Viking Energy Partnership

Viking Wind Farm

Technical Appendix 14.4
Estimated Peat Extraction Volume and Potential Reuse Options

March 2009

Viking Energy Partnership
The Gutters Hut
North Ness Business Park
Lerwick
Shetland
ZE1 0LZ

Mouchel Ltd
Unit 11, Scion House
Stirling University Innovation Park
Stirling
FK9 4NF
Tel. 01786 449 131
Fax. 01786 449 852

FINAL ISSUE	Name	Signature	Date
Prepared by	Malcolm Macfie		04/03/2009
Checked by	Stuart Bone		10/03/2009
Approved by	Malcolm Macfie		12/03/2009

CONTENTS

LIST OF TABLES

APPENDICES

See Environmental Statement Volume 4b for A3 Figures

This Report is presented to Viking Energy Partnership in respect of the Viking Wind Farm and may not be used or relied on by any other person or by the client in relation to any other matters not covered specifically by the scope of this report.

Notwithstanding anything to the contrary contained in the report, Mouchel Ltd is obliged to exercise reasonable skill, care and diligence in the performance of the services required. Viking Energy Partnership and Mouchel shall not be liable except to the extent that they have failed to exercise reasonable skill, care and diligence, and this report shall be read and construed accordingly.

This report has been prepared by Mouchel. No individual is personally liable in connection with the preparation of this report. By receiving this report and acting on it, the client or any other person accepts that no individual is personally liable whether in contract, tort, for breach of statutory duty or otherwise.

1 INTRODUCTION

This report forms a Technical Appendix to Chapter 14 (Soil and Water) of the Environmental Statement for Viking Wind Farm (Mouchel, 2009a) and should be read with reference to this chapter.

Viking Energy is currently progressing plans for a wind farm on the north Shetland Mainland, centred at the settlement of Voe, approximately 27km north of Lerwick. The area of interest is divided into four quadrants, two to the east and two to the west of the A970 route, as shown in Figure 14.4.PER01 (in Volume 4b)

The altitude ranges from sea level (0m AOD) at Aith Voe and Olna Firth to the Scalla Field peak of 281m AOD.

The western area (Delting Quadrant and Kergord Quadrant) of the site is dominated by a number of steep ridges and associated valleys, with the eastern side (Collafirth Quadrant and Nesting Quadrant) consisting primarily of rounded hills.

There are a number of watercourses draining the site. The major streams tend to run north–south or south–north due to the topography of the area. Lochs and lochans are found on hill tops, on plateaux and in valleys.

There are a number of residential properties within the site. These tend to be situated close to the boundaries of the four quadrants.

The predominant land use across the site is upland moor, used for rough grazing. Surrounding land uses include crofting and aquaculture, including mussel, oyster and salmon farming around the coast. Sullom Voe Oil Terminal is located approximately 3km north west of the Delting Quadrant.

The construction process for the development is planned over five years, with work taking place from early spring to late autumn. Civil engineering work will be carried out in years 1 to 4, with turbine installation occurring in years 3 to 5.

During the construction process, significant excavations are required for turbine bases, cut and fill roads, hardstanding and other infrastructure. This will inevitably result in a large excavated volume of peat. There are a number of opportunities for peat to be reused, for instance in the reinstatement of borrow pits and along the road margins, but this is unlikely to provide sufficient for the total excavated volume.

The primary objective at this stage is that the volumes of peat that will be excavated and the capacity to reuse the peat should be estimated so that the balance is known, at least in broad terms. By doing this, appropriate storage techniques and other mitigation can be considered and a best practice approach agreed in advance of any excavation taking place. To do this requires the access track construction type (floating or not) to be determined and associated volumes computed from recorded or extrapolated peat depths. A similar exercise is required for the turbine bases, hardstanding areas, compounds, substations and borrows pits.

The issue of peat storage and use is critical, as inappropriate storage may result in sediment transport and wash out. Also, poorly located loads could conceivably have an adverse impact on peat stability. The identification of peat storage locations and peat disposal locations can only sensibly follow from the results of the volume calculations referred to above. Other considerations may include haul distances and identification of other safe locations if borrow pits are insufficient, or not the only locations to be used for peat disposal / storage.

The suggestion by Scottish Environment Protection Agency (SEPA) that peat reused to landscape borrow pits might require licensing under the *Pollution Prevention and Control (Scotland) Regulations 2000* (known as PPC) has been noted. The licensing requirement will be dependent on a range of factors, including the need for restoration, environmental risk, etc, and also in part, on the deposition depth of peat within the borrow pits or indeed elsewhere. It has been accepted by SEPA for previous wind farm projects, including the proposed Muaitheabhal Wind Farm on the Isle of Lewis, that backfill of peat for reprofiling of around 1.2m depth can safely be classified as restoration, while more excessive use of peat may be considered as a waste management issue.

Until the estimated volume of excavation is known the final excavated profile of the borrow pits is undetermined. However, a reasonable judgement on the excavated volume and extraction profile for the borrow pits can be found in Technical Appendix 14.2 – Borrow Pit Assessment (Mouchel, 2009b), with an extract provided in Table 6.

2 STAKEHOLDER INVOLVEMENT

The potential reuse of excavated peat is recognised as being an important area by Viking Energy. In compiling this document, the views of both SEPA and Scottish Natural Heritage (SNH) were sought through video/teleconference and by e-mail correspondence. Specific concerns or issues raised during this dialogue have been addressed.

SEPA noted the lessons to be learned from previous projects such as Braes of Doune Wind Farm, where infilling of a borrow pit with peat slurry had left a hazardous bog area that was fenced off. This area presents a potential issue for the developer during decommissioning.

SEPA's National Waste Policy Unit suggest that for each site, peat management proposals are detailed as far as possible at the planning stage and that they are developed in full consultation with the local SEPA officer.

SEPA also indicated that their understanding was that Shetland peat was not suitable for horticultural use, with the suggestion made that it dried to a hard material.

SNH noted the lessons to be learned from development at Whitelee, where a thin layer of surplus peat was spread over a wide area. Due to a lack of anything to consolidate or hold the peat in place, this material was subsequently washed off by rainfall into surrounding watercourses, with the consequent impacts on those sensitive receptors.

3 ESTIMATION OF EXCAVATED PEAT VOLUMES

Over 5,700 peat probes and site wide indicative peat depth mapping have been undertaken during the EIA process. Using this data allows classification of peat depths across the whole site into appropriate bands. Following discussion regarding likely construction practices, it was decided to use two depth classifications; up to 1m, where the road construction method would be 'cut and fill'; and greater than 1m, where 'floating' roads would be used. In this case, peat in excess of 1.0m is termed 'deep' but that may be in the context of road construction and as stated above is not necessarily deep in the broader picture, where peat depths of several metres have been found.

The turbine locations, borrow pit locations and access roads can be superimposed upon this indicative peat depth map, or where possible compared against actual probing data in order to estimate the peat depth associated with the infrastructure and to aggregate this to give an estimate of the total excavated volume. For the purpose of calculations it has been assumed that all soil cover across the site is peat. It has been suggested that where soil depths are less than 0.5m, this is not peat. However, at this stage it is considered impracticable to differentiate different soil types, particularly as the value of 0.5m is a somewhat arbitrary figure and, even at shallow depths, the soil may be organic in nature.

For Shetland, in particular, the means of accounting for haggs/gullies when estimating peat volumes is significant. As this is a conservative estimate of peat volumes, we would propose using the highest level of peat surface as the surface level (designated as 'processed peat depth').

