the use of the peat turves and upper acrotelmic material and will not general fall under waste management controls as the peat turves would not be classified as waste in these circumstances.
- Drainage ditch blocking as part of restoration proposals for raising water tables to restore blanket or raised bog, carried out in accordance with existing guidance and advice from SNH.
- Used to cover the base of borrow pits once quarrying has ceased. The developer must, however, demonstrate that the use of waste peat will have an ecological benefit. A waste exemption may be applicable in this case.

The re-use of waste peat shall not be permitted in the following circumstances:-

- To create excessive ‘shoulders’ on road edges or cut slopes.
- Spreading across existing vegetation or recently felled areas of woodland as there is no ecological benefit and smothers the existing vegetation.
- To fill borrow pits (unless carried out under a Pollution Prevention and Control (PPC) Permit – see *Disposal* section below).

6.4 Recycling / Recovery / Treatment

Examples of recycling / recovery / treatment of waste peat include the following:-

- Use as a fuel for personal or commercial purpose;
- Use as a compost / fertiliser; and
- Stabilisation of waste peat by mixing with other substances (such as cement binder). However there can be environmental disadvantages to this option.

These activities will likely require approval from SEPA.

6.5 Disposal

Where none of the above options is practicable and waste peat is identified at the site, the only remaining option may be disposal.

Any intention by the developer to dispose of waste peat, for example, into an on-site borrow pit, will require a PPC Landfill Permit.

Another disposal option available to developers is disposal of waste peat at a commercial, permitted landfill off-site. This option would require the developers to take into consideration landfill tax, transport costs, etc.

If the peat loses much of its integral structure, it may be classed as a 'liquid waste'. If this occurs, SEPA would not issue a PPC Permit for either on-site or off-site disposal without some form of pre-treatment.

Where there is no justified requirement or demonstrated need for peat to be re-used or where the peat is unsuitable for the intended use it is likely to be classified as a waste and any activity involving it classed as a disposal activity.

SEPA should be consulted on any disposal proposals at as early a stage as possible.

7. PEAT MANAGEMENT GUIDANCE

7.1 General

On sites where significant peat is proposed to be excavated and re-used or otherwise disturbed, a Peat Management Plan (PMP) should be created to identify the methodology of excavation and outline the proposed re-use options. The document should provide site specific information on peat conditions at the site (such as thicknesses, morphology and descriptions from ground investigation, etc.), approximate volumes of peat that may be excavated during the construction operation, how the peat will be handled, and where the peat will be reused, if anywhere.

The following sub-headings provide some information on the PMP and mitigation measures. However, additional information should be collected and used to create and compile a site specific PMP prior to the construction phase.

7.2 Note on the Classification of Peat

Peat generally consists of two distinct soil layers: the upper acrotelm and the underlying catotelm.

The acrotelm is the upper layer in which water table fluctuations generally occur. Its thickness usually varies between 0.3 m and 0.5 m, depending on the habitat (some literature quotes thicknesses of up to 1m).

The catotelm is the lower layer of peat that is permanently below the water table. Under these anaerobic conditions, microbial activity and peat decomposition is very slow. The catotelm comprises relatively decomposed compacted peat, and water movements are slow.

To further categorise peat, the 'von Post' scale of humification provides guidance on how to classify peat based on the degree of decomposition (ranging from H1 (completely undecomposed) to H10 (completely decomposed)). It also provides a visual field description of water content (B1 (very low moisture content) to B5 (very high moisture content)).

Information should be collected on the morphology of peat during the ground investigation phase. This information should be supplemented with additional information collected during the construction phase, which can be fed into a Geotechnical Risk Register (GRR) as the construction works progress.

7.3 Peat Conditions

Peat conditions should be determined through a site walkover and ground investigation information. Information on recorded peat thickness and morphology of the peat together with any laboratory test results for the peat should be reported within the PMP.

It should be noted that peat can be highly variable in nature and can vary considerably in thickness and characteristics across relatively short distances, both vertically and laterally.

