



Viking Energy Partnership

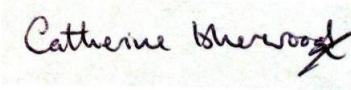
Viking Wind Farm

Technical Appendix 14.2 Borrow Pit Assessment

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APPENDICES

See Environmental Statement Volumes 3 and 4b for all A3 Figures and Technical Drawings

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1 INTRODUCTION

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

Viking Energy Ltd are currently progressing proposals for a wind farm on North Mainland in the Shetland Islands. The proposed wind farm site is located approximately 27km north of Lerwick and is roughly centred on the settlement of Voe (grid reference HU 4077 6320). The area of interest is divided into four quadrants, with two quadrants to either side of the main A970/A968 route which runs north–south across the island. The quadrants are known as; Delting, Collafirth, Kergord and Nesting. All four quadrants of the proposed 150-turbine wind farm comprise areas of open moorland used mainly for rough grazing.

To minimise the volume of foreign material brought onto the site and any consequent environmental impact, borrow pits located within the site will be used to source as much of the necessary material for track construction as possible. Viking Energy has calculated that 1,420,000m³ of aggregate material will be required for the construction of access tracks, turbine base back-fill, compounds and hard-standing areas.

Mouchel was commissioned to undertake a borrow pit assessment for this development site. The aims of this assessment were to provide:

- A preliminary indication of the suitability of the bedrock as a road building material;
- Potential borrow pit locations;
- Indicative borrow pit dimensions;
- Indicative extraction volumes;
- Estimates of overburden at borrow pit locations;
- Indication of potential extraction methods;
- Recommendations for geotechnical testing;
- Preliminary borrow pit reinstatement and rehabilitation proposals.

This document outlines Mouchel's method for borrow pit assessment along with the analysis undertaken, conclusions drawn and recommendations for borrow pit design and location.

It should be noted that all borrow pit information provided within this report is indicative only, and is based on desk study and reconnaissance survey alone. No intrusive investigation has been carried out, and consequently the suitability of the rock, suggested extraction methods and volumes are broad estimates and should be treated as such.

2 PROJECT METHODOLOGY

The project involved a desk study and engineering geology walkover surveys.

The desk study consisted of a review of information with regard to the Viking Wind Farm site which included examining available geological and hydrogeological data together with additional information relating to the site. These included:

- 1:50,000 and 1:10,000 Ordnance Survey topographic maps;
- Digital elevation model (DEM) data;

- DiGMap GB digital geology mapping, British Geological Survey;
- British Regional Geology guide vol. 1: Orkney & Shetland, Institute of Geological Sciences (now British Geological Survey) 1976;
- The Geology of Scotland (4th Edition);
- Aerial photographs;
- Groundwater vulnerability map of Scotland;
- Hydrogeological map of Scotland 1:625,000;
- Soil Survey of Scotland 1:250,000 Sheet 1.

During the desk study potentially suitable sites for borrow pits were identified across the site area.

Visual site inspection and general geological survey work were undertaken in March 2006, with targeted geological fieldwork undertaken on 19-25 February 2008 and 17-28 November 2008. Photographs and detailed field notes were taken at each site, recording the geological and hydrogeological aspects of each identified location. A hand-held GPS unit was used to determine grid references to at least 30m accuracy.

In excess of 60 potentially suitable sites were identified around the site, including existing quarries or borrow pits near the site boundary. Using the estimated volume of aggregate required for the infrastructure, minimising the number of borrow pits whilst at the same time keeping a good coverage across the site, 14 possible borrow pits have been assessed in detail from the potentially suitable sites identified. These include 11 sites within the wind farm boundary and three existing quarries.

A map of the borrow pit locations is given in Figure 14.2.BP01 (in Volume 4b), showing all the identified sites and highlighting the 14 chosen localities.

3 DESK STUDY

3.1 Geology

The geology of Shetland consists partly of metamorphosed sedimentary rocks of Moinian and Dalradian age, and partly of sedimentary and igneous rocks of Devonian age. The Shetland Islands are elongate and dominated by north–south trending geological units cut by a series of similar trending faults.