The estimated surface dimensions for roads, turbine bases, hardstanding areas, compounds and borrow pits are estimated using agreed values or measurements from GIS. Within each of these categories the estimated lengths or numbers / dimensions are broken down into shallow, medium and deep peat. The subtotal and total volume of excavated peat for each type of construction can then be calculated.

Where practical, the estimated excavated peat has been categorised by quadrant, to aid further development of a management plan.

Most of the calculation rationale for the excavations and reuse is probably evident; however salient points are provided for each class of infrastructure, as discussed below.

3.1 Access Tracks

As stated previously, the break point between cut and fill and floating road has been identified as 1.0 m. Some judgement is required as to the preferred construction method for a stretch of road where the probing data indicates variable depths. In general, where the majority of the points are less than 1.0 m and the higher values are less than 1.5 m, cut and fill construction has been assumed. During cut and fill construction, all of the peat is removed back to bedrock.

For construction of sections of floating road, it has been assumed that no peat requires to be excavated.

For all sections of road, it has been assumed that as road construction progresses some peat will be reused along the margin of the road and a nominal 1m wide strip 0.3 m deep has been assumed on either side of the road. The total length of track on the site has been measured to be 117.5 km.

As part of this exercise, the roads were split into different types as identified by Viking Energy. These are generally identified by a track width plus batter. It is reasonable to assume for calculation purposes that the peat depth at all points will be 1 m and that consequently the batter will be at 45º. This means that half of the peat in the batter will be removed. It is however recognised that a shallower angle may be preferable in practice to maximise bank stability. Analysis of the peat probing data for those stretches of track that are proposed to be cut and fill yields an average peat depth of 0.5 m. For a 1 m width drainage channel, this allows for a batter angle of 26.6º on average. Indicative track dimensions are:

- Single track – 6 m running width plus 0.5 m shoulder either side plus 1 m batter (either side, at 45º so 50% of peat excavated), plus 1 m for a drainage channel (one side only). This gives a total equivalent width of 9 m for peat excavation.
- Double track – 8 m running width, plus 0.5 m shoulder either side, plus 1 m for a drainage channel (one side only). As these roads need to be more robustly constructed, the batter may be larger (assume 2 m instead of 1 m). This gives a total equivalent width of 12 m for peat excavation.
- Operational track – 6 m width plus 0.5 m shoulder either side, plus 1 m batter, plus 1 m for a drainage channel (one side only), giving a total equivalent width of 9 m.
- Other track (Borrow Pit access: assumed to be single track) – 6 m width plus 0.5 m shoulder either side, plus 1 m batter, plus 1 m for a drainage channel (one side only), giving a total equivalent width of 9 m.

For all track types, it is assumed that there will be cable trenching, but that this would be backfilled with peat, so would have a net zero effect on peat excavation.

The distribution of track types on the site is provided in Table 1 below.

Table 1 - Distribution of Track Type

Track Type	Collafirth (km)		Delting (km)		Kergord (km)		Nesting (km)		Totals (km)		
	C&F*	Float*	C&F*	Float*	C&F*	Float*	C&F*	Float*	C&F*	Float*	Overall
Single	0.51	5.57	4.34	17.00	9.85	18.71	2.83	24.85	17.53	66.14	83.67
Double			3.62	4.07	1.62	5.30	4.70	9.11	9.93	18.47	28.40
Operations					2.04	0.62		0.78	2.04	1.40	3.44
BP Access			1.36				0.66		2.02		2.02
Total	**0.51**	**5.57**	**9.32**	**21.07**	**13.51**	**24.63**	**8.18**	**34.74**	**31.51**	**86.01**	**117.52**

C&F – Cut and Fill, Float - Floating

For this exercise, it has been assumed that for all cut and fill sections of track, the peat depth is the weighted average for the two identified depth categories, namely 0.5 m and 0.5 - <1m. Based on the analysis provided in Table 2 below, this equates to a peat depth of 0.5 m.

Table 2 - Measured Peat Depths by Range Across The Site

Peat Depth Range (m)	Number of Locations Surveyed	Average Peat depth in band (m)	Percentage of Locations Surveyed
0.0 to < 0.5	931 (616)	0.21 (0.21)	16.2% (10.7%)
0.5 to < 1.0	1095 (915)	0.68 (0.69)	19.1% (15.9%)
1.0 to < 1.5	1176 (1137)	1.19 (1.20)	20.5% (19.8%)
1.5 to < 2.5	1929 (2294)	1.88 (1.96)	33.6% (39.9%)
= 2.5	614 (783)	3.06 (3.21)	10.7% (13.6%)
Total / Aggregate	5745 (5745)	1.37 (1.55)	100% (100%)

With reference to Table 2, results in parentheses represent 'processed depth values', these results take account of local peat micro-topography, assisting with describing the peat depth to a nominal 'surface level' taking account of local erosion features, where evident. For example:

- if peat probing on a uniform, uneroded surface - no adjustment is made;
- if peat probing in a gully location - the processed result adds the gully depth to the peat depth result;
- if peat probing occurs on an isolated hagg - the height of hagg is subtracted.

It is noted that the application of processed probing values tends to promote peat depths in the deeper ranges.

It is suggested that any required passing places on single track road are sited on floating sections of road to negate the need to excavate additional peat.

Using the assumptions above, the data for peat excavation related to access tracks is 154,700 m^3. A breakdown of this figure is provided below in Table 3.

Table 3 - Excavation Volumes (m^3) by Quadrant & Track Type

Track Type	Collafirth	Delting	Kergord	Nesting	Totals
Single	2,272.5	19,539.0	44,329.5	12,735.0	78,876.0
Double	-	21,702.0	9,690.0	28,188.0	59,580.0
Operations	-	-	9,180.0	-	9,180.0
BP Access	-	6,120.0.0	-	2,947.5	9,067.5
Total (m^3)	**2,272.5**	**47,361.0**	**63,199.5**	**43,870.5**	**156,703.5**

The total length of track on the site is 117.5 km. It is reasonable to assume that peat can be used for profiling of banks etc along the length of the track. For this exercise, it has been assumed that a 1 m wide, 0.3 m high strip of peat will be utilised for banking along the entire length of site tracks. This will reduce the total volume of excess peat by 70,500 m^3.

3.2 Turbine Bases

The excavations for the foundations for turbine bases have been identified as being 25 m by 25 m (625 m^2) in area. The concrete foundations themselves are planned as being 22 m by 22 m by 1.02 m. It is assumed that the remaining area is battered at 45 degrees. The peat depth at each turbine has been obtained from the probing at the turbine location, or from the nearest probing data where the turbine location has not been probed. In addition, associated with each turbine location there are two areas of hardstanding, one of 1,500 m^2 (permanent installation) and the other of 354 m^2 (temporary installation). For both of these, it has been assumed that peat will be excavated to bedrock level.

It has been assumed that the excavated area for the turbine base and temporary installation area will be re-covered with 0.5 m of peat. Only four of the turbine bases are shown to be sited in areas with peat depth less than 0.5 m, so this is considered to be a reasonable assumption. This assumed depth is to take account of the fact that when the base and hardstanding area are constructed the foundation level will be further below the surface where the peat was deep as opposed to shallow. Some backfilling above the concrete base may be with excavated rock, but thereafter peat would be used.

The permanent hardstanding area adjacent to the turbine bases is essential for crane operations and will be retained for heavy maintenance as required. It has been assumed that all peat will be excavated and no floating type construction will be used, which gives an upper bound figure for peat volume. Although some re-vegetation is expected, no peat would be spread across the permanent hardstanding area.

The estimated volume of peat excavated at turbine bases and associated hardstanding areas is approximately 575,000 m^3 and that reused is approximately 73,500 m^3. A breakdown of this by quadrant is provided in Table 4.

