Appendix 1

Condition 10 Cutaway Bog Rehabilitation

10.1 Following termination of use or involvement of all or part of the site in the licensed activity, the licensee shall:

10.1.1 Decommission, render safe or remove for disposal/recovery, any soil, subsoils, buildings, plant or equipment, or any waste, materials or substances or other matter contained therein or thereon, that may result in environmental pollution.

10.1.2 Implement the agreed cutaway bog rehabilitation plan (refer Condition 10.2).

10.2 Cutaway Bog Rehabilitation Plan:

10.2.1 The licensee shall prepare, to the satisfaction of the Agency, a fully detailed and costed plan for permanent rehabilitation of the cutaway boglands within the licensed area. This plan shall be submitted to the Agency for agreement within eighteen months of the date of grant of this licence.

10.2.2 The plan shall be reviewed every two years and proposed amendments thereto notified to the Agency for agreement as part of the AER. No amendments may be implemented without the written agreement of the Agency.

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10.3 The Rehabilitation Plan shall include as a minimum, the following:

10.3.1 A scope statement for the plan; to include outcome of consultations with relevant Agencies, Authorities and affected parties (to be identified by the licensee).

10.3.2 The criteria which define the successful rehabilitation of the activity or part thereof, which ensures minimum impact to the environment.

10.3.3 A programme to achieve the stated criteria.

10.3.4 Where relevant, a test programme to demonstrate the successful implementation of the rehabilitation plan.

10.3.5 A programme for aftercare and maintenance.

10.4 A final validation report to include a certificate of completion for the Rehabilitation Plan, for all or part of the site as necessary, shall be submitted to the Agency within six months of execution of the plan. The licensee shall carry out such tests, investigations or submit certification, as requested by the Agency, to confirm that there is no continuing risk to the environment.

Reason: To make provision for the proper closure of the activity ensuring protection of the environment.

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BORD NA MÓNA

BORD NA MÓNA ENERGY LIMITED

Cutaway Bog Rehabilitation

A document to detail the rehabilitation and aspects of decommissioning of the Oweninny Works in compliance with Condition 10 of IPC Licence Ref. No. 505, and incorporating rehabilitation following the development of the proposed Oweninny wind farm

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May 2003

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Fig.2. OAE1 (Bellacorick): Map showing production, cutaway and new development bog, bog remnants, watercourses, lakes and other predominant physical features.

Fig.3. OAE2 (Bangor): Map showing production, cutaway and new development bog, bog remnants, watercourses, lakes and other predominant physical features.

Fig. 2 & 3.The colour code for these two figures is as follows:

Red shading:	bog remnants
Yellow shading:	new development bog
Green shading:	forestry
Brown shading:	production bog
Pink shading:	cutaway bog
Blue shading:	natural lakes

The Bord na Móna boundary is highlighted in black, while the courses of the main rivers are illustrated. The production areas are highlighted and labelled, allowing for ease of reference to particular areas mentioned in the text.

Fig.14. Aerial photograph of the OAE1 (Bellacorick) site. This shows the peat production areas relative to the surrounding areas. At the Bellacorick site, cross reference with Fig. 2 shows areas of cutaway bog that are revegetating and areas where the underlying gravel hills have been revealed. Also clearly visible are bog remnants, watercourses and forestry areas.

Fig.15. Aerial photograph of the OAE2 (Bangor) site illustrating the location of the peat production areas relative to Bangor town and the main watercourse of the Owenmore River. Cross-reference with Fig. 3 will highlight the different habitat / bog conditions visible on the map. Clearly visible are the new development areas referred to on page 26.

Fig.22. New design layout for *Phase 1* of the wind farm project.

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PART 1

REHABILITATION OF THE OWENINNY BOGLANDS

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1 INTRODUCTION

Research into the after-use of cutaway industrial peatlands has been ongoing by Bord na Móna since the 1960s. Initially the main focus was on finding a commercial after-use for these areas and a number of experimental trials were established across the range of Bord na Móna peatlands to determine the success of vegetable growing, forestry, grassland and biomass crops. In latter years the focus has shifted towards allowing the post-industrial peatland areas to naturalise and revert to wetland and dry wilderness areas. A number of alternative after-uses have been explored at the Oweninny Works, including coniferous forestry, biomass, agricultural grassland, wind-energy and wetland creation. The former options have proven commercially inviable while the latter two options are deemed viable and beneficial to the area.

Bord na Móna submitted a rehabilitation plan as part of the IPC Licence for the cutaway boglands of the Oweninny Works to the EPA in January 2002. This rehabilitation plan was essentially a generic plan that outlined the criteria defining successful rehabilitation at the Oweninny Works and described a number of test programmes that incorporated the principles and methods of rehabilitation. The EPA approved the rehabilitation plan in June 2002 (Ref. No. 505). The condition that refers to cutaway bog rehabilitation within the IPC Licence is Condition 10 (Appendix 1). Both decommissioning of the site and rehabilitation of the cutaway boglands are addressed under Condition 10, encompassing the totality of the Oweninny Works.

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Since the submission of the original rehabilitation plan in January 2002 a number of issues have been clarified and further developments that will impact on the rehabilitation plan have been brought to light. These are outlined as follows:

- The closure date for the Oweninny Works has been set for December 2004.

- There has been an application to Mayo County Council for planning permission to establish a large wind farm on the Bord na Móna Bellacorick Holdings. The plan is a joint venture between Bord na Móna Energy Ltd. and ESB (Electricity Supply Board).

- Subsequent to approval of the initial plan, Bord na Móna has continued to develop the specifics of the rehabilitation plan for the Oweninny Works. Formal consultation proceedings with statutory bodies and other parties with a recognisable concern for rehabilitation of the Oweninny Works were initiated in December 2002 (the original rehabilitation plan was circulated for comments).

In the light of these developments, Bord na Móna is progressively updating the rehabilitation plan, providing more detail in the event of the after-use at the Oweninny Works being (a) the development of replacement wetland habitats, and (b) the establishment of a wind farm. Following the consultation process involving those interested parties the scope of the plan will be outlined. This document therefore, represents the updated rehabilitation plan as a work in progress and the outcome of consultations to date is included.

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2 AIMS OF THE REHABILITATION PLAN

The aim of rehabilitation of the Oweninny Works is to ensure the stabilisation of the peat production area, while encouraging the area to blend with the surrounding Atlantic blanket bog landscape. The approach requires initial active rehabilitation work (blocking drains, etc.), followed by monitoring of effectiveness of this work. However, it is anticipated that natural processes of revegetation and vegetation succession will lead to the area becoming self-sustaining and stabilised, comprising a mosaic predominantly of man-made wetland habitats that will contribute to the existing natural biodiversity of the area.

The aims of this document are outlined as follows:

- To outline a detailed cutaway bog rehabilitation plan for the Oweninny Works (OAE1: Bellacorick and OAE2: Bangor), to include a breakdown of habitats on site, the range of conditions and rehabilitation work necessary to provide for the stabilisation of the site. The plan will include estimated timeframes for rehabilitation (and some decommissioning) measures to be completed.
- To outline *Phase 1* of the Oweninny Wind Farm project, detailing the impact of *Phase 1* of the wind farm development (incorporating pre-, during and post-construction phases) on the current rehabilitation plan[1].

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[1] The rehabilitation plan for the proposed wind farm has been developed in tandem with the re-design of the road and wind turbine network to mitigate any negative impacts on the initial rehabilitation plan. This general approach to the design of the wind farm taking cognisance of the criteria outlined in the original rehabilitation plan (submitted January 2002) for the site in general, provides the blueprint for development of rehabilitation plans for subsequent construction phases (*described later*).

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3 DEVELOPMENT OF A SCOPE STATEMENT FOR THE REHABILITATION PLAN *(WORK IN PROGRESS)*

The development of the rehabilitation plan has been ongoing since 1996 and the key issues of rehabilitation were identified between 1996 and 1999 through postgraduate research work (Farrell 2001) conducted through the Botany Department at University College Dublin. Formal consultation with other interested parties has been initiated, during the course of which additional issues of concern have been identified, therefore broadening the scope of the rehabilitation plan.

3.1 Consultation

Following notification from the EPA (letter dated 26/11/02), Bord na Móna forwarded a copy of the *Rehabilitation of Cutaway Bog Plan* (January 2002) to the relevant agencies, authorities and affected parties as identified by Bord na Móna and the EPA. These included:

- Dúchas, National Parks and Wildlife Service (Divisional Ecologist and Regional Conservation Officer)
- North West Regional Fisheries Board
- Mayo County Council
- Coillte
- An Taisce
- Irish Peatland Conservation Council

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3.2 Scope of the Rehabilitation Plan

The scope of the rehabilitation plan seeks to address issues of concern as identified by Bord na Móna and the consultees. The consultees have highlighted a number of issues of concern in addition to the key issues identified previously. To date, the key issues identified are:

- Categorisation of the habitats on site and proposed rehabilitation measures for each habitat type
- Stabilisation of the Oweninny boglands
- Maintenance of silt control measures *(decommissioning)*
- Remediation of water courses *(decommissioning)*
- Management of the SACs within the Bord na Móna Holdings
- The timeframe for cutaway bog rehabilitation
- The impact of the proposed Oweninny Wind Farm development on the current rehabilitation plan

This scope will be further revised and updated according to the outcome of further consultations, and will lead to the development of a scope statement for the plan.

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4 REHABILITATION OF THE CUTAWAY BOGLANDS FOLLOWING CLOSURE OF THE OWENINNY WORKS

4.1 Background Information

A comprehensive botanical study of the Oweninny Works was initiated in the mid-1990s. The main aim of this study was to identify key features in stabilisation of the Oweninny boglands following cessation of industrial activity. The work has provided an ecological understanding of the cutaway bog, and an insight into the future landscape development of the Oweninny Holdings post-industrial peat extraction (Farrell 2001).

The main criteria[2] defining successful rehabilitation of the OAE1 and OAE2 sites are:
(i) Stabilisation of the peat production areas[3]
(ii) Mitigation of silt run-off and,
(iii) Re-establishment of peat-forming communities where possible.

There are a number of issues that must be addressed to allow for stabilisation of the site in its entirety and these are addressed within this document. However, the main areas of concern are those areas that were utilised for peat extraction. The work has therefore concentrated on rehabilitation tools to (a) encourage revegetation of the peat production sites and (b) maximise the potential contribution of these post-industrial areas to local biodiversity. This will involve the development of a replacement peatland landscape that will complement the surrounding Atlantic blanket bog landscape, the greater area of which comprises a network of SACs and NHAs (Fig.1).