North Mainland is cut by several major strike-slip faults trending north–south, in particular the Walls Boundary Fault (WBF), the Nesting Fault and the Melby Fault. The WBF is thought to be the northward extension of the Great Glen Fault and has undergone several phases of movement during its geological history. The rocks within the proposed development area lie predominantly between the Walls Boundary Fault to the west and the Nesting Fault to the east, with a small section of the Nesting quadrant lying to the east of the Nesting Fault.

Shetland is divided into two geologically distinct sections, typically called East and West Shetland and separated by the WBF. The East Shetland succession, east of the WBF, consists of a thick sequence of north–south trending metasediments with a vertical or steep dip, younging to the east. The rock types vary from schist and gneiss to quartzite and metalimestone. The sequence has been intruded by plutonic igneous complexes of variable composition, and is cut by a sequence of sills and dykes. The development area lies entirely within the East Shetland succession.

The solid geology is extensively covered by drift deposits, mostly composed of blanket peat and glacial material. Blanket peat is fairly extensive across the development area, forming a nearly unbroken cover over much of the site. There has been significant erosion on some hill and ridge tops, in places exposing the mineral soil. The peat is slightly more broken further south, giving more bedrock exposure especially in the Kergord quadrant and the area to the east of the Nesting Fault in the Nesting quadrant.

The peat is often underlain by a thin irregular layer of glacial till; the till is sometimes exposed in stream and road sections, especially in areas where peat is absent. Hummocky till or moraine deposits are noted in some localised areas with thin peat. Alluvium is present in small amounts in some river valleys but is very minor in extent, as are the occasional lacustrine deposits. Marine beach deposits are present along much of the coastline with minor blown sand in places. Glaciofluvial material is confined to a small area south of the Kergord quadrant.

Maps of the solid and drift geology are presented in ES Figures 14.1 and 14.2, respectively (both in Volume 3).

3.2 Hydrogeology

The Viking Wind Farm site is mostly underlain by impermeable Pre-Cambrian basement rocks. These rocks have very restricted groundwater flow, mostly through shallow, near-surface fracture systems, joints and along fault lines. Groundwater storage is equally restricted to these fractures and faults, as the crystalline nature of the rocks themselves prevents significant infiltration by groundwater. There are a few bands of metalimestone or marble that cross the site; these are susceptible to chemical weathering and dissolution, particularly along lines of pre-existing fractures, joints or bedding planes. In consequence, there may be increased groundwater flow and storage capacity within these bands, through these widened fractures and discontinuities.

Groundwater infiltration in the study area, based on geology, topography and baseflow data, is estimated to be between 100 and 300mm per year (Robins, 1988).

Given the impermeability of the underlying solid geology throughout the site it is likely that perched water tables exist in the more permeable overlying drift deposits. This will be most evident in peat deposits in areas of low relief or hollows, which will be almost fully saturated with a water table close to or at the surface. As a result there is little capacity for storage and most rainfall will become surface run-off. Lateral seepage through the peat provides a low baseflow for local watercourses. Where peat is located on steeper slopes the water table will be depressed and the area drier.

The impermeable nature of the bedrock across the area means that water may accumulate at the peat/bedrock interface. Such pooling of water may reduce the cohesion between the peat matrix and the bedrock and could act as a trigger for peatslides; however, this is difficult to assess without intrusive site investigation.

The groundwater in this area is dominantly classed as 4d (vulnerable) with small areas of classes 4a-c and 5. This classification reflects the low permeability and low groundwater storage capacity of the metamorphic and igneous bedrock combined with the very variable soil and drift cover, meaning that any contaminant could potentially enter the groundwater rapidly but would be slow to disperse or dilute once in the aquifer. In areas with deep peat, the peat would act as a barrier to the entry of contaminants into the groundwater although it would also serve to restrict access of water into the bedrock for dilution purposes.

3.3 Suitability of Bedrock as Aggregate

Many of the igneous and metamorphic rocks on Shetland have been used to supply aggregate for road construction (Mykura, 1976). The igneous rocks present are mostly coarse-grained, such as granite and gabbro. Granites and some mafic igneous rocks are currently quarried as aggregate on Mainland. The less foliated metasedimentary rocks are likely to provide good aggregate (Collis & Fox, 1985); these include gneisses, quartzites, psammites and marbles. The more fissile schists may be suitable but are likely to have greater variability and their use should be subject to appropriate testing. Schists and phyllitic schists are also quarried as aggregate on Mainland Shetland.