Table 4 - Peat Extraction (m^3) at Turbine Bases

	Collafirth	Delting	Kergord	Nesting	Totals
Number of Turbines	8	33	47	62	150
Peat Extracted	39,359.0 m^3	129,818.0 m^3	182,083.0 m^3	223,991.0 m^3	575,150.0 m^3
Peat Reuse	3,916.0 m^3	16,153.5 m^3	23,006.5 m^3	30,349.0 m^3	73,425.0 m^3
Peat Balance	35,343.0 m^3	113,665.0 m^3	159,076.0 m^3	193,642.0 m^3	501,725.0 m^3

3.3 Compounds

These are temporary set down and working areas which will be reinstated when the work is complete. Peat depth for each compound is based on actual probing data at each location. It has been assumed that no peat will be used for reinstatement of the construction compounds following construction. While reinstatement of compounds is common on completion of construction works, it is likely that some of the compounds will be retained for operational use such as maintenance, storage etc. By assuming no reinstatement, we have taken a conservative view for assessment purposes.

Should all of the compounds be reinstated, using a nominal 0.5 m of peat (or depth to surface where peat depth is less than 0.5 m), this would require approximately 32,000 m3 of peat. This is a small amount in terms of the total extracted peat volume.

The conservative approach is to assume all peat will be excavated, as in reality, geotextile and road material may be laid across the area and potentially no peat excavated. However assuming excavation gives an upper bound figure in terms of peat volume estimation.

At this stage, an area of 10,000 m^2 has been assumed for each site compound requiring construction, though in practice it is likely that some will be smaller.

It has been estimated that a total of 72,000 m^3 of peat would be extracted.

Table 5 - Peat Extraction (m^3) at Site Compounds

Site Compound I.D.	Width (m)	Length (m)	Peat Depth (m)	Peat Extracted (m^3)
CCC01	100	100	1.0	10,000
DCC01	100	100	1.5	15,000
DCC02	100	100	0.4	4,000
KCC01	100	100	1.5	15,000
KCC02	100	100	0.3	3,000
NCC01	100	100	1.0	10,000
NCC02	100	100	1.5	15,000
Total				**72,000**

3.4 Borrow Pits

It is reasonable to assume that borrow pits are located where rock is close to the surface. On this basis, it has been assumed that the overburden at borrow pit sites will have an average depth of 0.5 m. For the majority of borrow pit locations, dimensions have been estimated based on field survey and desktop investigation. Figures for Borrow pit surface area and dimensions are taken from Technical Appendix 14.2 – Borrow Pit Assessment (Mouchel, 2009b). These are detailed in Table 6. It has been assumed that an average peat depth of 1.2m will be used in re-profiling the borrow pits as part of reinstatement activities. This value was previously proposed for a proposed wind farm development on Lewis and was found to be acceptable by SEPA.

It is estimated that approximately 73,700 m^3 of peat/overburden will be extracted, with the potential for up to 176,800 m^3 to be used for reinstatement.

3.5 Substations

It is currently planned for there to be three substations on the site, smaller versions each in the Delting and Nesting quadrants with a larger facility adjacent to the convertor station in Kergord. It has been assumed that the foundation for the Delting and Nesting substations will be 5 m x 10 m and that all peat will be removed from the foundation area, with no reuse of peat. For the Delting substation, local peat probing indicates a peat depth of 1.7 m, giving a peat volume to be extracted of 85 m^3. For the Nesting substation, the peat depth is estimated to be 0.3 m giving an estimated volume to be extracted of 15 m^3. The Kergord substation has been assumed to be twice the size of the others (10 m x 10 m). An estimated peat depth of 1.5 m yields an estimate of extraction volume of 150 m^3. Thus, the total estimated volume for extraction is 250 m^3. This is very small relative to the estimated volume to be extracted across the site.

3.6 Convertor Station

This construction is separate from the wind farm construction, but will be used to convert the electricity generated by the wind farm into a suitable form for transmission into the grid. Although not included in the site totals, the estimated peat extraction required at this location is 28,000 m^3. This is based on a surface area of 28,000 m^2 and estimated peat depth of 1.0 m. Note that this area may include the area identified in section 3.6 for the Kergord substation.

Table 6 - Peat Extraction (m^3) at Borrow Pits

Borrow Pit I.D.	Approximate Footprint Dimensions (m) *	Approximate Footprint Area (m2)	Maximum Depth (m)	Approximate Extraction Volume (m^3)	Overburden		Reinstatement Volume (m3) (@ 1.2 m depth)	Excess Peat Required (m^3) (assuming reuse of overburden)	Reuse per Quadrant (m^3)
					Assumed Thickness (m^3)	Assumed Volume (m^3)			
DBP01	65 x 87	2,980	22	40,000	0.5	1490	3,576	2,086	22,610
DBP02	114 x 174	17,190	25	195,000	0.5	8595	20,628	12,033	
DBP03	109 x 124	12,130	15	115,000	0.5	6065	14,556	8,491	
CBP01	98 x 107	9,520	10	73,000	0.5	4760	11,424	6,664	6,664
KBP01	87 x 100	7,730	20	80,000	0.5	3865	9,276	5,411	26,110
KBP02	118 x 105	11,020	25	148,000	0.5	5510	13,224	7,714	
KBP03	130 x 98	10,460	25	131,000	0.5	5230	12,552	7,322	
KBP04	96 x 90	8,090	18	80,000	0.5	4045	9,708	5,663	
NBP01	140 x 138	17,700	10	138,000	0.5	8850	21,240	12,390	47,768
NBP03	90 x 93	7,750	23	83,500	0.5	3875	9,300	5,425	
NBP04	68 x 130	8,420	20	83,500	0.5	4210	10,104	5,894	
NBP05	132 x 145	16,890	15	161,000	0.5	8445	20,268	11,823	
NBP06	140 x 130	15,560	15	169,000	0.5	7780	18,672	10.892	
NBP09	56 x 38	1,920	10	10,500	0.5	960	2,304	1,344	
Total		**147,360**				**73,680**	**176,832**	**103,152**	**103,152**

* Please note that borrow pits are not regular in shape. Footprint dimensions represent the maximum length and width whereas footprint area is derived from the indicative design.

4 PEAT VOLUME BALANCE

Section 2 above details the estimated volume of peat excavation and reuse for each element of construction. The figures from this section are summarised in Table 7 below.

Table 7 - Summary of Peat Extraction and Potential Reuse

Infrastructure Description	Estimated Peat Volume Excavated (m^3)	Estimated Potential for Peat Reuse (m^3)
Access Tracks	156,700	70,500
Turbine Bases and Hardstandings	575,000	73,500
Site Compounds	72,000	32,000*
Borrow Pits	73,700	176,800
Substations	250	0
Convertor Station	28,000*	0
Total	**877,650**	**320,800**

* Figure included for information only. Not included in total.

From this, the balance of surplus peat as a result of construction activities may be determined. Clearly, excavations at turbine base (including hardstanding areas) account for the majority of excavated peat, with a volume of 575,000 m^3, while road construction requires excavation of 156,700 m^3 of peat. Additional peat excavation is required for site compounds (72,000 m^3), borrow pits (73,700 m^3), and substations (250 m^3).

In total, the estimated excavation volume is 877,650 m^3. However, there are a number of opportunities for reuse of excavated peat. These include: backfilling of turbine bases and temporary hardstanding, for which it is estimated that 73,500 m^3 of peat can be reused; banking at roadsides for which 70,500 m^3 can be reused; and 176,800 m^3 for restoration of borrow pits. In total, the potential for reuse of excavated peat is 320,800 m^3.