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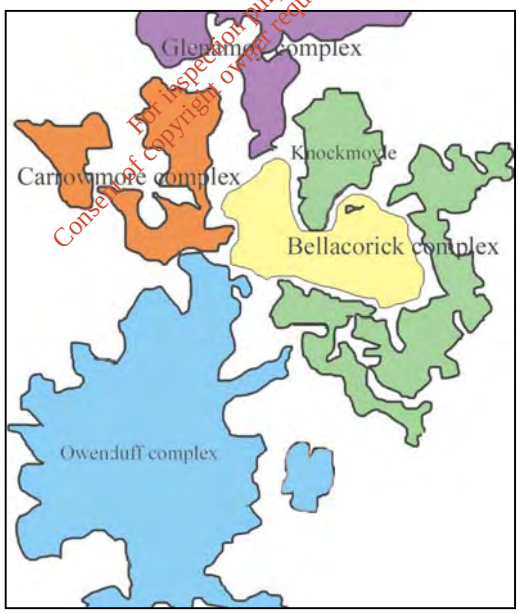


Fig.1. The location of candidate SACs in relation to the peat extraction site at Bellacorick (yellow shading) *after Farrell 2001*. The production area is central to Carrowmore, Glenamoy, Owenduff and Bellacorick bog complexes. These sites will be protected under the EU Habitats Directive. The Bangor extraction site is located south of the Carrowmore and North-west of the Owenduff complex. This site is also central to the network of NHAs and SACs in the Bangor area.

[2] These are the basic criteria as identified in the consultation process to date. They may be subject to modifications.
[3] Stabilisation of these areas infers revegetation. Once stabilised there will be no potential peat run-off from the site, which will cover the second criterion for successful rehabilitation.

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The rehabilitation work to date has focused primarily on cutaway bog areas, and this will ultimately extend to the totality of the Oweninny holdings upon cessation of peat extraction. This has involved (a) the establishment of a baseline vegetation study of the cutaway (1996-1999), (b) experimental work that focussed on determining suitable methods of encouraging vegetation establishment (1996-1999) and (c) large-scale application of the rehabilitation methods (March 2001 *to date*).

An outline of the results attained from each of these steps is described here. An estimate of work required to rehabilitate the site completely will also be presented, with an associated timeframe for completion of the work. Decommissioning of the Oweninny boglands is associated with rehabilitation and reference will be made as to how these two processes are inter-linked. Reference will also be made to the issues of concern that were identified through consultation with interested parties.

The scientific background to the rehabilitation work carried out on the cutaway bog is outlined in Farrell 2001, Farrell & Doyle 1998, and Farrell & Doyle 2003.

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4.2 Categorisation of Habitat Types

The Oweninny Works comprises a complex of habitat types, ranging from hard standings to intact bog to open water areas. Condition 10 of the IPC Licence refers to cutaway bog only. Cutaway bog is the term used to describe industrial peat production areas after the peat of commercial value has been extracted. However, in 2004 the Oweninny Holdings at Bellacorick and Bangor in their entirety will be considered as cutaway bog from the point of view that there will be no further demand for peat by the ESB and the site will be redundant of its industrial application. The term *Oweninny boglands* is therefore a more appropriate umbrella term that includes all of the component habitat types as outlined below.

A breakdown of the Oweninny boglands is outlined in Table 1. These areas are also marked on Figs 2 & 3 (Maps of the production, cutaway, new development, bog remnants, etc.)

Table 1. Breakdown of the Oweninny Holdings

	Hectares		
Bog condition	**OAE1**	**OAE2**	**Total**
Production	1303	680	1983
New development	646	628	1274
Cutaway	1946	78	2024
Forestry	682		682
Bog remnants			400-500
Other areas			<100
Total area	**5051**	**1481**	**6532**

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With reference to Table 1, production bog is that from which peat is still harvested from (peat production will cease either in September 2003 or 2004 depending on rainfall and drying conditions). Cutaway bog refers to peat fields that have been economically exhausted of their peat resource. These cutaway areas may be out of production for a period of up to 20 years. Parts of the cutaway bog, particularly at the OAE1 site have been planted, predominantly with conifers. This area is on a 60-year lease to Coillte (in operation since 1988).

New development refers to areas of Atlantic blanket bog that were ditched, but the surface vegetation was never removed. In general, these areas have begun to rewet again through the natural in-filling in of drainage channels. The bog remnants represent vestiges of the former Atlantic blanket bog complex that pre-existed industrial development at the site. As part of the rehabilitation plan, these areas are recognised as important seed sources and wildlife corridors throughout an otherwise industrial landscape. *Other areas* include watercourses, workshops, etc. and these areas generally come under the heading of decommissioning.

The areas requiring the greater amount of rehabilitation work are those that have been intensively utilised for peat extraction. Intact bog remnants and new development areas will require minimal interference.

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The Oweninny Holdings therefore, comprises a range of habitat types and/or bog conditions, including habitats that were never part of the peat production process. The following habitat types are distinguished:

(a) Shallow peat production fields (less than 1m peat depth)
(b) Cutaway bog (generally less than 0.5m peat depth)
(c) Areas of unstable peat (emerging gravel hills)
(d) Gravel hills (no peat remaining)
(e) Deep peat production fields (more than 1m peat depth)
(f) New development[4] (drained but never fully developed for peat production)
(g) Bog remnants
(h) *Other areas* – railway lines, workshops, roadways, silt ponds, watercourses, etc.

Each of these habitat types will be accounted for in the rehabilitation process, requiring specific rehabilitation measures, e.g. bare gravel hills will have different limitations to revegetation than bare peat fields or silt ponds. Also, there are different issues of concern associated with individual habitats, e.g. on-site rivers and streams may require alternative *remediation* (decommissioning) measures as identified through consultation with the NWRFB[5].

The proportion of each habitat and/or bog condition is outlined in Table 2 (also shown is the habitat type that each 'complex' is assignable to, *after Fossitt (2000)).* This highlights that up to 50% of the area will comprise cutaway bog conditions at the time of closure in 2004 (shallow production bog has the same physico-chemical characteristics of cutaway bog). This is the habitat type that has been dealt with in greatest detail. Up to a quarter can be considered as requiring minimal rehabilitation work (new development and bog remnant areas), while deep production areas will require extensive drain blocking (the least studied of the bog conditions). *Other areas* are covered under the decommissioning procedures and forested areas will remain under Coillte stewardship until further notice.

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Table 2 Percentage of habitats/bog conditions relative to the total area of the Oweninny boglands (6532ha)

Habitat/bog condition	**Area (Approx.) ha**	**% Total area**	**[6]Habitat complex (Fossitt 2000)**
Cutaway	1250	20%	PF2
Gravel areas (cutaway)	750	11%	ED1
Shallow production	1000	15%	PB3
Deep production	1000	15%	PB3
New development	1274	20%	PB4
Bog remnants	400-500	6-8%	PB4
Forestry	682	10%	WD4
Other areas	<100	<2%	

[4] This category can be further broken down into areas of minimal and extensive drainage impact (*see later*).
[5] NWRFB: *North West Regional Fisheries Board*
[6] The habitat types are assigned to habitat complexes as described in the classification system devised by *The Heritage Council* (Fossitt 2000). The assignment is considered justifiable on the basis of the dominant habitat represented within each complex, e.g. cutaway bog is assigned to ***PF2, Poor fen and flush***, as the dominant vegetation is poor fen although there are sporadic patches of other vegetation types occurring (*see later*).

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4.3 Rehabilitation of the Oweninny Boglands

4.3.1 Rehabilitation of cutaway bog, shallow production bog, areas of unstable peat and gravel hills (46% of total holdings)

The work carried out between 1996 and 1999 focussed largely on cutaway bog areas, the results of which are outlined here. This sub-section deals with the greater part of the Owenniny boglands that will require rehabilitation work. The habitat complex and/or bog conditions dealt with in this sub-section includes cutaway bog, shallow production bog (i.e. almost cutaway and may be exhausted of peat within the next two production seasons), areas of unstable peat on slopes and bare gravel hills.

4.3.1.1 A baseline ecological study of industrial cutaway Atlantic blanket bog (work completed 1996-1999)

A comprehensive baseline study of the cutaway bog was carried out to determine the present condition and the factors affecting revegetation of the peat fields (June 1997-August 1999, *this baseline study is described in detail in Farrell 2001 and a general overview is provided here*).

4.3.1.1.1 Physico-chemical conditions of the cutaway bog

The Bord na Móna extraction policy favours harvesting of as much peat as possible, until (a) peat is contaminated by the underlying substrate and ash levels exceed accepted ESB standards, (b) a layer of bog timber is encountered, or (c) continued drainage is no longer feasible. Industrial peat extraction at Bellacorick has therefore, resulted in a heterogeneous landscape of gravel hills and shallow peat. The cutaway fields are distributed among current production fields, with cutaway withdrawn from production on a yearly basis.

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The pH of cutaway peat fields ranges from pH 3.8 to 4.5. In peat-filled depressions, drainage water from the surrounding elevated areas provides some nutrient enrichment, with pH ranging from 5.0 to 5.5. Where isolated pockets of fen peat (usually less than 10m^2) are exposed, peat pH ranges from 5.9 to 6.4. The cutaway peat fields have intact drainage channels, so that the fluctuating water-table remains below the peat surface for most of the year. On parts of the cutaway where peat was extracted until the underlying substrate was encountered, the underlying glacial till has been revealed. The glacial till comprises acidic gravel and sands that together are compacted and nutrient poor, with a pH of around 4.5. The cutaway bog therefore comprises an extensive area of acidic peat with isolated pockets of fen peat and gravel hills and ridges distributed throughout the sites[7].

[7] The Bellacorick bog complex has developed over a glacial landscape of eskers and kames. As the peat is extracted these glacial features are revealed. The underlying glacial geology at the Bangor site is less undulating.

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4.3.1.1.2 Plant communities establishing on cutaway bog

When peat fields are taken out of production they are typically devoid of vegetation, subject to fluctuations in water-table (where drainage channels are still intact) and the peat is generally compressed from the weight of machinery traversing the bog. Due to the nature of the underlying topography at Bellacorick, production and cutaway fields are interspersed amongst each other and it is therefore impossible to isolate cutaway fields hydrologically without affecting drainage of adjacent production fields (Fig. 4). The water-table of these shallow peat cutaway fields is therefore fluctuating and ideal for the spread of *Juncus effusus* (Soft Rush).



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Fig.4. *Juncus effusus* establishes in drains and then spreads across the cutaway fields. The peat field on the left is in production while the field on the right is cutaway, with *J. effusus* and *J. bulbosus* establishing. Colonisation of the cutaway generally begins within the first year of the field being taken out of production.

The classification system used here is that of the Braun-Blanquet approach, with reference to the system outlined by *The Heritage Council* (Fossitt 2000) for comparison. Under this system the cutaway bog complex habitat is assigned to the category ***PF2, Poor fen and flush*** (Fossitt 2000). This broad habitat complex is used, as poor fen is the most extensive habitat encountered within the cutaway complex with discrete patches of other habitats occurring sporadically throughout the poor fen vegetation.

In total, fourteen plant communities, including pioneer and rudimentary types, were recorded from the cutaway bog (Table 3). The most extensive plant community is a rudimentary poor fen type that is dominated by *Juncus effusus* with a bryophyte layer of *Campylopus introflexus* and *Polytrichum commune*. Poor fen vegetation is considered a precursor of ombrotrophic bog conditions and as such, is considered a replacement peatland community. The *Polytrichum* hummocks create a suitable micro-climate for hummock-forming *Sphagnum* species (Fig.5) while waterlogged pools are commonly colonised by *Sphagnum cuspidatum*.