3.4 Assessment of Possible Flood Risk

The widespread occurrence of small perched lochans across the wind farm site poses a significant hazard to construction work, especially to blasting related to borrow pit excavation. The blasting could damage the peat dam holding the water, causing sudden catastrophic flooding; this could, in turn, flood the borrow pit locality if topography is not properly considered prior to borrow pit development.

This risk has been evaluated for each proposed borrow pit presented in the following assessment. In all cases, the borrow pits are sited well away from perched lochans and as they form topographic highs they are very unlikely to be subject to flooding.

4 ENGINEERING GEOLOGY WALKOVER SURVEY

A walkover survey of the site was conducted during March 2006 by a Chartered Engineering Geologist, with supporting fieldwork conducted on the 19-25 February 2008 and 17-28 November 2008. Visual site inspections, photographs and detailed field notes were taken reporting the geological and hydrogeological aspects of each of the identified locations. A hand-held GPS unit was used to obtain locations to at least 30m accuracy.

During the desk study and walkover survey a total of 61 potential borrow pit locations were identified around the site. These included 32 within the development area and 29 existing borrow pits or quarries nearby. Of these 61 sites, 14 were chosen for further detailed assessment. These choices included considerations of the amount of aggregate required, a good coverage of the site to restrict necessary aggregate transport and minimising the total number of borrow pits in order to limit the environmental and noise impact of the extraction.

The chosen sites include 11 within the development area and three existing quarries which lie near entry points for site access routes. The following sections give specific information about each site and are accompanied by A3 technical drawings presented in Volume 4b as Figure 14.2.BP-DBP01 etc. Note that the borrow pit list is not sequential (i.e. there are no NBP02, NBP07 or NBP08 pits).

Due to the large size of the site it is anticipated that all the borrow pit sites within the site boundary will be required to produce aggregate. Extraction from existing quarries or borrow pits is dependent on the granting of appropriate permissions, which may not be practical owing to potentially increased disruption to local residents, traffic on public highways and disturbance of recognised geological features. For this reason, borrow pits DBP01, NBP03 and NBP04 have been assessed on the basis that some of these will be used, rather than all. This gives an extra allowance of aggregate built in to the calculations.

4.1 Borrow Pit DBP01

Borrow Pit DBP01 is an existing disused site, known as Valayre Quarry, beside the B9076. It lies approximately 2km north of Brae, at grid reference HU 3689 6949. It should be noted that Valayre Quarry has been designated as a Site of Special Scientific Interest (SSSI) for its rock exposures.

This location is situated roughly halfway between two of the access routes into Delting quadrant, which makes it a good place from which to make the relatively small volume initial extractions before the borrow pits within the site itself are reached, whilst at the same time avoiding aggregate loads being transported through the settlements of Brae and Voe. The main quarry face is about 270m long and up to 20m high (Figure 1). Slope angles are in the range of 5-10° and the site is at an elevation of 15-40m above ordnance datum (AOD). Peat depths were not measured due to the difficulty of gaining access to the top of the quarry wall, but are likely to be thin.

Figure 1 Photograph of DBP01: View of main quarry face looking south-east



The proposed extraction would follow the existing quarry face, cutting back into the hill to the south-east of the quarry. The lithology, shown in Figure 2, has a variable texture:

- Dark grey;
- Medium- to coarse-grained;
- Well-foliated and platy, with foliation varying from mm-scale to over 1m;
- Some fracturing and jointing;
- Fresh to discoloured;
- Schistose GNEISS;
- Strong to very strong.

Figure 2 Close-ups of bedrock at DBP01: (a) Variable fabric, fracturing and shearing (hammer 30cm long); (b) Massive gneissose banding (scale bar 2m).