This results in a residual surplus of 556,850 m^3 of peat from site construction activities.

Both of the extraction and reuse volumes could change significantly due to construction practices on the site resulting in smaller peat volumes if (a) more floating type construction was used or (b) road margin reinstatement was undertaken with a wider / deeper strip of peat. Similarly, changes in road routing could affect the total volume of peat extracted.

The construction phase for the Viking Wind Farm is planned to take 5 years, with civils work carried out in years 1 – 4. Using the figures from Table 7, this suggests a total excavation volume of approximately 219,400 m^3 per year, with an annual surplus of approximately 139,200 m^3.

Assuming that construction will only take place for six months of the year, from early spring to autumn, and that construction will take place 7 days a week during this period, this equates to approximately 1200 m^3 of peat excavated per day, with approximately 760 m^3 of this being excess peat.

5 ONSITE PEAT STORAGE

Whether or not there is a surplus of peat generated from construction activities, there will be an ongoing need to store volumes of excavated peat on site, either for restoration purposes or for subsequent use or ultimate disposal.

Good practice onsite storage of peat is discussed in more detail within the Sediment Management section of the Viking Wind Farm Environmental Statement (Mouchel, 2009a) and within Technical Appendix 14.1 - Peat Stability Assessment (Mouchel, 2009c).

6 RESTORATION OPTIONS

In tandem with the wind farm development, Viking energy is developing a Habitat Management Plan for the site (Envirocentre, 2009). A significant aspect of this is the restoration of areas of blanket bog. A number of potential restoration opportunities are identified, several of which require the use of additional peat. Details of these opportunities are provided in the paragraphs below.

Use of peat for modifying drainage (e.g. by blocking drainage channels or infilling low gradient drainage channels). Consideration will need to be given to the suitability of peat for each location as there will be a risk of deposited peat being washed away. It may be possible to use peat in conjunction with other structural materials. Where peat is non-cohesive, it may be possible to use "sandbagged" peat topped by turves. Where natural retention exists, it may be possible to use larger volumes of peat to infill areas of erosion.

Lochan stabilisation and repair will be carried out using a combination of hard defences such as rock and timber, and soft defences such as compacted peat. Further detail can be found in the Habitat Management Plan (Envirocentre, 2009)

Most of the initial restoration work is likely to be focused around the Nesting quadrant. The pilot area is approximately 10 km^2 in area. Assuming a peat depth of 1.5 m and that peat reuse will be equivalent to 0.01% of the area for infilling of gullies, eroded areas etc, then approximately 15,000 m^3 of peat would be required. Delivery of this peat to point of use will require to be carried out using a tracked dumper carrying approximately 5 – 6 tonnes per trip or other appropriate low bearing transport, to cross areas of peat. The practicality of transporting peat across the site and the potential for damage to peat along the route compared to the benefits of restoration will be considered at each stage of the habitat plan.

Although there may be further opportunities for peat use in restoration, dependant on confirmation of environmental benefit in the pilot area, the likely timescale for gauging success is several years. As a result, there are likely to be limited additional opportunities to use surplus excavated peat during construction to support restoration activities.

However, should it be possible, during the construction process to demonstrate environmental benefit from the restoration activities, this option should be revisited, both to provide a beneficial use of excavated peat and because opportunities to source peat for restoration activities will be reduced post construction.

7 PEAT REUSE OPTIONS

A number of potential options for reuse of peat have been identified. Some of these options have been used elsewhere, with varying levels of success. The intention here is to highlight both successful and unsuccessful techniques, to allow consideration of appropriate methods and so that best practice can be applied on the Viking Wind Farm.

7.1 Restoration of Turbine Locations / Hardstanding Areas

As described in section 3.2 for the turbines and hardstanding areas and section 3.3 for the compounds, there is a potential opportunity for reuse of peat in reinstating the area in and around this infrastructure. The quantities of peat reuse for this purpose were estimated in section 3.2 above to be of the order of 73,500 m^3.

7.2 Backfilling of Borrow Pits

Table 6 demonstrates that the on site borrow pits have the potential to yield approximately 1,500,000 m^3 of aggregate. This volume is significantly larger than the estimated total volume of peat extracted, which is of the order of 877,650 m^3. Although, in principle, all of the excavated peat could be accommodated within the volume extracted from the borrow pits, there are a number of reasons why this is not likely to be practical, including topography and stability of the peat used to infill.

Previously at Braes of Doune Wind Farm, peat was used to infill site borrow pits. This exercise yielded at least one borrow pit filled with unstable material that had to be fenced off for health and safety reasons. There is an ongoing risk associated with these features which will need to be addressed at the end of the operational phase of the wind farm, if not earlier.

Section 3.4 uses the assumption that an average depth of peat of 1.2 m will be used for reprofiling of borrow pits. With a structured reprofiling, using fibre mats and/or geotextile layers and/or acrotelmic turves to provide structure and stability to the peat, it may be possible to use additional peat for reprofiling. For example, using an average depth of peat of 2 m rather than 1.2 m would use an additional 120,000 m^3 of peat. Based on a total borrow pit surface area of approximately 147,000 m^2, an average peat depth of approximately 4 m would be required to utilise all surplus peat for borrow pit restoration.

Potential design principles for the restoration of borrow pits are described below and in Figure 1 and Figure 2.

There are 2 principal types of peat:

- The upper (acrotelm) layers are quite fibrous, contain plant roots etc and are (for peat) relatively dry with some tensile strength; given an average peat depth across the site of 1.55 m (Table 2), and assuming that the acrotelm is 0.3 m, then careful harvesting of the acrotelm would yield approximately 170,000 m^3 of this type of peat.
- The lower (catotelm) layers are highly amorphous, with very high water content and can be of very low strength.

Disturbing the peat from its in-situ mass also significantly reduces the strength of the bulk material. Complete disturbance of the structure of the peat means that re-creation of an in-situ peat bog may not be feasible.

Data from the geotechnical investigation carried out to inform the Peat Stability Assessment (Mouchel (2009c) *Viking Wind Farm Environmental Statement - Soil and Water (Chapter 14; Technical Appendix 14.1 Peat Stability Assessment*.) revealed that the peat was relatively undecomposed at depths up to 1 m and that shear strength in the upper 0.5 m was higher due to the fibrous nature of the peat. This suggests that there may be more acrotelmic peat than estimated assuming the acrotelm is 0.3 m deep.

The more fibrous, acrotelmic peat would be set aside to recreate a more stable and visually satisfactory surface to the restored peat. If necessary, to provide additional stability degradable jute reinforcing layer and/or additional acrotelmic material could be used.

Catotelmic peat, in particular, has a very high water content, low permeability and low strength. Complete disruption of the intact structure can be expected to occur during excavation and handling. When placed in the final repository therefore, it can be expected to have a very low strength, leading to a number of issues:

- low bearing capacity, making it a hazard to people or animals walking on it;
- propensity to slide off slopes, at angles as low as 5º. This can often be propagated by local stress changes such as imposed by plant movements and rainfall events (1:10 gradient = 5.7º.);
- A significant amount of water will be released, which will have a high suspended solids content, and
- Access difficulties for normal plant onto the backfilling area.

To encourage stability, the peat should be spread in the thinnest layers possible during the works. This could involve spreading using traditional methods, or placement with long-arm excavators. Traditional compaction would not be feasible on peat, but it could be "tracked" into place with a machine on "bog-master" tracks.