Two cutaway plant communities that have established spontaneously where drainage has been impeded on the cutaway bog are considered as peat-forming communities (*Sphagnum*

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cuspidatum-Eriophorum angustifolium and Calluno-Sphagnion communities). Seven plant communities are considered as rudimentary forms of plant communities recorded from Atlantic blanket bog complexes. There are isolated areas of fen and grassland communities but these are restricted to areas where there are subtle differences in the nutrient content of up-welling springs and/or proximity to drainage waters.

Table 3. Plant communities (following Braun-Blanquet nomenclature, see White & Doyle 1982, with reference to Fossitt 2000) and associated habitat conditions that have established on industrial cutaway Atlantic blanket bog.

Habitat conditions	**Plant community (*after White & Doyle 1982)***	**Plant community (*after Fossitt 2000)***
Waterlogged peat	Pioneer *Juncus bulbosus* community Pioneer *Eriophorum angustifolium* community Litorelletea Typhetum latifoliae *Sphagnum cuspidatum-Eriophorum angustifolium* Calluno-Sphagnion	PF2 Poor fen and flush PB Bogs FL2 Acid oligotrophic lakes FS1 Reed and large sedge swamps PB Bogs PB Bogs
Frequent fluctuations in water-table	Pioneer *Juncus effusus* community Sphagneto-Juncetum Caricetum paniculatae	PF2 Poor fen and flush PF2 Poor fen and flush FS1 Reed and large sedge swamps
Dry peat	Calluno-Ericetum	HH1 Dry siliceous heath
Mineral soils/ploughed peat-mineral soil	Salicion cinereae Tussilaginetum Charetea Centaureo-Cynosuretum	WS1 Scrub ED3 Recolonising bare ground PF1 Embryonic rich fen GS1 Dry calcareous and neutral grassland

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Where peat remains on a slope (a common feature of the cutaway at Bellacorick due to the undulating sub-surface contours), there is little or no vegetation establishment. The peat is unstable and summer drying and high rainfall can lead to baring of the underlying hills. These bare gravel areas are assigned to the class ***ED1, Exposed sand, gravel or till*** (Fossitt 2000). The exposed gravel hills present a compacted, exposed and nutrient-poor habitat for colonising plants. These areas require rehabilitation measures to accelerate revegetation and stabilise any patches of remaining peat. It was noted that where the gravel had been disturbed (usually by Bord na Móna machinery) and small shelter ridges created, vegetation had established. Experimental work was carried out to examine the use of a number of measures to encourage vegetation establishment in these areas (*described later*).

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Fig.5. *Sphagnum subnitens* establishes through the ground layer of *Polytrichum* hummocks, forming epicentres of *Sphagnum* hummocks that gradually spread through the area. The *Sphagnum* patches are typically red (at the centre of the photograph) or pale green (right foreground).

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4.3.1.2 Conclusions from the baseline study

The vegetation survey of the cutaway bog provides (a) an outline of the plant communities that have established on industrial cutaway Atlantic blanket bog, and (b) the range of environmental conditions prevailing on the cutaway. The main features can be outlined as follows:

(i) Vegetation establishes relatively soon after peat fields are taken out of production (generally within one year).

(ii) The most extensive vegetation type establishing is poor fen (Sphagneto-Juncetum (PF2) dominated by *Juncus effusus*).

(iii) Where the water-table is at and/or above the cutaway surface and conditions are largely ombrotrophic, peatmosses (*Sphagnum* species) establish. In these areas, even on shallow peat, peat-forming communities occur spontaneously.

(iv) Vegetation is slow to establish on gravel areas and where peat is unstable, i.e. on sloping areas.

(v) Where small pools and ridges have been created on gravel hills or on areas of peat on slopes, vegetation (poor fen) establishes.

These observations illustrate the range of conditions on the cutaway bog and allow for the development of a set of criteria on which successful rehabilitation can be measured.

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4.3.1.3 Criteria for successful rehabilitation of the cutaway bog

Rehabilitation of the cutaway will be considered successful when the remaining peat of the cutaway fields has been stabilised, which will involve the establishment of a vegetation cover. Revegetation of the cutaway bog is therefore the primary objective (and basic criterion) of the rehabilitation programme (Farrell 2001; Farrell & Doyle 1998, 2003). While revegetation occurs with minimal active rehabilitation management on flat fields, rewetting of cutaway fields could result in more extensive development of replacement peat-forming communities (Farrell 2001; Farrell & Doyle 1998, 2003). Therefore, the secondary rehabilitation objective for the cutaway bog is to promote the establishment of peat-forming communities, where possible.

To reiterate, the criteria for successful rehabilitation of the cutaway bog are outlined as follows:

- Stabilisation of the peat production areas through revegetation and,
- *In turn* mitigation of potential peat run-off from the site.
- [8]Re-establishment of peat-forming communities where possible.

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[8] The establishment of peat-forming plant communities has been observed to occur spontaneously throughout the stands of *Juncus* as outlined.

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4.3.1.4 Developing rehabilitation measures for cutaway bog

In considering rehabilitation of the cutaway bog (cutaway, shallow production bog, unstable peat on slopes and gravel hills inclusive) at Bellacorick, a range of factors must be taken into account. It will not be possible to apply any one particular approach to the entire area, as there is such a broad range of conditions on site. While flat areas revegetate with relative ease, sloping gravel areas must also be taken into consideration.

Where peat remains on level surfaces, the primary aim will be rewetting and establishment of embryonic peatland communities. This will require blocking of the field drains at regular intervals and/or blocking main out-falls from production areas to flood areas of the cutaway.

Where peat is on a slope and/or the underlying mineral soil has been exposed, the primary aim will be to encourage revegetation that will stabilise the peat substrate. It will be impossible to restore embryonic peatland communities on the bare mineral soil substrate: the objective will be to encourage establishment of some form of pioneer vegetation that will provide shelter for further vegetation establishment and succession. *Therefore the rehabilitation objective will vary within the cutaway bog at Bellacorick depending on the substrate type and slope.*

4.3.1.4.1 Experimental rehabilitation trials

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The general observations of the baseline vegetation study provided the basis for the selection of potential management strategies for each cutaway substrate type. A number of experimental trials were established to test the effectiveness of the rehabilitation measures. These are outlined below (*a more exhaustive description can be found in Farrell 2001 and Farrell & Doyle 1998, 2003*).

Hydrological manipulations – rewetting flat areas of peat

A number of experimental rewetting sites were established on parts of the cutaway in 1997. One such site involved isolating an area of cutaway bog (approx. 0.5ha) that was relatively flat with a sparse cover of *Juncus effusus* (Fig. 6). The area was hydrologically isolated by constructing a peat ridge using a Komatsu dozer, which prevented run-off of water and maintained a high water-table (average 30cm over peat surface).

Within two years there had been extensive spread of *Sphagnum cuspidatum* and the vegetation shifted from rudimentary poor fen to an embryonic bog community (*Sphagnum cuspidatum-Eriophorum angustifolium*). The site was revisited in September 2002 and a 100% cover of *Sphagnum* was recorded (compared to approximately 30% in September 1999, Fig. 7). This demonstration area illustrates that flooding areas dominated by *Juncus effusus* or areas with patchy vegetation cover will create a habitat suitable for the establishment and rapid spread of *Sphagnum*, and therefore restoration of peat-forming conditions[9].

[9] It is generally accepted that flooding large areas is unsuitable for *Sphagnum* establishment. Previous research has shown that large water-bodies experience considerable wave-action. *Sphagnum* establishment requires focal areas from which to spread, e.g. *Juncus* tussocks and relatively shallow water. The conditions created in the experiment described above are ideal for *Sphagnum* spread. Relatively small flooded areas (site-specific) created throughout larger cutaway areas will promote the spread of *Sphagnum*.

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Fig.6. Experimental area before rewetting (August 1997). The vegetation was patchy with *Juncus effusus* and *Eriophorum angustifolium*. Total vegetation cover was approximately 40%. The peat was shallow (average 45cm), with numerous pine remains.

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Fig.7. Experimental area after rewetting (August 1999). A peat ridge was constructed around the experimental area to prevent water run-off. The vegetation cover increased to over 90%, with the greatest increase attributed to the spread of *Juncus bulbosus*. The water-table remained high and encouraged the spread of *Sphagnum cuspidatum*. The overall character of the vegetation is similar to the *Sphagnum-Eriophorum* community described from intact and cutaway bog.

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Surface sculpting - creation of pools and ridges

Manipulation of peat and gravel cutaway surfaces encourages plants to establish on areas that would otherwise be exposed. The sculpting of relatively flat surfaces creates a mosaic of pools and ridges where *Sphagnum* species may become established and also serve as core areas from which vegetation can spread across the cutaway bog.

A number of large pools (20m x 20m) were excavated from bare gravel slopes and shallow peat slopes on cutaway at Bellacorick in 1998 using a D6 dozer. Where springs were encountered these pools revegetated rapidly, predominantly developing a species-poor *Juncus bulbosus*-*Sphagnum* community. Pools with peat bases remain wet and provide hospitable conditions for invading plants. Where no springs are present the gravel bases dry out quickly and remain dry except during heavy rainfall. Grassland species establish in these areas. Although revegetation of these areas is particularly slow, after 5 years these areas have developed significant vegetation cover.

Ploughing on slopes

Ploughing along sloped areas using the blade of a D6 dozer has proven successful in promoting vegetation establishment on bare gravel and peat remaining along slopes. Gravel hills were ploughed so that the resulting ridges were approximately 1m apart, and depressions being half a metre deep. Ploughing created a series of ridges and furrows that provide shelter for plants, therefore increasing the vegetation cover in these areas. Initial colonisation is slow but steadily increases to cover an area within 3 to 5 years (see Appendix 2).

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4.3.1.4.2 Conclusions from experimental work

A number of conclusions can be drawn from the experimental work and two fundamental aspects have been shown to be useful for revegetation purposes at Bellacorick. These two simple tools form the basis of all the rehabilitation work that had been carried out on the cutaway bog.

Rewetting***:*** Blocking drains and preventing water-run-off by means of peat ridges encourages the spread of the spread of *Juncus effusus* and more typical peatland species such as *Eriophorum angustifolium*, and ultimately the spread of *Sphagnum*. The outcome results in development of embryonic peat-forming communities and the experimental rewetting has proven successful in encouraging the spread of *Sphagnum cuspidatum* and the establishment of a typical peatland community within a relatively short period of time[10].

This rehabilitation tool can be applied to 50% of the Oweninny Works (approx. 1250ha of cutaway bog and up to 2000ha deep and shallow production bog). Field drains can be blocked and discrete areas flooded in up to 80% of the current production areas.

[10] It should be noted that rewetting is dependent on slopes. It is not feasible to rewet where the slope is too great, therefore, embankments will be constructed to stabilise the peat and it is likely that poor fen will establish.

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Ploughing**:** disturbance and ploughing of gravel and/or peat-covered slopes stabilises peat and increases vegetation establishment in areas that were otherwise slow to colonise. This rehabilitation measure will be appropriate approx. 11% of the Oweninny boglands (i.e. 750ha gravel areas).