Within areas of deeper peat, the soils are likely to have generally higher moisture content and layers of fibrous through to amorphous peat may be present within the soil profile.

Information from the ground investigation will allow a peat thickness plan to be created to give an indication of peat thicknesses along the corridor routes and would assist in the final design layout.

7.4 Excavation and Reuse Volume Estimates, and Reuse Requirements

7.4.1 *Peat-generating Activities*

The following activities are may generate volumes of peat and / or disturb the peat during the development of this project:-

- Excavations for the road alignment;
- Construction of road embankments / cuttings;
- Construction of parking laybys and viewpoints;
- Service trenches;
- Drainage systems; and
- Piling construction methods.

7.4.2 *Estimated Peat Volumes Generated*

An estimate of the volume of peat that may be excavated should be calculated. This should use ground investigation information obtained along the route in the calculations. The calculations should provide estimated volumes of acrotelmic and catotelmic peat as well as the overall volume of excavated peat.

It should be noted that the volume that will be provided will only be an estimate based on the average peat thickness between probe locations and topography over the length of the proposed road.

7.4.3 *Use of Peat in Borrow Pit Restoration*

Should borrow pits be used to win aggregate for the development of the road (as opposed to importing rock from a local quarry), peat may be re-used within borrow pits for the purpose of their restoration. However, the method of re-use and final restoration profile must be in keeping with the overall habitat, environmental reinstatement objectives and requirements at the site and present no residual risks from pollution to the environment or harm to human health.

Restoration should be carried out in a manner that promotes re-growth and prompt re-generation of the peat used for reinstatement. Methods should include placing acrotelmic material at the surface, turf-side up. Re-seeding may be carried out if approval is given by the site Ecologist prior to undertaking, to ensure that an appropriate seeding mix is used and is in keeping with the surrounding habitats.

All necessary measures, such as periodic wetting, should be carried out to prevent desiccation of the peat, which leads to carbon loss.

Only the quantity necessary for landscaping / peatland restoration should be used and the use of excessive volumes should be avoided.

Containment should be assessed to ensure that peat used in the restoration of borrow pits will not slide / creep from the location of placement. Potential environmental receptors downslope of the borrow pits due to be restored should be identified.

Care should be taken in the transportation and placement of peat so as to not cause unnecessary degradation to the peat. If the peat loses much of its integral strength and degrades into a ‘liquid’ form, treatment will be required prior to re-use.

The thickness of peat within the borrow pit restoration will not exceed 1m at any point within the borrow pit.

As noted in Section 6, the proposed re-use of peat at borrow pits will require to be approved by the relevant regulators, such as SEPA, THC and SNH, before being carried out and it is advised to consult with them at as early a stage as possible.

7.4.4 *Use of Peat for Other Purposes*

Consideration should be given to all potential re-uses for peat in accordance with current guidance and best practice.

In terms of the potential peat re-use options (in addition to re-use within borrow pits), the following options may be suitable:-

- Reinstatement of road verges, cut slope faces and embankments; and
- Restoration of degraded raised bogs (an Ecological survey would be required to identify areas, if any, where this would be an option).

Any proposals for the re-use of peat will require to be approved by SEPA, SNH and THC before being carried out. It is also recommended that a site Ecologist is consulted before and during the construction works.

Where an excess of peat exists, the excess may be required to be taken off-site and into landfill.