To encourage drainage and therefore both vertical and lateral stability, a granular drainage blanket would be placed in the base of the borrow pit, which in turn should be shaped to fall to a low point at the front "lip". This would also provide increased resistance to basal sliding. The drainage blanket should lead to a terminal stone bund at the down-hill end of the borrow pit, which, in combination with additional internal stone bunds breaking the restoration into 20-30 m cells, would provide lateral sliding resistance and manage drainage.

Careful selection of the stone grading should help to intercept fines and limit the suspended solids discharge. Nevertheless, the water discharged as the peat consolidates will have a high suspended solids content and would be passed through a series of settling ponds or other suitable sustainable drainage technique, depending on local conditions, to remove suspended solids prior to discharge to the local watercourses.

Given the timescale for construction, with civils work carried out over 4 years, the restoration of borrow pits is likely to be carried out sequentially. There will be an opportunity to refine the actual design for the second and subsequent borrow pits, based on experience on site and any general developments in best practice.

Figure 1: Outline Borrow Pit Backfill – Plan

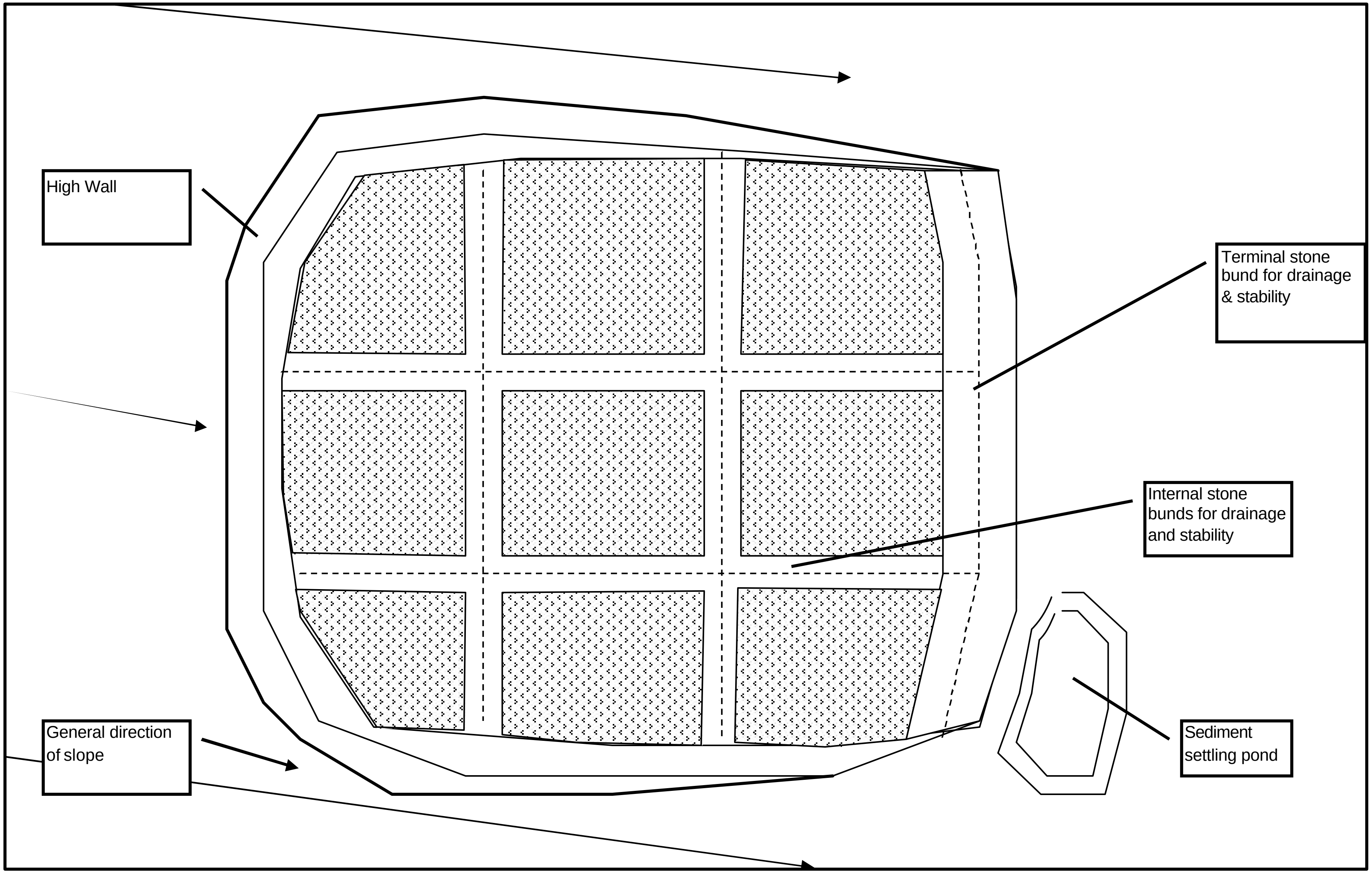
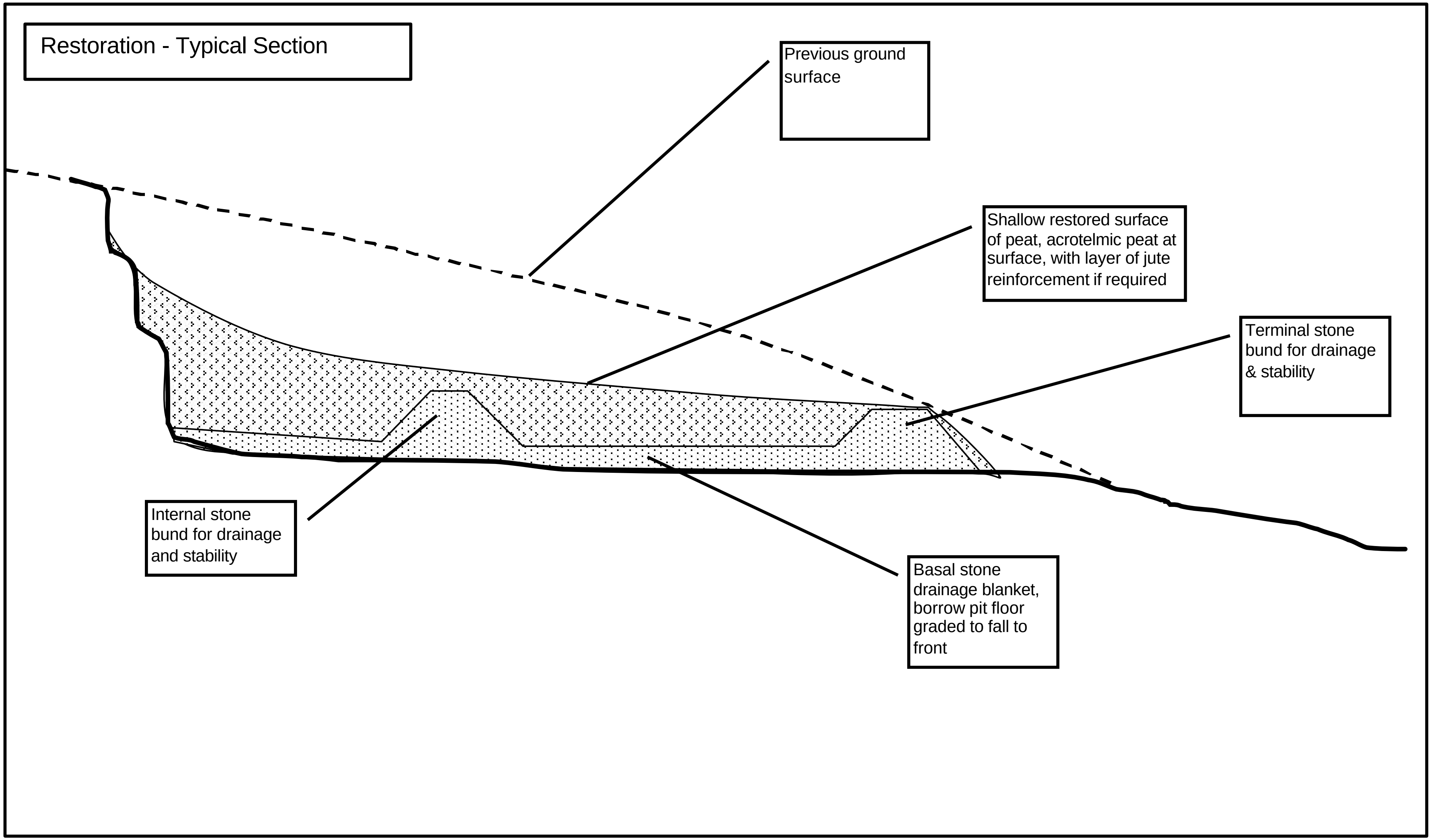