4.3.1.5 Conclusion: rehabilitation of cutaway bog, shallow production bog, unstable peat and gravel areas

Most of the work to date has focussed on the cutaway bog, areas of unstable peat and gravel hills. The work on cutaway bog can also be translated to areas of shallow production bog. These areas in total account for 75% of the total production area and 50% of the Oweninny boglands, and have been utilised most intensively for peat production.

Based on the research conducted and general observations, Bord na Móna is confident that these areas will be stabilised within a relatively short period following cessation of peat extraction. The areas described in this sub-section will revegetate either through natural processes or through intervention in the form of the rehabilitation tools tested in the experimental work described here.

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4.3.2 Rehabilitation of deep peat production areas (15% of total holdings)

Deep peat production bog is largely concentrated in parts of the production areas that were brought into development in the last decade. The greater percentage of this bog type is concentrated in Areas 13 and 14 at the OAE1 site (Fig. 2). There are also scattered pockets in Areas S5, S4 and Area 10 (Fig. 8). At the OAE2 site, deep peat production areas are concentrated mainly south of the Owenmore River (Fig. 3).

There has been no experimental work conducted on these deep peat areas as they are regarded as most significant for peat production and are therefore essential to attaining the annual production yields.



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Fig.8. Deep peat production bog in Area 10. These areas appear in stark contrast to the patchwork nature of shallow production areas where cutaway fields are interspersed amongst production fields. The peat is relatively deep, generally more than 1m, and the drains correspondingly so. The underlying glacial features are recognisable by the rolling nature of the production bog. This habitat can be assigned to ***PB3, Cutover bog class.***

The rehabilitation aim in these areas will be to accelerate revegetation of the peat fields and stabilise these areas to reduce peat run-off. The surface peat of these production fields is generally less humified and therefore less susceptible to run-off in high rainfall periods than shallow, highly humified peat. The peat is also more fibrous and should re-colonise within a relatively short period owing to the seed bank contained in the peat. The proposed rehabilitation of deep peat production areas will involve blocking of each of the field drains at specific intervals (depending on variations in slope), in an attempt to raise the water-table relative to the peat surface and reduce large-scale fluctuations.

While there are no examples within the site to illustrate the timeframe within which this would occur, it is estimated that these areas should revegetate with relative ease. Demonstration areas to identify the rate of revegetation in deep production areas will be established as soon as possible to determine the success of potential rehabilitation measures. The vegetation is likely to develop *Molinia* and *Eriophorum* with minimal cover of *Juncus effusus*.

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4.3.3 Rehabilitation of bog remnants and new development areas

4.3.3.1 Bog remnants (up to 8% of total holdings)

There are a number of bog remnants distributed throughout the Oweninny boglands, ranging in size from 0.5-15ha. These are identifiable on Figs 2 & 3 (shaded red) surrounded by areas developed for peat production, or forming the margins of the holdings and acting as a buffer zone adjacent to rivers and roads. One of these bog remnants, the Bellacorick iron flush, has been described scientifically on a number of occasions as it is home to a number of species that are either extremely rare or have restricted distributions within Ireland and Europe in general. This bog remnant, which is a SAC, is described in greater detail later.

These bog remnants remained untouched by Bord na Móna as they were unsuitable for development under the original PECO method of peat extraction. By their nature they are typically drier than areas of extensive Atlantic blanket bog complexes, as there is generally a severe slope at some point within the remnant that inhibited the use of Bord na Móna peat harvesting methods.

The remnants are diverse in habitats and consequently floristically diverse. Almost the full range of habitats typical of Atlantic blanket bog complexes is found within these bog remnants. The typical condition comprises an area of Atlantic blanket bog vegetation (Pleurozio purpureae-Ericetum tetralicis) with a number of bog pools, some of which may be drying out at the margins of remnants and becoming colonised by *Eriophorum* and *Carex rostrata* (Fig. 9 & 10). There is generally a high point within the remnant that is dominated by either *Molinia*-grassland or dry heath. There may be occasional patches of willow scrub and rich fen vegetation. The remnants are usually bordered by a narrow fringe (up to 2m) of dry heath that indicates the margin of drying-out caused by the hydrological isolation of the remnant. A list of the habitat types recorded from the bog remnants at Bellacorick is outlined in Table 4. There are a number of plant communities recorded from these areas, all of which are assigned to the Braun-Blanquet and Heritage Council classification system. The vegetation complexes found within bog remnants can also be generally assigned to the ***PB4, Lowland blanket bog class*** (Fossitt 2000).

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The shrub species, bearberry (*Arctostaphylos uva-ursi),* more commonly found on highland areas, was found growing on one bog remnant (Farrell 2001). This is the only record of this species growing on low altitude blanket bog. These remnants provide a proximal source of local species and serve as a corridor for plant and/or animal species in an area where the local habitat range has been largely restricted. There is evidence of their use by red grouse (*Lagopus lagopus*), a species that currently has a limited and contracting distribution in Ireland.

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Fig.9. On large bog remnants at Bellacorick (up to 15ha), the vegetation is typical of more extensive Atlantic blanket bog complexes. A drainage channel running through this area (right-middle-ground) has been deepened to assist drying of the adjacent production fields, causing edge-drainage effects.

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Fig.10. *Sphagnum cuspidatum-Eriophorum angustifolium* community shown here established on a dried-out lake within a bog remnant. The lakebed has been almost completely covered by *Eriophorum angustifolium* with a bryophyte layer of *Sphagnum cuspidatum*.

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Some of these areas and parts of particular bog remnants are considered of botanical significance. Any disturbance or development within and/or in close proximity to these bog remnants would damage their botanical integrity.

There will be no large-scale rehabilitation required for any of the bog remnants. There may however, be scope for blocking drains that run through the remnants and /or restoring the previous water levels in bog lakes and pools. This has been conducted in one such area, Swan's Lough (*described later*).

Table 4. Plant communities (following Braun-Blanquet nomenclature, see White & Doyle 1982, with reference to Fossitt 2000) recorded from bog remnants within the Oweninny boglands.

Class	**Order**	**Alliance**	**Association**	**Fossitt (2000)**
Oxycocco-Sphagnetea	Eriophoro vaginati-Sphagnetalia papillosi	Calluno-Sphagnion papillosi	Pleurozio purpureae-Ericetum tetralicis	PB3 Lowland blanket bog
	Scheuchzerietalia palustris	Rhynchosporion albae	Sphagno tenelli-Rhynchosporetum albae	FL1 Dystrophic lakes
			Sphagnum -Eriophorum community	FL1 Dystrophic lakes
	Sphagnetalia compacti	Ericion tetralicis	Narthecio-Ericetum tetralicis	HH3 Wet heath
Calluno-Ulicetea	Vaccinio-Genistetalia	Genisto-Callunion	Calluno-Ericetum cinereae	HH1 Dry siliceous heath
Litorelletea uniflorae	Litorelletalia uniflorae			FL2 Acidic oligotrophic lakes
Scheuchzerio-Caricetea nigrae	Caricetalia nigrae	Caricion curto-nigrae	Sphagneto-Juncetum effusi	PF2 Poor fen and flush
	Caricetalia davallianae	Caricion davallianae	Campylio-Caricetum dioicae	PF1 Rich fen and flush
Phragmitetea	Magnocaricetalia	Magnocaricion	Caricetum paniculatae	FS2 Tall herb swamps
Franguletea	Salicetalia auritae	Salicion cinereae	Myricetum gale	WS1 Scrub
			Osmundo-Salicetum atrocinereae	WN7 Bog woodland
Molinio-Arrhenatheretea	Molinietalia	Junco conglomerati-Molinion	Junco acutiflori-Molinietum	GS4 Wet grassland
Nardetea	Nardetalia	Nardo-Galion saxatilis	Achilleo-Festucetum	GS3 Dry humid grassland

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4.3.3.2 Rehabilitation of new development areas (up to 20% of total holdings)

There are a number of areas of bog within the Oweninny Holdings that were ditched and drained in the 1980s and early 1990s with a view to extending the production area, both at Bangor and Bellacorick.

Peat was never harvested from these areas and they present various stages of drying-out Atlantic blanket bog with variable vegetation types. These areas are essentially stable as the vegetation was either never removed or the areas have been re-colonised. However, there is scope to block the field drains within these areas and encourage the areas both to rewet and retain *and/or restore* their Atlantic blanket bog condition. The vegetative conditions can be outlined as follows:

(i) Ditched and drained, but with a continuous vegetation cover comprising the full complement of Atlantic blanket bog species, e.g. Loughnahelly Bog (Fig. 11), the greater part of O'Boyle's Bog (Fig. 13) and Area 2 at the OAE2 site.

(ii) Ditched and drained in parts, screw-levelled to remove vegetation in marginal areas but vegetation re-colonising, e.g. parts of O'Boyle's Bog (Fig. 12).

(iii) Small, discrete areas that have experienced a greater drainage impact, e.g. adjacent Areas 13 and 14 (Fig.2).

In total, there are 1,274ha of new development bog between the Bangor and Bellacorick sites. The first two categories outlined above are hydrologically isolated from current production areas and are recognised as examples of degraded Atlantic blanket bog, but maintaining typical Atlantic blanket bog features with the potential to revert to a wetter situation if surface drains are blocked. This applies to 870ha of new development bog. The remaining areas are relatively small and scattered and there is greater evidence of drainage effects (extensive *Molinia* cover and establishment of *Calluna*).

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A notable case is the Loughnahelly site that is located west of the Bangor production area and is essentially isolated from all other areas of production bog. Loughnahelly Bog comprises more than 300ha of Atlantic blanket bog that was ditched in 1982 with no further work carried out since. There is a continuous vegetation cover in this area with the full complement of Atlantic blanket bog vegetation. Blocking of drains in this area would encourage the recovery of the site and stop any potential peat run-off. Some experimental work has been established on O'Boyle's Bog to examine the effects of blocking drains in these areas[11]. However, it is generally accepted that Loughnahelly, O'Boyle's and Area 2 at the Bangor site, which are the least developed of the production areas, could revert (with drain blocking) to truer examples of Atlantic blanket bog complexes.

The general aims in rehabilitating new development bog are:

(i) To prevent further drying-out of the bog

(ii) To encourage re-establishment of typical Atlantic blanket bog vegetation

(iii) To minimise the run-off of peat into the associated silt ponds, particularly in high rainfall periods.

[11] Further work will be continued following consultation with Dúchas and restoration experts within Bord na Móna.

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Fig.11. Loughnahelly bog was drained in the early 1980s. The area still retains typical Atlantic blanket bog features and may further revert to its original condition through blocking of drains.



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Fig.12. O'Boyle's bog was drained in the mid-1990s. This photo shows a field that is drained and the surface vegetation removed. The field is re-colonising with *Eriophorum*, patches of *Schoenus* and other typical bog species.

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Fig.13. O'Boyle's Bog comprises intact bog and bog that has been drained. In the foreground can be seen intact bog. A number of pools are found in this area indicating that the area is relatively intact. Blocking drains in the ditched areas would lead to rewetting of these areas and a return to relatively intact Atlantic blanket bog.