7.4.5 *Handling Excavated Materials*

The following should be considered when handling peat:-

- Where cut-and-fill techniques will be used, superficial materials, including peat / peaty soils should be excavated out to a suitable bearing strata. Superficial materials should be separated carefully during excavation, to keep peat (and peaty soils) and other soil materials (e.g. weathered rock, gravels and clays) apart. Turves of peat (approximately 0.3m to 0.5m thick) should be cut and stored temporarily nearby, where possible. These peat turves may then be used to re-vegetate side slopes (turves shall be placed vegetation-up).
- Where peat is in excess of 0.5 m thick, the acrotelmic and catotelmic materials shall be separated, with the acrotelmic material being retained for surface *in-situ* reinstatement. No catotelmic peat is to be used at the surface.
- Care should be taken when excavating peat to ensure that the acrotelm and catotelm layers are not mixed during stripping and storing.
- Handling peat can cause the internal structure to deteriorate and therefore make it more of a hazard when stored. It is therefore recommended that haulage distances should be kept to a minimum. Ideally, peat should be used as close to where excavated as is practical.
- The removal of peat from the site is considered to be the least desirable environmental option, and should be avoided if at all possible.
- The principal contractor will be required to implement all necessary pollution prevention and drainage measures prior to commencement of any works on site.

7.4.6 *Temporary Peat Storage*

The following should be considered by the principal contractor (once appointed) when storing peat:-

- Where peat is excavated for road construction, the upper acrotelm will generally be able to be side-cast until the track has been constructed and then pulled back over to dress any exposed cuttings.
- When peat is required to be stockpiled for longer periods of time, it is best practice to stockpile on ground that does not consist of peat. Areas of ground covered by only a thin layer of peat should be scraped away prior to use as a storage area, so that the peat is stored directly on the underlying superficials / rock. When peat is required to be stockpiled directly on deeper peat accumulations, these areas are required to be fully risk assessed, documented in a GRR and agreed between the local authority, Geotechnical Technical Advisor and Ecologist. No peat should be stored on marginally stable ground or on any other area identified as 'at risk'.
- Where possible the peat should be excavated, stored and reused as turves. If this is not possible, the peat should be re-seeded with a seed mix sympathetic to the local plant life when it is re-used.
- It is considered best practice to place the catotelm down first and to carefully lay the acrotelm (vegetated-side up) on top. This will help promote growth and reduce drying out.
- Peat should not be stockpiled above a height of 2.0m, as this can lead to stability issues within the peat stockpile itself and on any underlying peat. The approximate height of peat stockpiles should be recorded on the GRR to ensure that this is monitored.
- Peat stockpiles should be stored with as shallow a side slope as possible, but no steeper than 1:4, due to the low internal angle of friction of peat soils. This will reduce the likelihood of peat stockpile side slopes from slumping / failing. The angle will depend on the nature of peat being stored.
- Peat should be stored and reused as close to the source of excavation as possible to reduce the haulage distance.
- Due to the programming of the works there may be a need for the temporary storage of peat spoil prior to its final deposition. Peat should generally not be stored for more than 3 months.
- To maintain the integrity of the peat while it is in storage it may be necessary to water it, particularly during hotter, drier months. Wherever possible, water should come from a local source (abstracted and piped / transported from a stream nearby (with necessary approvals)). Care should be taken to water the peat with a fairly fine spray to avoid run-off and / or oversaturation.
- Cut-off ditches and suitable treatment systems such as settlement ponds should be constructed where peat stockpiles are constructed. This will ensure that leachate and sediment from the peat will not reach a watercourse.
- Where peat is to be re-used in large quantities, consideration should be given to the placement of catotelmic materials in layers to the bottom of the excavation, with the more competent acrotelmic materials to the top.

Generally the Principal Contractor will be responsible for acquiring all necessary permits. Storage of peat will require a Waste Management Licence as a minimum and potentially a PPC Permit.

7.4.7 *Estimated Peat Volumes for Re-use*

An estimate of the volume of re-usable peat should be included within the PMP.

Peat re-use volume may vary from those quoted in the PMP during the construction works, depending on local variations in peat thickness and the quality of peat, and taking cognisance of the construction methods adopted during the works. However, minor changes in peat volumes can be easily incorporated into the works during the construction period.

8. MITIGATION MEASURES

To reduce disturbance to peat and minimise waste peat generation, the following mitigation measures should be implemented. It is recommended that the principal contractor is aware of these measures when working on site.