4.2 Borrow Pit DBP02

Borrow Pit DBP02 (grid reference HU 3771 6691) lies on the south-west access route into Delting quadrant, 2.4km south-east of Brae. It is situated on a moderately steep west to south-west facing slope with extensive but scattered rock outcrop (Figure 3a). Good outcrop extends north from the proposed site for at least 400m, allowing for flexibility of position should this be required. The site elevation ranges between 90 and 125m AOD with slope angles in the range of 5-25°. Peat depths are variable across the site, usually <0.7m but in some places are over 1m.

The proposed borrow pit would lie along an axis running SW–NE and cutting back into the main slope of the hill, making use of existing breaks-in-slope and outcrop where possible. The rock identified at this site (Figure 3b) is:

- Pale to dark grey;
- Medium- to coarse-grained;
- Strongly banded, usually 1-10cm wide, with folding, some jointing and massive quartz veins present;
- Fresh to discoloured;
- Gneissose SCHIST;
- Strong.

Figure 3 Photographs of DBP02: (a) Overview of site from the south-west; (b) Close-up of bedrock, showing foliation and jointing (peat probe marked in 10cm divisions)



4.3 Borrow Pit DBP03

Borrow Pit DBP03, grid reference HU 4065 6985, lies in the central section of Delting quadrant on the north-east ridge of the Hill of Dale and near to the proposed track route between Turbines 12 and 16. The site takes advantage of the break-in-slope on the northern side of the ridge and covers an area of exposed mineral soil with bedrock outcrops (Figure 4). Slope angles range between $<1^\circ$ and 15° , and the site is at an elevation of 195-215m AOD. Recorded peat depths around this site indicate it is mostly fairly shallow at $<0.5\text{m}$.

Figure 4 Photographs of DBP03: (a) View uphill over site showing mineral soil exposure (peat probe 1m long); (b) Close-up of rock-step (hammer 30cm long).



The proposed borrow pit would lie along an axis running NNW–SSE into the side of the hill. The rock identified at this site (Figure 4b) is:

- Pale grey to white;
- Medium- to coarse-grained;
- Well-developed pervasive platy foliation, usually 5-10mm wide, with some folding and jointing;
- Fresh;
- QUARTZITE & PSAMMITE;
- Strong to very strong.

4.4 Borrow Pit CBP01

Borrow Pit CBP01, grid reference HU 4174 6604, is the only borrow pit in the Collafirth quadrant and is situated on the main access route into the site from the north-west. The site lies on the northern end of the Hill of Susetter where the slope steepens. Slope angles range between 3 and 18° with elevation between 95 and 110m AOD. Peat cover is mostly thin, typically between 0.3 and 0.7m, although is likely to deepen south and east from the exposed bedrock.

Figure 5 Photographs of CBP01: (a) View north-west over site showing rocky ridge; (b) Close-up of rock outcrop (hammer 30cm long)



The proposed borrow pit lies on the break-in-slope with a main axis running NNW–SSE. There are small outcrops near the top of the site, forming rocky ridges (Figure 5a) with small craggy outcrops towards the northern margin of the site. The lithology present is shown in Figure 5b and is:

- Pale to dark grey;
- Medium- to coarse-grained;
- Very strongly foliated with distinct colour banding, pegmatitic areas and quartz veins, tight folds visible in places;
- Fresh to discoloured;
- Gneissose SCHIST;
- Moderate to strong.

4.5 Borrow Pit KBP01

Borrow Pit KBP01 lies at the northern end of Mid Kame Ridge, beside the access route from the A970, at grid reference HU 4058 6073. It is situated on a moderately steep north-west facing slope immediately adjacent to the proposed track route. Slope angles range between 8 and 20° and the site is at an elevation of 90-115m AOD. No bedrock is exposed at the site, although there are areas of mineral soil across this part of the hill slope (Figure 6).

Peat cover is very variable, from 0.6m in the areas of mineral soil, to >1m both above and below the proposed site. It is also likely that the upper part of the bedrock is significantly affected by weathering, although cannot be confirmed without intrusive investigation.