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4.3.3.3 Conclusions: rehabilitation of bog remnants and new development areas

Both of these habitat types are considered stabilised already. These areas were never included in peat production areas and the surface has well-established vegetation. Within bog remnants, there may be minimal rehabilitation work required to restore water levels in bog lakes and pools, however it is generally accepted that a policy of no interference is the best approach to these areas.

New development areas have been drained extensively and in some places the surface vegetation damaged. These areas are however, considered stable. Rehabilitation will involve blocking of field drains to prevent further drying-out of the bog habitat and in some places the degraded Atlantic blanket bog may return to its former (pre-drained) condition. Further work will be initiated following consultation with Dúchas and Bord na Móna restoration experts.

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4.3.4 Consideration of the SACs located within the Oweninny Holdings

There are a number of SACs located within the Oweninny Holdings. These are as follows:

- Bellacorick iron flush
- L. Dahybaun
- Knockmoyle SAC complex

4.3.4.1 Bellacorick iron flush

The scientific importance of Bellacorick iron flush was first recognised by Mr. T.A. Barry of Bord na Móna in the late 1950s. Mr. Barry highlighted the uniqueness of the flush area and the site was subsequently transferred to An Taisce ownership for conservation purposes. A number of rare species and species with restricted distributions in Ireland have been recorded from the flush area, highlighting the rich habitat diversity that pre-existed the industrial development of the site (Doyle & Foss 1986; King 1958a, 1958b; Lockhart 1987, 1989a, b, 1999; Scannell 1958; Synnott 1970). The ownership of the site was transferred to An Taisce, who remain the current owners. Dúchas also own the peripheral area of the bog remnant, which comprises a buffer vegetation area around the flush proper.

The main feature of the flush is the presence of *Saxifraga hirculus* and a suite of bryophytes that are classed as boreal relics (Lockhart 1987, 1989a, b, 1999). The conservation value was first highlighted in the 1950s when four rare mosses (*Homalothecium nitens*, *Drepanocladus exannulatus* var. *rotae*, *Meesia tristicha* and *Sphagnum teres*) and the marsh saxifrage (*Saxifraga hirculus*) were recorded (King 1958a, b; Scannell 1958). The moss, *Meesia tristicha*, appears to have become extinct from the site and this may be attributed to drying of the area (Lockhart 1989b). The marsh saxifrage is protected under the Irish Flora Protection Order 1987 and listed under Annex II and IV of the EU Habitats Directive. The plant has been recorded from five sites in Ireland, one in County Antrim and four in County Mayo (Curtis & McGough 1988; Lockhart 1989b). Other rare species recorded from the site include the marsh fern (*Thelypteris palustris*) and the bog orchid (*Hammarbya paludosa*) (Synnott 1970).

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While the area has been fenced off from the surrounding Bord na Móna production bog, drainage of the surrounding peat production area and the island nature of the iron flush may be resulting in the progressive drying of the site. A survey was carried out to determine the distribution of *Saxifraga hirculus* within the flush in August 2001. More than 100 hundred flowering plants were recorded (C.A. Farrell, pers. obser.). The population may in the future however, be threatened by drying out of the flush. A study carried out in June 2001 as a follow-up to a similar study in 1982 indicates that the *Phragmites* population distribution is contracting (John Cross, pers. comm.). It is uncertain what this indicates, but it is likely that it indicates a drying out of the flush in general.

Dúchas and An Taisce have been notified of the development of the rehabilitation plan for the Oweninny boglands. Dúchas is currently developing a management plan for the site and this will be implemented following the consultation process.

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4.3.4.2 L. Dahybaun

This SAC is a large water body that is notable for the presence of *Naijas flexilis*, the slender naiad. L. Dahybaun is one of thirty recorded sites of the Slender Naiad, which is a red data species: considered rare in Ireland and in decline across Europe (Curtis & McGough 1988).

Other special botanical features within the area of the lake are the presence of two heathers of restricted distribution in Ireland and another Annex II species. These species are situated in and around L. Dahybaun, which is bounded by hand-cut turf areas to the south, commercial forestry to the east and milled peat fields to its north. The hybrid *Erica x stuartii* (*Erica mackiana x Erica tetralix*) was recorded growing close to the south edge of the lake, on a sloping area of intact bog. *Erica mackiana* was also found growing in abundance within close proximity on an area of extensive bog, south of the N59 (Van Doorslaer 1990).

There are no plans for any developments adjacent to L. Dahybaun and Bord na Móna will comply with the management guidelines set out by Dúchas for the site.

4.3.4.3 Knockmoyle SAC Complex

There is an area of Atlantic blanket bog that remains within Bord na Móna ownership that has been designated SAC. This SAC is located in the north-east corner of O'Boyle's Bog, adjacent to the Knockmoyle nature reserve but hydrologically separated from the Knockmoyle site by the Sheskin River. This SAC is an area of intact Atlantic blanket bog that is currently part of an area of new development bog. There was some drainage work carried out on O'Boyle's Bog in the mid-1990s, however the site was never fully developed for peat production except for the south-east corner (20 fields, see Fig.2 and previous description of new development areas).

A management plan for this area will be drawn up in consultation with Dúchas.

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4.3.5 Rehabilitation (Decommissioning) of *Other areas*

Both rehabilitation and decommissioning of the Oweninny boglands are dealt with in Condition 10 of the IPC licence. Decommissioning covers all areas of general hygiene within the Oweninny boglands: removal of machinery and potentially hazardous material, lifting of railway lines, silt control, remediation of watercourses, etc. The general decommissioning procedure as outlined by Bord na Móna and accepted by the EPA is outlined below and will be carried out in conjunction with the rehabilitation of the Oweninny boglands. However, they are recognised as separate procedures within the closure of the Oweninny Works. The main areas of concern can be broken down into:

- Silt control and remediation of watercourses
- General hygiene and elimination of potential pollutants

4.3.5.1 Silt control (decommissioning procedure with respect to watercourses)

Rehabilitation of the Oweninny boglands is closely linked with silt control. One of the criteria for successful rehabilitation is stabilisation of the Oweninny boglands through revegetation, which will stabilise all substrates and in turn remove the need for further silt control measures.

Drainage is an important feature of the operation of the peat production mechanism at Bellacorick and Bangor. There is an estimated 3000 km of field drains between the two sites, each of which eventually drains into a terminal silt pond that allows for settlement of suspended solids before entering the main river systems. There are currently 171[12] silt ponds in operation within the Oweninny boglands. The silt that builds up in these ponds is excavated on a regular basis by Bord na Móna to facilitate an efficient level of silt control. An extensive study was completed in 1999 to describe the different sub-catchments identifiable at the Bellacorick and Bangor sites. The location of each of these silt ponds and an outline of the catchment facilitated by each silt pond has been outlined and submitted to the EPA as part of the IPC Licence application.

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There are a number of streams and rivers draining the Oweninny boglands. The main rivers draining the Bellacorick site are the Sheskin, Ballymonnelly, Oweninny, Muing, Shanvolahan and Cloonaghmore rivers. The tributaries of these rivers include the Muingamolt, Muingaleeaun, Sruffaunamuingabatia, Fiddaunfura, Fiddaunagosty and Fiddaunmuinggeery. The courses of the majority of these tributaries have been altered through the development of the drainage network for peat production purposes. The main rivers draining the Bangor site are the Owenmore and Munhin Rivers.

The primary concern in relation to watercourses is the prevention of silt run-off into streams and rivers within and adjacent to the Oweninny Works. Other issues have been raised by the NWRFB, including (a) concerns that rehabilitation methods will alter the current discharge and flow regimes, (b) monitoring of discharges and (c) removal of silt build up in rivers and streams on- and off-site. These issues will be dealt with here, although in some areas there can be no definitive response until a comprehensive survey of the streams and rivers is conducted.

[12] 133 silt ponds at OAE1, 38 at OAE2.

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4.3.5.1.1 Silt control: developing replacement silt settlement areas

As outlined already, the main criterion of the rehabilitation plan is stabilisation of the Oweninny boglands. While this will allow the area to blend with the surrounding Atlantic blanket bog landscape, it will also mitigate against potential peat run-off from the site following cessation of peat extraction.

It is the aim of the rehabilitation plan to slow the movement of water through the peat production areas through (a) blocking of field drains, (b) creation of open water bodies in depressions and (c) developing replacement siltation areas for terminal silt ponds. Each of these aspects will work in tandem with the current flow regimes and sub-catchment areas identified on the site. At no point will Bord na Móna be altering groundwater flow regimes and as such a hydrological assessment of the site is considered un-necessary.

The rehabilitation plan for both Bellacorick and Bangor sites will involve blocking of the main out-falls and flooding areas of the cutaway – production bog complex. This serves a number of purposes. These are outlined as follows:

1. Establishment of replacement siltation areas that will with time overtake the functions of the current silt ponds
2. To facilitate raising the water-table within the cutaway – production bog complex to allow for development of replacement wetland communities.

Each of the silt ponds and associated main out-falls within the Oweninny Works will be characterised (currently underway). The location of the lowest point at which water will spill out into the watercourses off-site will be determined before any out-falls are blocked to ensure that the banks are substantial enough to withhold an increased volume of water. This is a noted concern of the NWRFB. Bord na Móna recognise that there will be some areas that this approach will not be practical and where this is the case, replacement siltation areas will be located further back from the terminal siltation area where conditions are appropriate.

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Bord na Móna is confident that the water-flow can be manipulated to filter the water sufficiently and without damage to existing river and stream-banks by this method. In the interim, Bord na Móna is undertaking to maintain the excavation of silt ponds at both the Bellacorick and Bangor sites until such time as they are no longer required (i.e. there is no further threat of silt run-off from the sites). The duration of this silt control is not known, and will be subject to EPA approval. However, as the peat production areas become revegetated and the peat on-site is stabilised there will be minimal levels of peat leaving the Oweninny boglands. This work will continue with continued consultation with the NWRFB to take full account of the issues of concern identified to date. Run-off from the site is currently monitored as a condition of the IPC Licence. Monitoring will continue at the intensity considered appropriate by the EPA.

Once silt excavation is deemed un-necessary, the silt ponds will remain undisturbed, *in situ*. When silt ponds become redundant, they quickly revegetate and naturalise. By means of vegetation establishing in the ponds, a further silt control mechanism is evoked, as water passing through these areas is filtered before entering main watercourses.

Where silt ponds are located on streams, the water will be re-diverted out of the silt pond to return either to the previous pathway of the stream and/or river or a newly excavated pathway. Where necessary, banks will be rebuilt and graded to mimic natural banks. There

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are silt ponds located on the Sruffaunamuingabatia, Muing and Ballymonnelly Rivers. These silt ponds will continue in use until such time as they are no longer required as a siltation mechanism. Following this, remediation of banks and diversion of the streams out of silt ponds will commence.

4.3.5.2 Other issues of concern with respect to watercourses

An ecological assessment of the Oweninny, Owenmore and Muing rivers will be conducted to determine whether there is a requirement for remediation measures of these rivers. This study will be completed by September 2003[13]. The results of this survey and agreed actions will be presented in a report separate to the rehabilitation plan.

Other issues such as future management of the Bellacorick Fishery will be addressed following further consultation with the NWRFB.

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[13] The survey will be conducted by Dr. J. Caffrey of the Central Fisheries Board.