Figure 2: Outline Borrow Pit Backfill - Typical Section



7.3 Access Tracks

As described in section 3.1, road construction will be either of cut and fill or floating type, depending on peat depth, with the transition from cut and fill to floating occurring at around 1 m depth. Some of the access tracks will be single width and others double, depending on location and planned use. In terms of peat reuse, it has been proposed that some peat can be reused at the road margins on either side to form road banking. It has been assumed that the banking would be 1 m wide and 0.3 m high. There is limited additional scope for using additional peat unless larger banks were required for the road.

7.4 Substations

No reuse of peat has been assumed for either the converter station or substation locations. In practice, it may be possible to reuse some of the excavated material for reprofiling or landscaping around this infrastructure. However, this is likely to be very small.

7.5 Peat Spreading

Method
This technique, which was used at the Whitelee Wind Farm, simply involves spreading of a thin layer of excavated peat over an area of the site.

Advantages and Disadvantages
Experience at Whitelee was that the peat deposited was washed away by rainfall, causing siltation and high turbidity in local watercourses.

The implication here is that the peat used was catotelmic peat which may be non-cohesive. It may be possible to carry out a similar exercise relaying acrotelmic peat (the top 20 – 30 cm) across low lying bog areas or areas where the surface vegetation of the peat has been eroded or damaged by grazing.

Assuming a depth of 0.3 m for the acrotelm and hence for cut turves, each 100 m^2 of coverage would require 30 m^3 of peat. Thus, assuming that across the site an area of 250 m x 250 m can be used to relay acrotelmic peat, this would require 18,750 m^3 of peat.

It may be practical to use or retain small quantities of peat, particularly if this is acrotelmic in nature, local to infrastructure such as turbines to support reinstatement activities. This may require some local engineering measures.

Spreading or laying of excavated peat on areas otherwise not involved in the construction of the wind farm could have adverse impacts on local habitats and ecosystems. The exception to this is where peat is being reused for habitat restoration as described in section 6.

Recommendations

It is considered that the disadvantages of widespread peat spreading outweigh the advantages and that this is not a viable option for the Viking Wind Farm.

7.6 Domestic Fuel use

Method
Peat cutting gives rise to turves (or sods) of peat which following harvest are allowed to drain naturally and dry in the sun and wind for a period of time, providing a fuel with a suitable

moisture content for burning. Peat cutting traditionally was carried out manually. Commercial peat cutting operations have automated this process using a tractor drawn auger.

It has been suggested that there may be an opportunity to allow the local population to harvest some of the peat for personal use as a fuel. There are some limitations to this, not least of which will be the logistics and safety of peat harvesting activities on a live construction site. For this to be workable in practical terms will require identification of a suitable area for peat cutting within the excavation footprint that would be excavated toward the end of the construction programme. It would also be necessary to have reasonable access so that it was practical to remove the cut peat from site. Realistically, the volume that will be removed by the local population is likely to be small.

Advantages and Disadvantages

Providing peat for the local population would potentially project a positive image of Viking and would provide a benefit to a section of the local population.

Assuming five hundred people take this opportunity up and remove 10 m^3 per person for three years during the construction process, this would account for 15,000 m^3 of surplus peat.

Assuming that on average the distance travelled by each individual or group is reduced, this would potentially be a carbon neutral exercise as any peat provided would replace peat (or other energy sources) from other locations/sources.

Normally when cutting peat, each individual or group of individuals would have a minimum of two return journeys – one to cut the peat and a second to collect dried turves. A centralised cutting operation would require only a single journey to pick up cut and dried peat turves, thus reducing total mileage.

The major disadvantage of this option is logistical, in that it will be necessary to plan any excavation for domestic use of peat around the construction programme.

Recommendation

This option provides an opportunity for reuse of a relatively small volume of peat. However, within the constraints of the construction programme, it may be practical to implement. It is recommended that the construction contractor is encouraged to include a scheme for providing cut peat to the local population, if practical within the construction programme.

7.7 Commercial Fuel Use

Method

Complementary to the domestic possibilities of peat as a fuel, it may be possible to use a proportion of surplus peat from excavation as a commercial fuel. Peat has been widely used as a fuel in Ireland, with a peak for peat cutting in the 1920's of six million tonnes (5.45 M m^3 assuming a peat bulk density of 1.1 te/m^3). Use declined through the 20th century to annual production of around one million tonnes in the 1970's. Over the last 30 years, mechanised peat extraction (using tractor drawn auger machines) has become the norm, with little hand cutting surviving. In the Republic of Ireland, the Bord na Mona still use 1 million m^3 of peat each year to produce peat briquettes. In the 1960's, there were four power stations in Ireland burning around 3,500 tonnes of peat (3182 m^3) per year. There are currently six peat fired power stations in Ireland, producing around 10% of the country's electricity requirement. These power stations use milled peat as a fuel source.

Advantages and Disadvantages

Peat has high moisture content, resulting in a relatively low thermal value. As a consequence, it is not normally cost effective to ship peat large distances.

There would be a requirement to dewater peat prior to use as a fuel. Dewatering is considered in more detail in section 8.1.

Peat is a natural product and as a result, peat quality (including calorific value and ash content) are variable.

There is a CHP plant in Lerwick. This is primarily a 'Waste to Energy' installation, burning waste from local waste streams. In addition to electricity generation, it supplies district heating services in Lerwick. There are periods throughout the year when insufficient fuel from waste is available to the plant.

As a result, the operators have independently started investigations into potential alternative fuel sources, including peat. However, there are a number of challenges to be overcome, including calorific value, transit time, etc to be solved before this becomes a practical option.

There is believed to be a demand for new heat sources for the district heating system.

Recommendation

This option may potentially provide an opportunity for use of surplus peat. Although the annual volume of peat use may be low, cumulatively the potential for reuse will be significant.

Currently, this option is best described as embryonic. It is possible that there will be logistical and practicality issues that in the long term would preclude this as a viable option. However, it is recommended that a dialogue is maintained with the CHP plant operators to provide support in exploring this option further to develop a fuller understanding of the benefits and disadvantages.

7.8 Dry Soil Mixing and Stabilisation of Peat

Method

The technology exists to stabilise peat, particularly for the access tracks, rather than having to excavate the peat and backfill with won aggregate from the borrow pits. This process involves the introduction of a slag / cement binder into the peat layers at a rate of 225kg / m^3 while blending with the peat using a high shear mixer. This precipitates a concrete-like material with shear strengths up to 2 kPa. As a result a net reduction of imported fill would be required in the overall scheme.