Figure 6 Photographs of KBP01: (a) View across the site to the south-west; (b) View downhill over the site to the north-west (peat probe 1m)



The proposed borrow pit lies along a NW–SE axis to take advantage of the slope angle. In the absence of exposed bedrock, the lithology has been described using mineral soil exposure alone, as shown in Figure 7, and is consequently incomplete:

- Pale grey;
- Medium- to coarse-grained;
- Well-banded;
- Granitic GNEISS;
- Strong to very strong.

Figure 7 Photograph of KBP01: close-up of mineral soil (peat probe 1m)



4.6 Borrow Pit KBP02

Borrow Pit KBP02 is situated in the north-central section of Kergord quadrant at grid reference HU 3918 5763. It lies on the northern ridge of Scalla Field leading down to the col at Scallafeld Scord and is adjacent to the proposed track route. The site is at an altitude of 205-240m AOD with slope angles ranging from 8 to 30°. Peat cover is very variable, from <0.1m adjacent to outcrop to >1m in other sections.

Figure 8 Photographs of KBP02: (a) View south-west across borrow pit site to Scalla Field; (b) Rocksteps exposed on the northern end of the ridge (peat probe 1m)



The proposed borrow pit lies on the western side of the ridge to take advantage of the steeper rocky slopes in this area (Figure 8a). Bedrock is exposed across the site as a series of small rocksteps (Figure 8b), rough slabs and rocky knolls, becoming more poorly exposed on flatter ground to both the east and the west. The lithology is:

- Mid- to pale grey;
- Medium to coarse-grained;
- Well-foliated with distinct folding (Figure 9a), colour banding and a porphyroblastic texture in places (Figure 9b);
- Fresh to discoloured;
- Psammitic SCHIST;
- Strong.

Figure 9. Photographs of KBP02: (a) Close-up of folded psammite; (b) Close-up of foliated schist with porphyroblasts (scale bars marked in 10cm sections)



4.7 Borrow Pit KBP03

Borrow Pit KBP03 is located in the central section of Kergord quadrant, at grid reference HU 3834 5527. It is situated on the north-west ridge of the West Hill of Weisdale which runs down to the division between Maa Water and Lamba Water. The ridge section has considerable but scattered rocky outcrop (Figure 10a), mostly as a series of rough slabs. Peat depths are quite variable, with pockets of >1m, although it is <0.6m across most of the site. The site is at an elevation of 140-170m AOD and has slope angles ranging from 2-23°.

Figure 10 Photographs of KBP03: (a) View north-west over borrow pit site; (b) Close-up of narrowly foliated bedrock (scale bar 20cm)



The proposed borrow pit has an axis running NW–SE to follow the ridge line and make best advantage of the slope angles. The lithology, shown in Figure 10b, at the site is:

- Pale grey;
- Fine to medium grained;
- Very well and narrowly foliated on a mm-scale with distinct colour banding throughout;
- Fresh to discoloured;
- SCHIST & PSAMMITE;
- Strong to very strong.

4.8 Borrow Pit KBP04

Borrow Pit KBP04 lies at the southern tip of Kergord quadrant adjacent to the main southern access route, at grid reference HU 3792 5057. The site is on the south-facing slope of the Hill of Sound just above the A971. The slope has a moderately steep gradient and a small scattering of bedrock and boulders (Figure 11a). Slope angles range from 4-25° and the site is at an elevation of 125-150m AOD. Peat cover is shallow across the whole slope, mainly in the range of 0.2-0.3m.

The proposed borrow pit follows a N–S axis to take best advantage of the slope in this area. The exposed lithology, described from the small amount of outcrop visible at the site (Figure 11b), is:

- Pale grey;
- Medium to coarse-grained;
- Very well-banded with pervasive but poorly developed foliation;
- Fresh to discoloured;
- Gneissose SCHIST;
- Strong to very strong.

Figure 11 Photographs of KBP04: (a) View south over borrow pit site; (b) Close-up of bedrock (peat probe 1m, marked in 10cm sections)



4.9 Borrow Pit NBP01

Borrow Pit NBP01 lies at the northern end of the Nesting quadrant at grid reference HU 4198 6151. It forms the main borrow pit for the northern section of the Nesting quadrant. It is sited on the southern ridge of South Filla Runnie, cutting into the west-facing slope where there is good bedrock exposure and a suitable break-in-slope. Site elevation is between 110 and 130m AOD with slope angles up to 17°. Recorded peat depths are shallow, mostly <0.5m.