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4.3.5.3 General hygiene and elimination of potential pollution (as approved by EPA)

Purpose

The purpose of this procedure is to ensure that Bord na Móna Energy Ltd. will take all the necessary steps to protect the environment from pollution, following termination of use or involvement of all or part of the site in the licensed activities. Bord na Móna Energy Ltd. shall decommission, rendering safe or remove for disposal/recovery, any soil, subsoils, buildings, plant or equipment, or any waste, materials or substances or other matter as listed in Table 5, contained therein or thereon.

Scope

The scope of this procedure covers the following locations.

- Tea-centres
- Workshops
- Transport Centres
- Out loading facilities
- Offices

[14]Decommissioning of the bog, and associated tea-centre, workshop, out-loading & offices will commence in accordance with the Decommissioning Schedule as outlined in Table 5 below. It will take place either before implementing the agreed cutaway bog rehabilitation plan or during implementation of the plan, depending on the facilities and services required to carry out the plan.

Depending on the commercial reality and conditions at the time, a Bord na Móna site may also be offered for sale.

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4.3.5.4 Conclusion: decommissioning of the **'Other areas'** *within the Oweninny boglands*

While rehabilitation of the Oweninny boglands is considered a separate issue to decommissioning, there is a certain amount of overlap with respect to silt control and mitigation of peat run-off. Bord na Móna is committed to maintaining silt control measures until such time deemed appropriate by the EPA.

In the meantime, an integral feature of the rehabilitation plan involves the establishment of replacement siltation areas that will complete the functions of terminal and other silt ponds and lead to a redundancy of the silt ponds, which will in time, naturalise. There will be no alteration of flow regimes between sub-catchments or groundwater flow. Where silt ponds are located on streams and rivers, the watercourses will either be diverted around the silt ponds or the ponds will be remediated to mimic natural bank conditions. This can only be conducted when there is demonstrably no further requirement of these ponds.

[14] Depending on approval of the wind farm proposal, some of the tea-centres and workshops may be required during the construction period of the wind farm.

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Table 5. Decommissioning Schedule

Items for removal/disposal/recycling or re-use.	**Removal Period following termination of use.**	**Method of Disposal/Recovery**
Oil/Diesel/Petrol Tanks	6 months	Agreed recycling contractor or Re-use
Oil/Diesel Barrels	3 month	Agreed recycling contractor or Re-use
Waste Oil	3 month	Agreed recycling contractor
Oil Filters	3 month	Agreed recycling contractor
Oil-traps/interceptors	6 months	Agreed recycling contractor or Re-use
Grease Drums	3 month	Re-use or Disposal
Batteries	3 month	Agreed recycling contractor or Re-use
Anti-freeze	3 month	Re-use
Fluorescent Lights	3 month	Agreed recycling contractor or Re-use
Scrap Metal	6 months	Agreed recycling contractor
Scrap Machines/Parts	12 months	Agreed recycling contractor or Re-use
Rail Lines/Switches	6 months	Agreed recycling contractor or Re-use
Septic Tank & Puraflo	12 months	Removal & Disposal/re-use
Polythene	6 months	Balled and Recycled – Agreed recycling contractor
Geo-membrane	3 month	Re-use
Buildings	12 months	Demolition and Disposal
Portacabins	12 months	Re-use or Demolition
Fencing	12 months	Removal and reuse/disposal
Wooden Pallets	3 month	Disposal or Re-use
Swamp Shoes	3 month	Re-use or Disposal
Ash/Cinders	6 months	Disposal
Canteen Waste	3 month	Disposal – Waste Contractor

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4.4 Summary of Rehabilitation Methods

The main habitats and/or bog conditions and proposed rehabilitation methods have been outlined. To summarise:

- Cutaway bog, shallow production bog, unstable peat and gravel hills have been studied at the greatest level. Vegetation establishes relatively quickly on shallow peat and these areas will be dominated with poor fen vegetation (Sphagneto-Juncetum) that may with time develop into ombrotrophic peat-forming plant communities. Areas of unstable peat and gravel hills are slower to revegetate and will require more intensive rehabilitation management, such as ploughing and/or construction of embankments. These categories account for up to 75% of the total production area and therefore the most rehabilitation sensitive (50% of total holdings).
- Deep peat production areas have been least studied however, it is estimated that with blocking of the field drains, vegetation should establish with relative ease. The vegetation will be dominated by *Molinia*-grassland, with *Eriophorum* and probably reduced occurrence of *Juncus* (25% of production area, 15% of total holdings).
- Bog remnants and new development areas are considered stable entities (27% of total holdings). Bog remnants require a policy of avoidance and therefore require minimal management. New development areas will require blocking of drains to facilitate rewetting and renaturation of these areas.
- Future management of the SACs located within and adjacent the Oweninny Works will be outlined by Dúchas in the appropriate site management plans. These are currently in preparation and Bord na Móna will comply and assist where possible with their implementation
- Silt control measures will continue at both the Bellacorick and Bangor sites until such a time, as there is no further run-off from the site. This will involve the establishment of replacement siltation areas within the Oweninny boglands. As revegetation of the boglands progresses there will be minimal peat run-off and silt ponds will naturalise. Streams with silt ponds located on their course will be diverted and/or banks will be remediated.
- *Other areas* such as tea-centres and removal of wastes will be decommissioned appropriately following and during closure of the Oweninny Works.
- Conifer plantations will require no rehabilitation management and the future of these stands will depend on the owner, Coillte, to decide time of harvesting, future management, etc.
- The rehabilitation of each habitat and/or bog condition will be completed within two years of cessation of peat production at the Oweninny Works. Practical aspects of the rehabilitation plan are discussed in the next section.

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5 PRACTICAL ASPECTS – OUTLINING A REHABILITATION PLAN FOR THE OWENINNY WORKS

The baseline ecological study and the experimental trials carried out on the cutaway bog (1996-1999) and subsequent consideration of the remaining habitat and/or bog condition types, have provided the backdrop for development of a large-scale rehabilitation programme. Aspects of this programme were initiated in March 2001 and some of the work completed to date is described here. The remainder of the work and an estimated timeframe for completion of the rehabilitation tasks is also outlined.

5.1 Quantifying the Work Required on Site to Rehabilitate the Oweninny Boglands

The distribution and extent of the main habitat types are outlined in Figs. 2 and 3. These maps show production bog, cutaway bog, new development bog, bog remnants and conifer plantations as well as the main hydrological features of the site. In addition to these maps, the aerial photographs for the OAE1 and OAE2 sites clearly show the variation in conditions on the ground (Fig. 14 & 15). The aerial photographs can be related to Fig. 2 & 3, and illustrate the diversity of the Bellacorick Holdings: gravel areas, revegetating cutaway bog, new development, etc.

An attempt is made here to (a) outline the machinery and resources required for rehabilitation of the Oweninny boglands, and (b) to describe some of the work completed and the insights provided by this work to date.

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5.1.1 Rehabilitation work required for the totality of the Oweninny boglands: machinery and resources required

The rehabilitation methods have already been outlined. In order to conduct this work however, specific machinery is required for each rehabilitation measure.

Rehabilitation work has involved a range of machinery, primarily dozers (D6 and D4) and excavators. A D6 dozer was purchased by Bord na Móna in April 2002 and has been applied solely to rehabilitation at the Oweninny Works. This machine has been working primarily on rehabilitating gravel areas however, when drying conditions are good, it can be used to work on shallow bog areas to construct embankments and block drains. In general a lighter machine is required for this work such as the D4 dozer. This machine is more suitable for blocking drains as it works in a wider range of weather conditions. An excavator has been used to block drains on deep peat and new development areas. In summary, a D6 dozer is required for rehabilitation of gravel areas, a D4 dozer (or a dozer of similar size and track width) for blocking field drains and outfalls in former peat production areas and an excavator for filling in drains in deep-peat production areas. The excavator may also be used for blocking drains on bog remnants.

There are a number of excavator and D4 machines already on site that will be available for rehabilitation work once peat production ceases at Bangor and Bellacorick, and in some cases machinery may become available as production comes to a close in Bangor in September 2003. An estimate of the total time required to complete the rehabilitation work in each habitat and/or bog condition type is outlined in Table 6. The estimate is based on work completed and one machine working continuously on each habitat and/or bog

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condition type. This estimate will be taken into consideration when outlining the timeframe of rehabilitation at the Oweninny Works[15].

Table 6. An estimate of the total time required for rehabilitation of each habitat and/or bog condition type, and machinery required to complete the work.

Habitat/bog condition	**Area (Approx.) ha**	**% Total area**	**Machinery required**	**Rehabilitation time (days)**
*Cutaway	2250	35%	Dozer	300+*50*
**Gravel areas	750	11%	D6 Dozer	425+*50*
***Deep production	1000	15%	Excavator	250+*50*
***New development	1274	20%	Excavator	300+*50*
† Bog remnants	400-500	8%	Excavator	90+*50*
†† Forestry	682	10%	N/A	N/A
‡ *Other areas*	50-100	1-2%	Silt excavators	N/A
‡‡ **Total**				**1,365+200**

**Cutaway includes current cutaway bog and shallow production bog. Estimated time is based on 10ha rehabilitation work per day (blocking field drains)*
***Rehabilitation work on gravel areas will be largely completed by January 2004. This total includes up to 200 days of rehabilitation work already completed on gravel areas.*
****Based on an estimate of 5ha of bog rehabilitated per day*
† *Minimal work will be required on bog remnants*
†† *Coillte is responsible for forested areas*
‡ *Decommissioning of other areas will require a range of machinery to lift railway lines, maintain silt control, remove rubbish and other aspects outlined in Table 5.*
‡‡ *An additional period of time is incorporated into the total figures to compensate for unforeseen weather and working conditions.*

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The greater part of the rehabilitation work will be required in former production areas. Each production area comprises a range of habitats and therefore a number of rehabilitation methods may be employed in any one area. An example of how this rehabilitation will be approached is outlined in section 5.2.1.

[15] It should be noted that the estimate provided (Table 6) of days for rehabilitation is simply an outline of the man-hours required to complete the work and **not of the duration of rehabilitation work**. Some of the rehabilitation work will be dependent on the time of year, weather conditions and/or other unforeseen occurrences. The rehabilitation approach employed at the Oweninny Works will involve initial rehabilitation work followed by monitoring of the success of the rehabilitation work (sometimes over a period of up to a year, which may be shorter or longer). This may be followed by further re-enforcement of peat embankments, additional rehabilitation measures, etc., if deemed necessary. It is important to recognise that the work will also be phased. For example, diversion of streams from silt ponds is dependent on the need for the silt pond to be maintained. It is estimated that silt control measures will continue for a number of years following cessation of peat production. Therefore, certain aspects of rehabilitation and/or decommissioning will be phased over a number of years following 2004.

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5.2 Rehabilitation Work Completed to Date

Extensive areas of cutaway bog have already revegetated across the Bellacorick and Bangor holdings. More than 50% of the cutaway bog eliminated to date has a vegetation cover, while more recent cutaway or areas where glacial till has been exposed currently have no vegetation (Table 7). The greater portion of the current cutaway bog area comprises flat fields that already have extensive vegetation cover (predominantly poor fen). Most of the revegetation has occurred at the Bellacorick site and this corresponds with the greater proportion of cutaway bog. The revegetated areas can be clearly seen from the aerial photograph (Fig.14).