Advantages and Disadvantages

The primary advantage of this approach are a reduction in excavated peat, potentially up to the excavation volume for access tracks of around 154,600 m^3, with an equivalent reduction in the requirement for aggregate.

The major disadvantages of this technique are the potential for pollution of the surrounding bog due to the pH change caused by the addition of alkaline cement to an acidic environment.

Given that the stabilised material is a concrete like material, there is a high likelihood that this will form a barrier to water flow through the peat and consequently would significantly alter the hydrological regime.

Recommendations

The potential for significantly reducing the requirement to excavate both peat and aggregate is attractive. However, due to the significant potential environmental impacts of this technique, it is recommended that this option is not considered.

7.9 Commercial Horticulture

Method
It was suggested that there may be opportunities to use surplus peat for horticultural purposes, including fertilising of council flower beds etc. The majority of peat for horticultural purposes is milled peat. This would require to be dried/dewatered (see section 8.1) prior to milling.

Assuming local (Shetland) use only, with an area of 0.1 km^2 given a 10 cm application of peat each year for 3 years, the potential usage would be 3,000 m^3. Data from the Office For National Statistics on Mineral Extraction showed that for the UK in 2007, 885,000 m^3 of peat was extracted in the UK (231,000 m^3 in Scotland). Virtually all of this material was used for horticultural purposes.

Advantages & Disadvantages
SEPA noted that their understanding was that peat from Shetland was of low value in horticultural terms, partly because it dried out to form a hard, difficult to use, material

There is unlikely to be a significant local market for peat, therefore quantities of peat used are likely to be low.

The need to dry / dewater and mill mean that this is unlikely to be a viable option.

Recommendation
It is recommended that this option is not pursued any further.

7.10 Off-site Infill

Method
Section 7.2 discusses options for restoration of site borrow pits using surplus peat. In addition to using an acceptable quantity of peat into the site borrow pits for landscaping, there may be opportunities to carry out a similar exercise using some of the many existing abandoned borrow pits and disused quarried areas around Shetland unrelated to the project.

In order to progress this further, we would need to seek a view from SEPA on the merits of the proposal, identify suitable locations and enter into discussions with the owner/operator.

The potential for reuse is dependant on the surface area of any identified opportunity for reinstatement. Assuming a similar depth as used for onsite borrow pits (1.2 m), then each 100 m^2 would require 120 m^3 of peat. Assuming potential for restoration of offsite areas aggregating 200 m x 200 m, this would require 48,000 m^3 of peat.

Advantages and Disadvantages
There are two primary advantages of this option, in that it provides another potential use for excavated peat and that it offers the opportunity to restore historic quarries, with the concomitant environmental benefits of improved aesthetics and improved habitat and ecological potential.

There could be difficulty in dealing with the owners of private developments, so this option would probably only be viable with large, council owned landfills / quarries, where a clear benefit would be identified.

There are logistical issues with the transport of peat from the site to other locations.

There is a risk that this option could generate a negative perception of Viking Energy, based on public perceptions of off-site use of peat.

Recommendation
It is likely that there will be significant logistical issues with this option, both in terms of identifying and reaching agreement with owners of these facilities, in the logistics and impacts of transporting peat around the island and in the perceptions of the local population. It is therefore recommended that the disadvantages of this option far outweigh the advantages and it should not be pursued.

8 PEAT TREATMENT & DISPOSAL OPTIONS

At present, SEPA's National Waste Policy Unit are developing a draft Position Statement relating to development on peatland, however, this is still at an early stage and is unlikely to be available to provide guidance prior to submission of the Viking Wind Farm ES. It is recommended that this document is considered following publication to ensure that best practice is adopted.

It is likely for the Viking Wind Farm, that even allowing for the maximum practical volume for all of the reuse options, there will still be a significant surplus of peat to deal with. This section gives an overview of some possible routes for dealing with this material.

8.1 Dewatering

Method
In its natural state, peat contains in excess of 90% water by weight. For peat to be a viable fuel source, the water content must be significantly reduced. Traditional drying methods using sun and wind drying will typically yield a dry solids content of 40% - 60%. The major limitations of this method are the area required for drying material, the timescale for drying and potential peat stability issues of large volumes of peat effectively being stored while drying.

An alternative to this would be mechanical drying. Given that peat contains of a large number of very small, electrostatically stabilised particles, pretreatment is likely to be required. Pretreatment can involve heating, freezing or addition of chemical additives (flocculants).

Mechanical filtration: Mechanical filtration using rollers, filters or screens can be used to reduce the moisture content to 65 – 80%. Lower moisture contents can normally only be obtained by use of organic solvents. The use of organic solvents is not recommended due to the risk of spill and subsequent pollution, the cost of such solvents, and the logistics for containment, recycling and disposal.

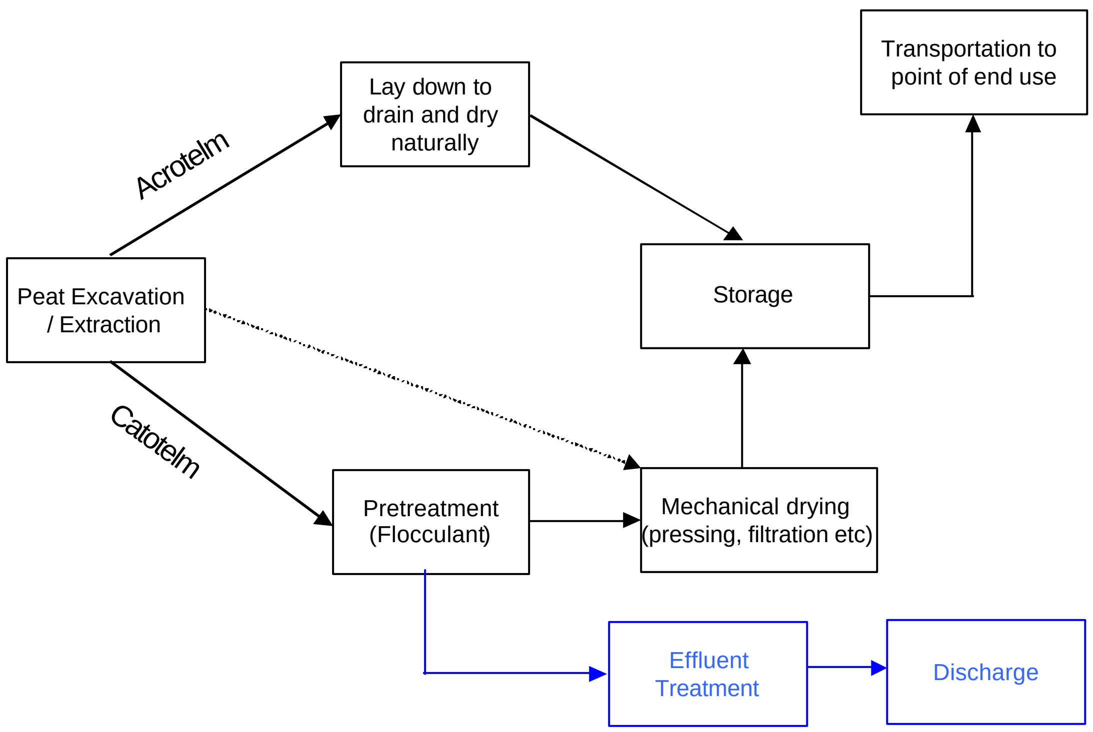
Pressure Filtration: Drying may be carried out by means of pressure filtration using a cationic polyelectrolyte and with pH adjustment to pH 3.