Figure 12 Photographs of NBP01: (a) View of main outcrop looking south; (b) Close-up of marble showing jointing and included chert band (GPS handset 11cm long)



This proposed borrow pit cuts into the ridge along a ENE–WSW axis. Bedrock is exposed in a series of ice-smoothed outcrops across the top and side of the ridge with rocksteps to about 3m high (Figure 12a). The rock type is:

- Mid- to pale grey-brown;
- Fine to medium-grained;
- Well-jointed with folding and some colour banding, including small chert and pegmatite bodies;
- Fresh to discoloured;
- MARBLE;
- Strong to very strong.

Figure 12b shows a close-up of the exposed marble, including a chert band just above the GPS handset.

4.10 Borrow Pit NBP03

Borrow Pit NBP03, grid reference HU 4211 5619, is an existing disused borrow pit immediately east of the A970 (Figure 13). In common with NBP04, this borrow pit is situated near the main access to South Nesting as well as fairly close to the access routes to North Nesting and Mid Kame ridge in the Kergord quadrant. This makes it an excellent place from which to source aggregate for immediate access requirements, until borrow pits within the site can be reached.

Figure 13 Photographs of NBP03: View of existing borrow pit back wall looking east (peat probe 1m long)



The proposed extraction would extend the existing borrow pit back into the side of East Kame ridge along an E–W axis and would also widen the pit both north and south of its current position. Slope angles in the area are between 10 and 20° and the elevation ranges from 65-95m AOD. Peat depths were not measured due to difficulties of access but are likely to be shallow.

The rock present at the location is:

- Pale grey;
- Coarse-grained;
- Massive with some jointing in places and a poorly developed foliation;
- Fresh to discoloured;
- Gneissose GRANITE;
- Strong to very strong.

Figure 14 Close-up of bedrock at NBP03: detail of exposed granitic bedrock showing massive nature (GPS handset 11cm long)



4.11 Borrow Pit NBP04

Borrow Pit NBP04 is situated 300m south of NBP03, at grid reference HU 4212 5587, and is also a disused quarry. Like NBP03, it lies immediately east of the A970 and is currently disused although the extraction here was more extensive than at NBP03. The quarry has been partially back-filled (Figure 15), which restricts access to the existing quarry walls and which may require removal if the quarry is to be reopened.

Figure 15 Photograph of NBP04: View of main backwall of quarry looking east, showing partial back-fill at right-hand side of photograph



The proposed extraction would extend the quarry back into the side of East Kame ridge along an ESE–WNW axis. Slope angles in the area range between 10 and 16° with the elevation ranging from 75 to 100m AOD. Peat angles were not measured due to difficulty of access but are likely to be shallow.

The lithology present at the site is shown in Figure 16 and comprises:

- Mid- to pale brown;
- Medium- to coarse-grained;
- Heavily fractured with strong and pervasive colour banding, quartz veins in places;
- Variably discoloured to disintegrated, decomposed to a sand-like consistency in places;
- Gneissose GRANITE;
- Moderately weak to strong.

Figure 16 Close-ups of bedrock at NBP04: (a) View of exposed bedrock in backwall of quarry (peat probe marked in 10cm sections; (b) Close-up of water-worn channel through bedrock (GPS handset 11cm long)



4.12 Borrow Pit NBP05

Borrow Pit NBP05 lies near the south end of Nesting quadrant, near the main access route into the site, at grid reference HU 4380 5684. It is situated just north of the summit of the Dud of Flamister and takes advantage of the slope to the east side of the hill. The area has been subject to extensive peat erosion, with large sections of the hilltop eroded to the mineral soil (Figure 17a), some of which has begun to revegetate. The site is at an altitude of 155-170m AOD with slope angles ranging between 1 and 15°. Recorded peat depths are up to 0.6m although some remnant peat banks on the hill summit may be up to 1.5m thick.