Table 7. Breakdown of cutaway bog[16] revegetated areas (OAE1 and OAE2 inclusive).

Cutaway	**Total**	**Revegetated**	**Rehabilitated**	
	ha (approx.)	**%**	**ha**	**%**
Gravel	750	10	500	67
Flat peat areas	1250	75	453	35
Total	**2000**	**50**	**953**	**51**

In total, rehabilitation work has been carried out to date on areas of cutaway bog (more than 453ha – 35% of 1250ha), gravel hills and areas of unstable peat on slopes (67% of 750ha). To date 50% of the current cutaway bog area has been rehabilitated and will continue to be monitored to assess success of the rehabilitation work. This represents almost 25% of the total production-cutaway bog area. Approximately 50% of the cutaway bog has already revegetated to some degree, the greater proportion being on flat areas where there is a layer of peat remaining.

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Ploughing of gravel hills is ongoing at Bellacorick. To date, gravel areas in Areas 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 4A, Rail 17A-18A, Rail A-B, C, D, F, S1C, S2A, S2B, S4 have been rehabilitated. This technique (*described previously*) has proven successful on other gravel areas to encourage vegetation establishment on otherwise bare areas.

Work is ongoing on gravel areas and will be completed by 2004, while possible work on other cutaway areas has been largely completed. It is generally impossible to carry out any rehabilitation work on cutaway bog situated within active production areas, as there may be a likelihood of preventing free-drainage of adjacent production areas. This is not considered problematic, as these areas are quick to revegetate once taken out of production. Gravel areas, however, are relatively easy to access for rehabilitation work with machinery, as high points are easily isolated from production areas and have no impact on drainage. Gravel hills are also slower to colonise and therefore, active rehabilitation management is a pre-requisite.

[16] Cutaway refers to that area considered as cutaway at the time of writing. It does not refer to the totality of the Oweninny boglands.

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5.2.1 Test areas to demonstrate the effectiveness of rehabilitation tools

5.2.1.1 Area 3 (Rail 14-18) (see Fig.2)

The existing wind-farm at Bellacorick was established in an area that encloses 90ha of cutaway bog. This area is effectively isolated from current production bog and provided an opportunity to monitor rehabilitation measures on a larger scale than previously studied. A site plan was developed for this area, providing a template for future rehabilitation of unit areas of bog. The approach has involved the following steps:

1. Mapping of habitats, vegetation types present and total vegetation cover to date within the area
2. Mapping the main outfalls and high points
3. Outlining the rehabilitation tools required in each part of the area
4. Carrying out the work required (ploughing, drain blocking)
5. Monitoring vegetation and hydrological changes

The work commenced in March 2001: gravel hills were ploughed using a D6 dozer and field drains were blocked using a D4 dozer.

Blocking of field drains has slowed down the movement of water though the area and leads to reduced drying-out of the peat fields. A peat ridge was constructed across ten production fields to further slow down the movement of water (shown as point **B** in Fig. 16). Excess water spills over into low points within the area, which are either blocked by high peat fields or are the main out-fall areas. All out-falls from this area have been blocked and this has led to the creation of four open water bodies, the largest water-body covering 2ha and reaching depths of 2m in places (shown as point **A** in Fig. 16). The level of that water-body is maintained by an out-fall that was excavated in the adjacent high field. All water from the 90ha cutaway catchment enters the most southern water-body (Fig. 17), and any peat that may be carried in the water settles in the water-body.

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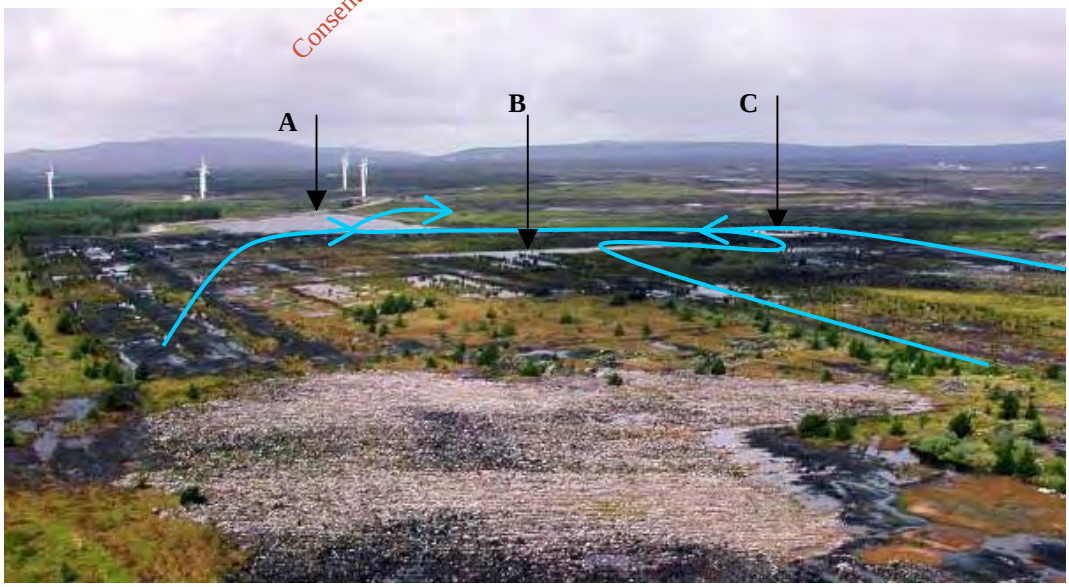


Fig.16. An aerial view of the rehabilitation work completed in the south-west part of Area 3. The gravel areas were ploughed and are starting to revegetate. The direction of water-flow in this area is highlighted with the blue lines. All of the water enters the terminal water body at the south-west corner (**A**). Water flows south-westerly through the water body marked **B**, turns in a north-westerly direction to water body **C**, into the water-body at **A** and in turn into the River Muing.

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Fig.17. The terminal water body in Area 3. All of the water in the catchment enters this artificial water-body that was formed by blocking the main out fall that flowed underneath the high field on the left of the picture. Water exits at the left middle ground of the picture into the R. Muing. Any peat carried in the water settles in the water-body before exiting the catchment. The levels of suspended solids and total solids are currently being monitored to validate this.

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The total vegetation cover in the area was 60% before rehabilitation commenced. Initial, sparse colonisation occurred within the first growing season and is expected to increase steadily within three years (based on previous studies). Fixed-point photography is used to monitor large-scale vegetation changes and the site was photographed from a number of viewpoints to keep a visual and easy reference guide to vegetative changes in the area. The results to date reflect previous observations – *Juncus bulbosus* spreads rapidly in shallow water and otherwise vegetation changes are slow, particularly where the levels of fields are variable (high fields adjacent low fields, or a difference of up to 30cm between adjacent fields).

A number of general observations were made and these are outlined briefly here:
High fields – blocking of field drains may hold enough water to keep these fields saturated in wet periods although excess water generally spills over onto adjacent lower fields. Where high fields are considerably high relative to the adjacent fields, these high fields may be used to facilitate flooding of discrete areas.
Volume of water – blocking field drains and main outfalls is effective in slowing down the movement of water through an area. As vegetation cover increases there will be an increased retention time of water within the peatland system, thereby leading to a reduction in the frequency and magnitude of spate events in streams draining the site.
Prevention of flooding - there is a constant flow of water through Area 3 and the water level is maintained relatively constant by an outfall excavated through the adjacent high field and intact bog margin. Initially, this out-fall was ineffective and led to flooding of the wind-farm road in high rainfall periods. Widening of the outfall from 1m to 2m in width

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ameliorated that situation. The width of the intact bog margin over which the water is flowing is 50m. There is no danger of this margin becoming destabilised.
Sloped fields – a number of peat fields are sloping and blocking of field drains may not hold water in situ throughout the year. In these areas ridges have been constructed perpendicular with the slope. It is hoped that these ridges will slow down the movement of water and allow for rewetting that will encourage revegetation and prevention of peat movement.

September 2002 Update

A number of additional works in Area 3 were completed between Sept 2001 and Sept 2002:

1. A gravel hill was dozed out along Rail 17 in order to flood the south-east corner. The area has flooded and there is up to 0.5m of water in some areas. It is anticipated that these flooded areas will become colonised with floating rafts of *Sphagnum* in the next few years (Fig.18).
2. Flood control – there were difficulties arising with flooding of the wind-farm road in the south-west corner. The embankment along the road was strengthened and improved at weak points using a Hitachi excavator.
3. An excavator was also used to excavate the water path between pools to reduce the potential levels of peat that would be carried in the stream.

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Fig.18. A gravel hill was dozed across 5 peat fields to create an open water area shown above (indicated by the red arrow). This was created on basis of previous experimental work where flooding of *Juncus* stands resulted in the expansion of *Sphagnum cuspidatum*.

As anticipated, vegetation cover within Area 3 has increased. In general high fields remain slow to colonise, nonetheless there are sparse populations of *Eriophorum angustifolium* establishing and these will spread further in coming years. Areas with shallow water have been colonised by rafts of *Juncus bulbosus*, with fragments of *Sphagnum cuspidatum* frequently occurring in these pools. The water exiting the system at the lowest point is free of suspended solids, indicating that there is no peat leaving the system and entering

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watercourses. The banks remain stable while the water is still finding a suitable level to enter the stream.

5.2.1.2 Rail 17A-18A and Swan's Lough

This area comprises approximately 20ha and was also isolated from active production areas. The area is notable, as it lies adjacent to a bog remnant and drained lakebed (see Fig.2). This site (including production area, bog remnant and drained lake) is interesting for the following features:

- *Arctostaphylos uva-ursi* was recorded on the bog remnant – this is the first recording of the bearberry on low-level Atlantic blanket bog. It is generally a feature of upland heath.
- St. Dabeoc's Heath, *Daboecia cantabrica*, was recorded from the cutaway within Rail 17A-18A. This species is typical of heathland vegetation and was previously never recorded north of Clew Bay in Co. Mayo.
- Swan's Lough– this drained lake basin was relatively intact and was becoming colonised by rich-fen vegetation, a generally restricted habitat in this area. The lake itself is considered an ecologically significant site within the Bellacorick production area.
- *Calluna-Juncus squarrosus* heath was developing on the gravel hills within the inactive peat extraction area.

Work commenced within Rail 17A-18A in May 2001 - bare gravel areas were ploughed. Field drains and main outfalls from the production area and the adjacent Swan's Lough area were blocked in July 2001. The water level in Swan's Lough has returned to the level that existed prior to peat extraction and a number of pools have been created in the adjacent peat extraction site. Once again, photographic records were taken to monitor changes in vegetation on site (Fig. 19 & 20).