Prior to confirming final road alignment

- Sufficient ground investigation information is collected to allow the preparation of a peat contour plan to assist in the final alignment design and the compilation of a PMP (and PSA and GRR).
- The road alignment should be positioned in areas to avoid where peat is thickest.

During Detailed Design

- The drainage design will need to ensure that the hydrological regime is not significantly altered to the detriment of the peat on site.
- Consideration should be given to the use of peat as restoration / reinstatement material for road verges / cuttings where appropriate.

During Construction

- Stockpiles of peat will be used for reinstatement purposes as soon as possible to avoid drying out of peat;
- Peat haulage distances will be kept to a minimum and reuse of peat should take place as near to the site of excavation as possible;
- The upper turves of peat will not be mixed with the underlying catotelm and the turves will always be placed on top, vegetated-side-up, to encourage growth and rapid recovery;
- Stockpiles of peat can be no more than 2m in height, and should be placed away from any areas of *in situ* materials known to be unstable;
- Stockpiles of peat will be positioned a minimum of 10m from any watercourse (approval may be required from site Ecologist and / or SEPA);
- All mitigation measures applicable to construction will be monitored regularly to ensure they continue to be effective;
- The condition of all stockpiled peat materials will be monitored regularly and watered as appropriate to prevent desiccation of the peat soils;
- All areas of reinstatement / restoration, will be monitored and reviewed regularly to establish the success (or otherwise) of such measures, and to implement any recovery strategies as appropriate.

Other Measures

- On-going assessment of ground conditions will be undertaken during construction; the results of this will be input into a GRR. If a risk of peat failure is identified, monitoring of ground conditions using suitable geotechnical instrumentation (e.g. inclinometers, etc.) as recommended by the approved geotechnical personnel should be undertaken.

- When finalising the detailed design it is recommended that there are consultations between all relevant parties in relation to peat management at the site (e.g. Principal Contractor, Ecologist, Geotechnical Technical Advisor, Highways Authority, SEPA, SNH). This will ensure that contingencies can be planned and agreed to ensure site works can progress with minimal disruption due to unforeseen events.

9. FURTHER WORKS

In order to assist in the detailed design of the scheme layout and construction methods through areas of peatland, sufficient ground investigation works shall be required. The ground investigation will not only allow a PMP for the site to be produced, but will also inform and be used within the PSA and GRR. This should be done once the preferred route option corridor has been selected.

As DMRB does not provide guidance on peat, it is advisable to carry out peat probing where peat is likely to be present at DMRB Stage 3, following a similar phased approach as is recommended in the *'Guidance – Developments on Peatland: Site Surveys'* document (Ref. 8) as outlined below:-

Phase 1 – probe the areas on a schematic 100m^2 grid within the route corridor. This will allow a peat thickness contour plan to be produced which can be used for the initial conception layout.

Phase 2 – following the design freeze, probes at 50m centres along the centreline of the proposed route and at approximately 25m either side of the centreline (depending on agreed micro-siting corridor). Approximately 10% of the probed locations should be cored (using Russian Peat Coring equipment) to allow samples of peat to be obtained for logging and testing. This will allow micro-siting of the alignment to avoid deeper pockets of peat.

Note:- Peat probing should be carried out using Mackintosh probes and the full depth of peat should be probed.

The first phase of probing allows an initial road alignment to be designed, which avoids the deepest areas of peat, and therefore reduces the overall disturbance to the peat. The second more targeted phase of peat probing allows the initial road alignment to be micro-sited, where required.

It is proposed that any ground investigation for the detailed design of the proposed development includes allowance for intrusive investigation of the peat soils. The aim of the intrusive peat investigation works will be to obtain a better understanding of the nature of the peat soils as well as groundwater conditions beneath the site.