The proposed borrow pit is oriented nearly E–W to take advantage of the steeper slope and exposed mineral soil. There is no exposed bedrock at the site so the lithological description has been derived entirely from mineral soils and is consequently incomplete. The lithology, shown in Figure 17b, is:

- Pale to mid-grey;
- Medium-grained;
- Well-foliated and platy with some limited colour banding;
- Fresh to discoloured;
- PSAMMITE;
- Strong to very strong.

Figure 17 Photographs of NBP05: (a) View across site looking north (scale bar 1m); (b) Close-up of mineral soil (scale bar 30cm)



4.13 Borrow Pit NBP06

Borrow Pit NBP06 is located on the eastern access route into the Nesting quadrant at grid reference HU 4656 5629. It lies on a well-defined rocky ridge with bedrock exposed as small rocksteps and slabs (Figure 18a). Slope angles range between <1 and 20° and the site is at an altitude of 75-100m AOD. Peat cover is variable across the site; on the ridge is it mostly no more than 0.5m but is deeper towards the edges and away from the rocky outcrops.

Figure 18 Photographs of NBP06: (a) View south down the ridge towards the access track (peat probe 1m); (b) Close-up of bedrock (hammer 30cm)



The proposed borrow pit is oriented N–S to take advantage of the steeper slope and thinner peat overburden on this side of the ridge. The lithology exposed at the site (Figure 18b) is:

- Mostly mid- to pale grey;
- Medium- to coarse-grained;
- Well-banded with jointing, folded in places;
- Fresh to discoloured;
- Granitic GNEISS;
- Strong to very strong.

4.14 Borrow Pit NBP09

Borrow Pit NBP09 is a small borrow pit site beside the eastern access route into the Nesting quadrant and immediately adjacent to the B9075. It is situated at grid reference HU 4651 5575 on the lower slopes of the Hill of Skellister. Bedrock is exposed in a series of rocky knolls and small rocksteps across the slope (Figure 19) and down towards the sea. The site is at an elevation of 40-50m AOD and slope angles range from 3 to 20°. Peat cover across the site ranges from <0.1m in areas adjacent to rock outcrops to >1m in the more boggy sections.

Figure 19 Photographs of NBP09: (a) View W over site showing rocky knolls and rocksteps; (b) Knoll at top of site (peat probe 1m)



The main axis of the proposed borrow pit runs nearly E–W to take advantage of the natural slope angles. Two rock types are exposed at the site. At the lower, eastern, end the lithology (Figure 20a) is:

- Mostly pale grey;
- Medium- to coarse-grained;
- Well-jointed with some gneissose foliation and colour banding visible in places;
- Fresh to discoloured;
- Granitic GNEISS;
- Strong to very strong.

At the western end, including the top of the site, the lithology (Figure 20b) is:

- Pale brown to grey;
- Fine to medium-grained;
- Well-banded with some jointing;
- Fresh to discoloured;
- MARBLE;
- Strong to very strong.

Figure 20 Close-ups of bedrock at NBP09: (a) Gneissic bedrock in lower part of site (scale 20cm); (b) Part of marble outcrop showing banded texture (peat probe 1m)



5 POTENTIAL BORROW PIT ASSESSMENT

The main part of the borrow pit assessment is in the form of technical drawings which can be found in Figure 14.2.BP-DBP01 etc (in Volume 4b). Each technical drawing includes a location map for the borrow pit within the site, a photograph of the borrow pit, a site plan showing the proposed borrow pit footprint and a schematic cross-section. It should be noted that the borrow pit footprints and cross-sections illustrated have been produced using available DEM data and field observations where appropriate and consequently they are not detailed designs but are indicative only.

Table 1 illustrates the proposed borrow pit dimensions for each of the 14 sites. The volumes given have been calculated from cross-sections of the borrow pit, taking into account the benches and gradients of the extraction face, and not from the borrow pit footprint dimension and depth approximations shown. It is anticipated that the borrow pits will be excavated predominantly by drilling and blasting given the hard and resistant nature of the metamorphic and igneous bedrock prevailing in the Shetland Islands. The approach at specific sites may vary given site-specific requirements or constraints; for example, extra care would be required for blasting should extraction be undertaken at Valayre Quarry (DBP01) to avoid damage to the protected exposures.