This raises the issue of discharge of and liquid removed from the peat in the dewatering process. With no pre-treatment of the peat, this would be identical to the water within the peat and could be safely allowed to re-enter the peat through a lagoon or other suitable permeable storage location. The use of additives complicates the situation and makes it likely that treatment of the water removed, such as pH modification, will be required prior to discharge.

There are other potential techniques for reducing moisture content in peat, including the use of thermal processes. However, most of these are still in the experimental stage.

The principal steps involved in dewatering of peat are illustrated in Figure 3.

Figure 3: Primary Steps in Dewatering Process



Advantages and Disadvantages

Dewatering of peat could significantly reduce the volume of surplus peat. Additionally, it is likely that the dewatering process will give rise to a denser, more cohesive material, which will be easier to handle and may also have better mechanical properties.

Acrotelmic peat can, in principle, simply be left to one side to drain and dry naturally, in the same way that cut peat turves would be.

There are several disadvantages of dewatering. Dewatering will require the presence of additional plant on site. This may in turn require additional hardstanding or other stable surface around the site from which to operate and also provides an additional potential source of pollution on site during the construction process. This disadvantage would be reduced in the eventuality that material were to be removed from site for landfill, where a single dewatering location may be more practical.

The best results for dewatering of peat are achieved by use of flocculants and/or solvents. These potentially introduce significant quantities of contaminants into any supernatant liquid, which will have to be treated (potentially requiring use of more chemicals) prior to discharge. This process will require a discharge licence.

Recommendation

While the issues surrounding the use of dewatering of peat are not insurmountable, there are significant barriers to its' use, including the logistical issues and the increased risk of pollution associated with pre-treatment of the peat and treatment of the resulting supernatant liquid prior to discharge.

8.2 Off-site Landfill to an Existing Facility

Method

Should all other options for use of peat for restoration and other activities fail to consume excess peat, the last option, based on the waste hierarchy, would be to consider offsite landfill. Should this be necessary, dewatering, as discussed in section 8.1 above, may be necessary, both to minimise the mass of material to be landfilled and due to the fact that the Landfill Regulations prohibit disposal of liquids to landfill.

Where necessary to landfill excavated peat, for the purposes of waste description the material would fall under the European Waste Catalogue (EWC) Chapter 17, "Construction and demolition wastes", and the EWC code "17 05 03, soil and stones" would apply. Provided there are no hazardous components within the waste, waste falling under this waste code is normally acceptable for disposal at an inert landfill site. However, on account of the high organic carbon content, topsoil and peat are specifically excluded. Furthermore, the waste acceptance criteria (WAC) limit for inert waste is <3% total organic carbon. Excess peat would therefore require to be disposed of at a non-hazardous waste landfill.

Landfill tax applies to all waste disposed of to a licensed landfill site. The landfill tax rates are currently £2.50/T for inert waste and £32/T for non-hazardous (non-inert) waste, increasing to £40/T on 1st April 09. Although WAC testing of the peat would exclude the material from being classed as inert (due to organic content), for the purposes of landfill tax assessment (HM Revenue and Customs, 2009c), peat is defined under "*Group 1 – naturally occurring rocks and soils, including peat*", to which the lower rate of tax (£2.50/T), normally applied to inert waste, would apply.

Advantages / Disadvantages

Landfilling of peat is undesirable as this is a naturally occurring biodegradable material. Decomposition will give rise to significant quantities of greenhouse gases and will take up valuable landfill space in a location where this resource is constrained.

Even though the lower rate of tax would apply, should large quantities of peat require to be landfilled, the cost would become considerable.

Movement of this material off site could potentially cause traffic issues. A worst case scenario of 200,000 tonnes per year for 4 years, assuming a six month construction window and 30 tonnes per trip, would result in an additional nine return journeys each day to landfill material during construction.

Recommendation

For reasons of practicality, cost and minimising environmental impact, landfilling should be considered only as a last option, should all other options have been exhausted.

9 CONCLUSIONS

A series of calculations have been undertaken to determine peat excavation and reuse volumes arising from each category of construction. These figures are deliberately chosen to present a conservative picture. The figures show that approximately 875,650 m^3 of peat will be extracted as a result of various activities, with the opportunity to reuse approximately 320,000 m^3 for reinstatement and restoration across the site. This leaves an excess of extracted peat of approximately 550,000 m^3.

Clearly, the opportunity for peat reuse only accounts for approximately 30% of the peat extracted during construction. Thus, consideration will be required of management options for this significant volume of peat, both in terms of storage during construction and for ultimate use or disposal.

The figures generated in this exercise are deliberately conservative and, of necessity, are in many cases estimated. Although no formal statistical analysis has been carried out, it is estimated that the error in the final figure could be up to 20%. Given the use of conservative values, it is likely that any error will be to overestimate the peat extracted.

It should be remembered that peat in its natural condition will contain in excess of 90% by mass of water. Given the volume of peat involved, the final mass of waste to be dealt with could be reduced significantly by the use of an effective dewatering system, however, there may be logistical challenges to dewatering.

Considering all identified potential routes for reuse of peat, it is apparent that the preferred option is to use surplus peat for restoration of borrow pits on site. While it is accepted that restoration may be possible using a lesser quantity of surplus peat, the advantages of onsite use far outweigh the disadvantages.

The main potential disadvantages for off-site use include:

- Limited landfill capacity in Shetland
- Practical difficulties in treatment such as dewatering
- Environmental impact of transporting large volumes of peat outwith the site
- Lack of accessible market for any potential peat products
- Limited scope in terms of scale for other options

There are several main advantages of on site use in restoration of borrow pits:

- Minimisation of transportation impacts
- Avoids offsite impacts of transporting material (e.g. dirt on roads)
- Conserves offsite landfill capacity
- Potential for creation of additional habitat on site
- Restoration and enhancement of borrow pit locations

It must be emphasised that the figures used in the above calculations are estimates based on design dimensions and the level of information available at this stage of the project. As the project develops through the design and construction phases, the layout may change as a result of micrositing; construction methods will be refined and may impact on extracted volumes and any of several other factors may impact, either positively or negatively, on the volume of peat extracted.

However, these changes will not impact on the order of magnitude of excavated peat. It is of the order of hundreds of thousands of tonnes, rather than millions or tens of thousands. Consequently, the options recommended here are likely to remain the most appropriate in terms of dealing with peat excavated during the construction process.

10 REFERENCES

HM Revenue and Customs (2009a), *A General Guide to Landfill Tax* - http://customs.hmrc.gov.uk/channelsPortalWebApp/channelsPortalWebApp.portal?_nfpb=true&_pageLabel=pageLibrary_ShowContent&propertyType=document&id=HMCE_CL_000509 (accessed March 2009).

HM Revenue and Customs (2009b), *Landfill Tax: Increases to Rates* - http://www.hmrc.gov.uk/budget2007/bn61.htm (accessed March 2009).

HM Revenue and Customs (2009c) Notice LFT1. A General Guide to Landfill Tax (May 2004).

Mouchel (2009a) *Viking Wind Farm Environmental Statement - Soil and Water (Chapter 14).*

Mouchel (2009b) *Viking Wind Farm Environmental Statement - Soil and Water (Chapter 14); Technical Appendix 14.2 – Borrow Pit Assessment*.

Mouchel (2009c) *Viking Wind Farm Environmental Statement - Soil and Water (Chapter 14; Technical Appendix 14.1 Peat Stability Assessment.*

Envirocentre (2009), *Viking Wind Farm Environmental Statement - Ecology (Chapter 10); Technical Appendix 10.9 Habitat Management Plan*