The investigation should include (as a minimum) the following elements:-

- Machine excavated trial pits for detailed examination and logging of peat soils;
- Window sample probe holes or boreholes to obtain information on the deeper peat deposits and the nature of the peat / substrate boundary;
- Installation of standpipes for groundwater monitoring; and
- Laboratory testing of peat soils including undisturbed samples if possible.

The phase 2 probing can be carried out at the same time as the ground investigation for detailed design (DMRB Stage 3). However, it should be noted that additional ground investigation may be required if significant micro-siting of the road alignment takes place. Information collected from the peat probing (and coring) and ground investigation should be used to compile a PMP (and PSA and update the GRR) for the site.

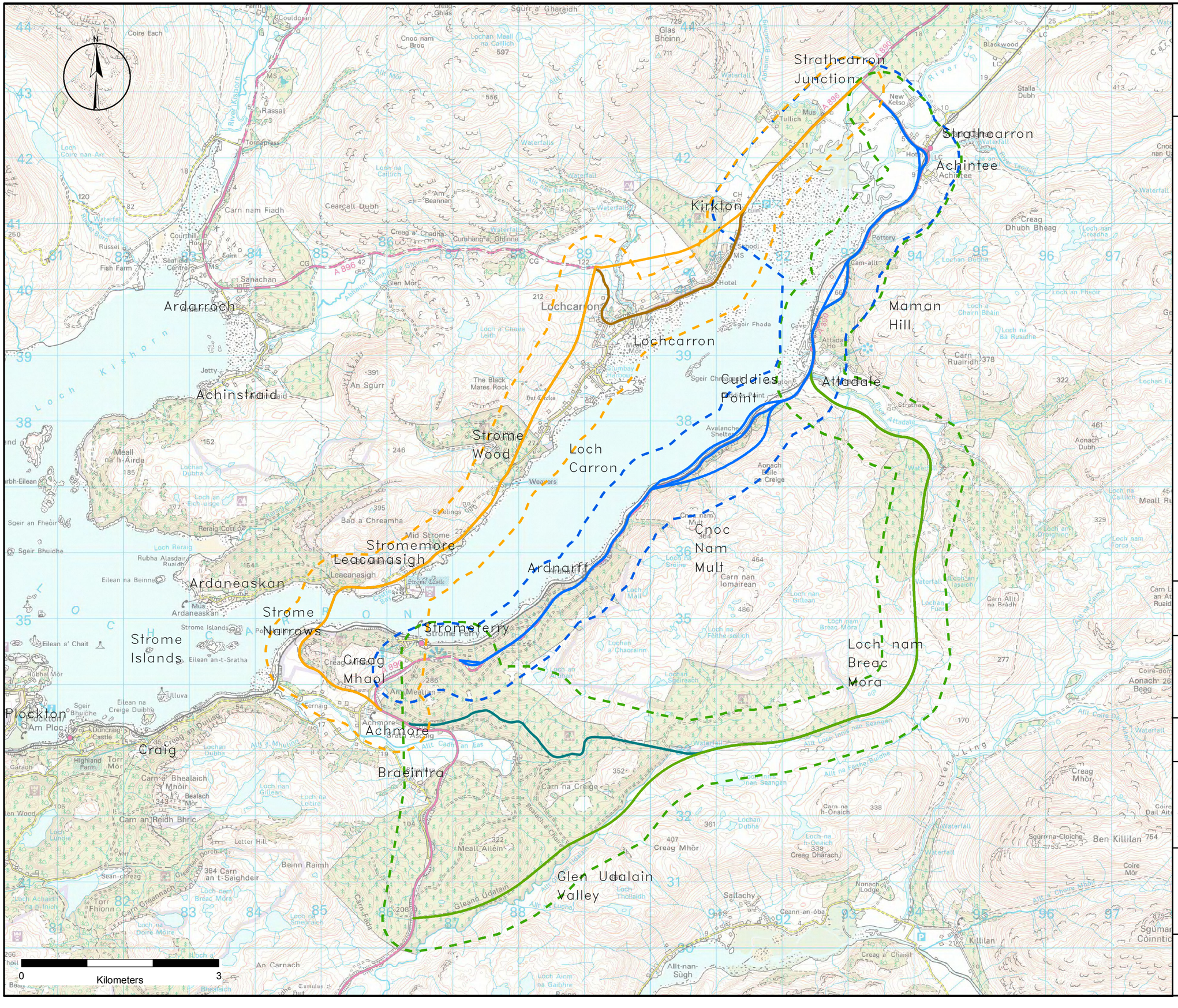
10. CONCLUSIONS

A summary of the conclusions are as follows:-

- Peat is an organic deposit that exhibits low bulk density, high carbon content, high water content, high compressibility and low tensile strength. Due to these limitations, it can be a difficult material to work with and should be managed appropriately.
- Peat is recorded on geological maps at discreet locations within all three corridor options and will require careful consideration for the chosen option during the detailed design stage.
- The DMRB does not contain specific information on construction roads through peat or on peat management. However, following documents relating to best practice construction methods for forestry roads and wind farms should reduce risks to the environment and human health and reduce costs during the construction phase.
- Various options for the construction in areas of peat have been discussed within this Technical Note; however the following options may be considered the most appropriate:-
  - *Avoidance of peat.* This is considered the best option wherever possible. It is recognised that total avoidance may not be possible.
  - *Excavation of peat.* Where it cannot be avoided, excavation of peat and founding the road on suitable underlying / imported material may be considered. The depth of excavation will depend on a number of factors.