It should be noted that the given borrow pit dimensions and volumes are estimates. Detailed ground investigations and geotechnical testing will be required to inform detailed design of the borrow pits.

Table 1. Indicative borrow pit dimensions & extraction volumes

Pit ID	NGR Location	Approximate footprint dimensions (m) *	Approximate footprint area (m ²)	Max. depth (m)	Approximate volume (m ³)	Probable extraction method
DBP01	HU 3689 6949	65 x 87	2,980	22	40,000	Drilling & blasting
DBP02	HU 3771 6691	114 x 174	17,190	25	195,000	Drilling & blasting
DBP03	HU 4065 6985	109 x 124	12,130	15	115,000	Drilling & blasting
CBP01	HU 4174 6604	98 x 107	9,520	10	73,000	Drilling & blasting
KBP01	HU 4057 6069	87 x 100	7,730	20	80,000	Drilling & blasting
KBP02	HU 3918 5763	118 x 105	11,020	25	148,000	Drilling & blasting
KBP03	HU 3834 5527	130 x 98	10,460	25	131,000	Drilling & blasting
KBP04	HU 3792 5057	96 x 90	8,090	18	80,000	Drilling & blasting
NBP01	HU 4198 6151	140 x 138	17,700	10	138,000	Drilling & blasting
NBP03	HU 4211 5619	90 x 93	7,750	23	83,500	Drilling & blasting
NBP04	HU 4212 5587	68 x 130	8,420	20	83,500	Drilling & blasting
NBP05	HU 4380 5684	132 x 145	16,890	15	161,000	Drilling & blasting
NBP06	HU 4657 5630	140 x 130	15,560	15	169,000	Drilling & blasting
NBP09	HU 4651 5575	56 x 38	1,920	10	10,500	Drilling & blasting
Total estimated volume (m³):					1,507,500	

* 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.

It will be observed that the total estimated volume is considerably in excess of the volume estimated as required for the construction work. During the assessment it was considered appropriate to assume that either but not both of borrow pits NBP03 and NBP04 would be used to supply aggregate, as they are situated so close together. Also, borrow pit NBP09

has a larger volume than is required, in order to make it exploitable. Should it be decided against reopening Valayre Quarry (DBP01), there should be sufficient capacity in locations elsewhere to source the relevant volume of material.

It is anticipated that, upon completion, the borrow pits will be partially reinstated. This will involve the reworking of faces to stabilise them, partial infilling with surplus material and landscaping. At each site there may be the potential for environmental enhancement by creating small wetlands or other desirable habitats. Reinstatement plans for Valayre Quarry, if applicable, would be discussed with Scottish Natural Heritage.

An assessment of the effects of the borrow pits on the local hydrology and hydrogeology has been undertaken and incorporated into the soil and water chapter of the Environmental Statement (Mouchel, 2009). This includes:

- Limiting entry of surface run-off into borrow pits;
- Limiting entry of groundwater into borrow pits;
- Drainage and treatment of water collecting in borrow pits;
- Storage of excavated material for post-use restoration and rehabilitation.

6 CONCLUSIONS & RECOMMENDATIONS

Engineering geology walkover surveys have been carried out across the site and 14 potential borrow pit locations have been identified from fieldwork visual appraisals and measurements and desktop data analysis. The surveys demonstrated that the areas of greatest potential in terms of bedrock excavation were located on the breaks in slope, slope sides and existing quarry sites. The peat depths at these sites are generally shallow and generally $\leq 0.5\text{m}$.

Using the information gathered, an assessment of borrow pit locations was carried out. Borrow pit dimensions and volumes were estimated and probable extraction methods identified. It is estimated that the total rock volume which could be extracted from the 14 identified sites is approximately $1,507,500\text{m}^3$ if all sites are used.

Detailed ground investigations, slope stability assessments and geotechnical testing will be required to inform the detailed design of the borrow pits.

7 REFERENCES

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We have used our reasonable endeavours to provide information that is correct and accurate and have discussed above the reasonable conclusions that can be reached on the basis of the information available. Having issued the range of conclusions it is for the client to decide which borrow pits to use and the methods of extraction, stabilisation and restoration appropriate to each site.