  - *Piled solution.* Should the peat be considered too deep for excavation, a piled solution may be considered.
- Alternative solutions for construction of roads over peat, which have been applied to low volume or temporary roads elsewhere, such as floating and displacement techniques, may offer benefits to cost (although possibly only in the short term) and environmental impact. The limitations of these construction techniques would require careful consideration by designers, contractors and the Client.
- A combination of suitable construction methods may be required across the length of the development for all options.
- To assist in the design of the road layout and construction options, a phased peat probing / coring exercise should be undertaken along the chosen route option at DMRB Stage 3. Ground investigation works for the detailed design of the road should also collect information on peat.
- Where excavation of peat is proposed, careful consideration for the re-use of peat should be carried out and proposals discussed with SEPA. If no acceptable re-use options are identified, or if there is surplus peat following re-use of the material, it may be considered waste and disposal may be required. SEPA should be consulted on any disposal proposals.
- A matrix outlining proposed construction methods could be developed, based on various peat conditions recorded during the detailed ground investigation; such as peat thickness, peat morphology, length of section of road to be constructed through the area of peat, etc.
- A Peat Management Plan should be prepared (at DMRB Stage 3) which provides details on the peat conditions at the site, estimated volumes of peat generated, re-use proposals,

storage and handling of the material and mitigation measures to reduce the disturbance and minimise the generation of waste peat.

APPENDIX A - PRELIMINARY ROUTE OPTIONS PLAN



URS

Key:

- Northern Routes Surveys Corridor (500m) — *Environmental Surveys*
- North Shore Route
- North Shore Alternative Route
- Online Routes Surveys Corridor (500m) — *Environmental Surveys*
- Online Routes
- Southern Routes Surveys Corridor (500m) — *Environmental Surveys*
- Southern Route
- Southern Alternative Link Route

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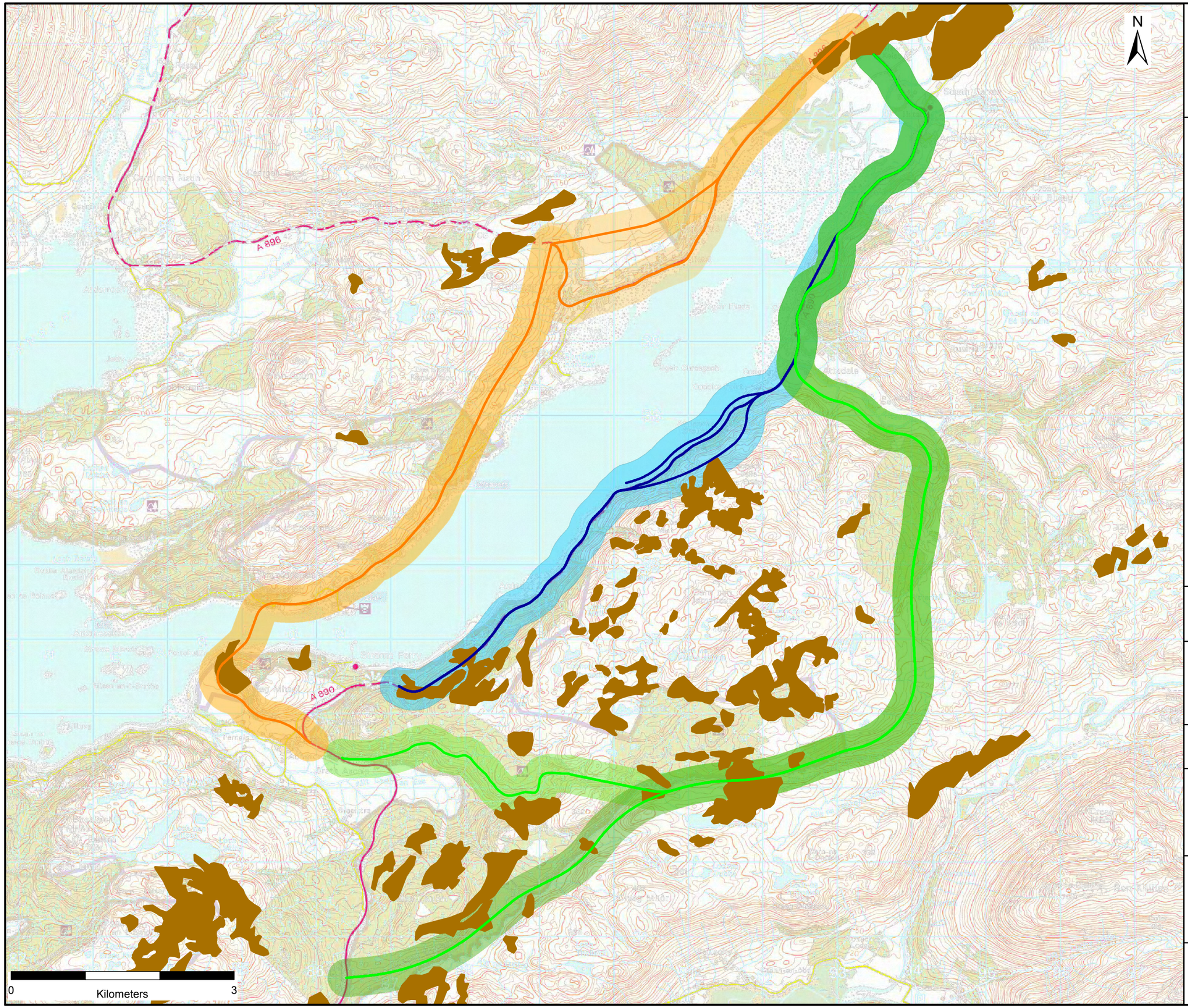
Title: Appendix 1: Survey Corridors

Drawing Number: 47065084 - APP1

Stromeferry Walkover Survey

APPENDIX B - PEAT LOCATIONS PLAN



URS

Legend

- North Shore Routes
- Southern Routes
- Online Routes
- North Shore Route 250m buffer
- North Shore Alternative Link Route 250m buffer
- Southern Route 250m buffer
- Southern Link Route 250m buffer
- Online Routes 250m buffer
- Peat (Reproduced from BGS Data)

Taken from http://www.bgs.ac.uk/data/mapViewers/

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Appendix 3: Peat Locations

DWG 47065297 - JB1

Stromeferry Walkover Survey