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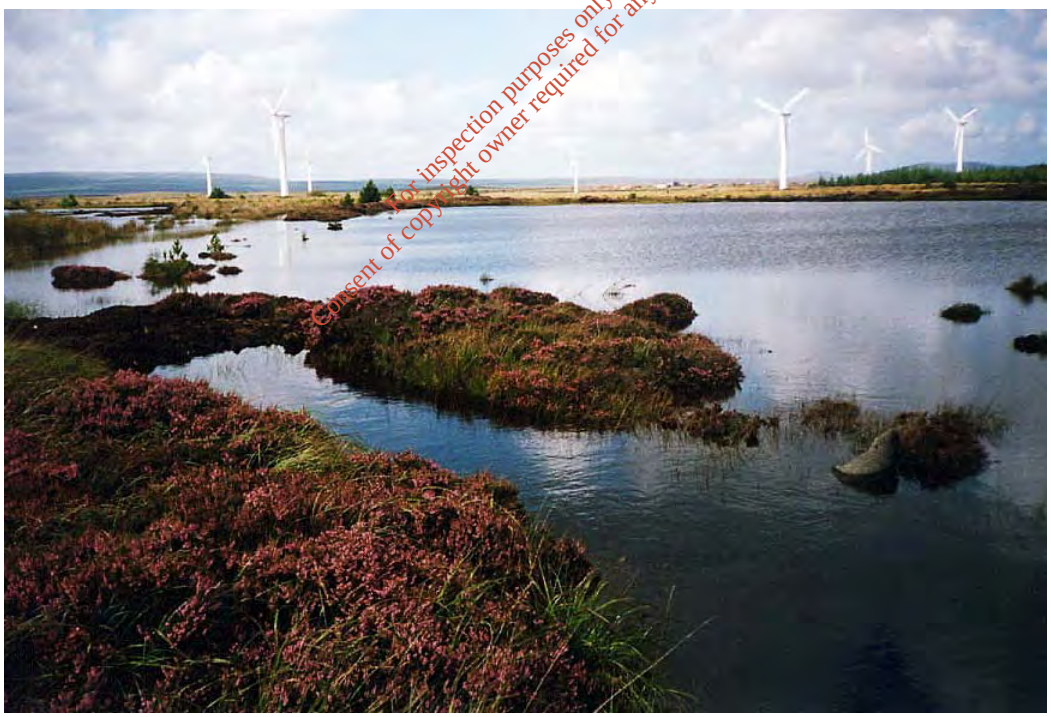
September 2002 Update

Further work was completed in the south-west corner of Rail 17A-18A. The out-fall draining into Area 3 was blocked and a small pool was created. Water exiting the area now spills over a high gravel embankment and this has created a small waterfall (Fig.21). It also serves to show that the water leaving the area is carrying no peat particles. The level of water in Swan's Lough remains relatively high with some fluctuations in drying periods. Fragments of *Sphagnum* plants were collected and spread into pools throughout the area to speed up the colonisation process. Revegetation of the area is progressing slowly.

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Fig.19. Swan's Lough prior to blocking of out-falls (July 2001). The lake bed is covered in an algal layer with some expansion of *Carex rostrata*.



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Fig.20. Swan's Lough after out-falls were blocked (photo taken from the same point in August 2001). The water level has returned to the original level in the southerly part of the lake.

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Fig.21. Water exiting the Rail 17A-18A catchment area spills out over a gravel ridge and subsequently is piped under the wind farm road into Area 3. The water from this area flows into the terminal water-body in Area 3. The water quality is currently monitored to validate that no peat is exiting the system and that the rehabilitation methods are successful in stabilising the substrates.

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5.3 Implementation of the Rehabilitation Plan

The work completed to date and an estimate of the basic work required to complete the rehabilitation plan has been outlined. An estimate of the working days required to rehabilitate the different areas has also been outlined. Peat production will continue at Oweninny up until September 2004. However, the amount of peat required for the remainder of 2004 will be minimal and therefore the current production area will not be required. It is likely that following September 2003, there will be no further peat extraction from the Bangor site. Also there will be no development within the O'Boyle's Bog and Loughnahelly Bog areas. These isolatable units are therefore available for rehabilitation work. Active production areas will not be available for rehabilitation until peat production ceases and in some areas until all peat piles have been removed to the ESB station. Based on this information a rough outline of the rehabilitation (and decommissioning) timeframe is outlined below.

5.3.1 Timeframe for rehabilitation of the Oweninny boglands

A general timeframe of activities during this phase can be outlined as follows:

March 2001 – to date	Rehabilitation of gravel areas and hydrologically isolatable areas of cutaway bog (70% gravel areas, 35% current cutaway area)
From today -Aug. 2004	Rehabilitation of gravel hills and hydrologically isolatable cutaway areas (*completed by January 2004*)
	General bog clean-up and removal of recyclable materials (*commencing April 2003*)
	Initiation of rehabilitation of O'Boyle's Bog, Loughnahelly Bogs and Bangor production areas
Sept. 2004 – Sept. 2006	Rehabilitation of Oweninny boglands: blocking all field drains, blocking main outfalls where possible to create replacement siltation areas, monitoring the effects of rehabilitation measures.
	Decommissioning of workshops, machinery, etc.
	Removal of railway networks
	Continuation of silt control measures
Sept. 2006 - ?	Continuation of silt mitigation measures
	Monitoring the effectiveness of rehabilitation work

It should be noted that this is an estimate of the length of time required to complete the rehabilitation work. It should be noted that this timeframe is dependent on weather conditions (*refer to Footnote 15*), while monitoring of the site will continue until such a time, as the Oweninny boglands are considered stabilised.

A costing of the rehabilitation programme is currently being developed.

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6 REHABILITATION OF THE OWENINNY BOGLANDS: GENERAL CONCLUSIONS

- Bord na Móna has developed a number of rehabilitation methods for the Oweninny Works. These methods have taken all habitat types and all issues of concern into consideration. In some cases there are surveys underway to assess the work required, e.g. the remediation of watercourses.
- Rehabilitation of the OAE1 and OAE2 sites will commence as soon as peat extraction ceases by Bord na Móna.
- A number of test programmes were established to demonstrate the effectiveness of the rehabilitation methods. These areas will continue to be monitored to document changes in vegetation cover. To date, rehabilitation methods have proven successful in accelerating the rate of revegetation in most areas. In some areas, revegetation will remain slow. This is a typical feature of peatland habitats.
- The criteria that define successful rehabilitation are stabilisation of bare peat and gravel areas through revegetation. Other aspects include mitigation of silt run-off, the future management of SACs and bog remnants, and potential restoration work in new development areas.
- The rehabilitation and decommissioning of the sites will be completed having taken account of issues of concern identified by the consultees. There will also be regular updates provided of the progress of rehabilitation work.
- The sites will continue to be monitored for a number of years after the rehabilitation work has been completed. The purpose will be to document the successional development of the new landscape and to remediate possible breaks in embankments, etc.
- The sites will remain in Bord na Móna ownership until the rehabilitation and decommissioning of the Oweninny boglands is completed. At that time, there may be a change of ownership depending on proposed alternative after-uses for the site and the outcome of consultation with interested parties.

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7 GUIDELINES FOR POTENTIAL CHANGES IN THE AFTER-USE OF THE OWENINNY BOGLANDS

The rehabilitation plan for the Oweninny boglands is a legal requirement and any proposed alternative developments at either the Bellacorick or Bangor production areas must take this plan into consideration. In particular, the criteria defining successful rehabilitation should be considered. To assist potential developers in designing a development for the area a number of criteria have been outlined by Bord na Móna. These criteria are essentially design guides for developers:

1. Within the development design, avoid bog remnants and areas of intact bog.
2. Minimise disturbance of bog remnant and intact bog edges. Areas proximal, particularly to bog remnants, may be required to maintain and/or enhance the ecological integrity of the habitats. Therefore, there should be no new excavations adjacent to these areas[17].
3. Any development should focus on the higher points and/or areas of shallower peat in order to minimise peat excavation and therefore potential environmental damage.
4. Lowest points in production areas, generally the location of main outfalls and terminal silt ponds should be avoided. These areas are focal points for the rehabilitation plan in developing replacement siltation areas and providing sustainable filtration mechanisms.
5. Minimise disturbance of established rehabilitated areas identified as of ongoing scientific interest, namely Area 3. This particular area has been established to provide an insight to the development of the future landscape.
6. Avoid disturbance of peat, or any activity that could destabilise peat banks, particularly on peripheral areas or steep slopes, and/or adjacent to streams and rivers.
7. A minimum distance from streams and rivers[18] should be considered where there is no margin of intact bog to isolate and/or mitigate against the potential run-off of peat into streams and rivers.
8. Where a development includes new development bog (i.e. areas not developed completely for peat production purposes), a policy of minimum impact on these areas should be adopted[19].
9. Where possible, use the existing road infrastructure as entry points to the sites.
10. The construction methods employed in any development should operate in a fashion to mitigate against potential peat run-off and siltation of streams and watercourses.

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[17] Restrict new developments within 15m (one peat production field width).
[18] A minimum distance of 50m should be considered.
[19] For example, if there is a road network passing through these areas, the road construction method should be adapted to minimise the footprint in the area. Concurrently, in advance of peat excavation for roads, the vegetative layer should be laid to one side and replaced on the excavated peat, which in turn should be deposited within 10m either side of the excavated roadway. When the drainage for the roadway is established, the peatland area between roadways should be rehabilitated (refer to *Rehabilitation Plan).*

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PART 2

REHABILITATION OF THE OWENINNY BOGLANDS INCORPORATING THE OWENINNY WIND FARM PROPOSAL

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8 THE PROPOSED OWENINNY WIND FARM

8.1 An Outline of the Proposed Wind Farm Development

Bord na Móna and the ESB have submitted a joint application for the development of a wind farm at the Bellacorick site in north-west Mayo. The wind farm design is a substantial development, with initial designs comprising the installation of up to 210 turbines inter-connected by an extensive road network (up to 87km additional track way). The initial proposal outlined the installation of turbines on a range of conditions – glacial till, cutaway bog, cut-over bog and intact bog, involving a number of construction phases – 6 in total – which would be completed within 10 years of the start-date of development.

Subsequent to the initial design submitted in October 2001, and following from the guidelines for potential after-uses outlined in **Part A** of this document and the outcome of consultations with interested parties, a number of modifications have been made to the wind farm design. There have been significant alterations to the road network design, a number of turbines in sensitive locations have been moved and the development for O'Boyle's Bog has been withdrawn from the proposal. In the light of these modifications, the rehabilitation plan for the Oweninny boglands and the wind farm proposal can proceed in tandem.

The wind farm proposal will impact on the rehabilitation plan, but this will be largely from the point of view of timeframes once the guidelines for development are adhered to[20]. The criteria defining successful rehabilitation are the same in both instances (with or without wind farm development): stabilisation of peat through revegetation, mitigation of silt run-off and establishment of wetland communities where possible.

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It is the aim here to illustrate how the rehabilitation plan and wind farm development can proceed together with minimal impact on either aspect. *Phase 1* of the Oweninny wind farm development was selected and the design guidelines set out in the rehabilitation plan were followed to develop an alternative road and turbine network. This alternative design is included here, and the rehabilitation methods also described.

There is a large degree of overlap[21] between rehabilitation plans described in **Part A** and **Part B**, highlighting the common features and concerns of Bord na Móna in relation to ensuring that the site is rehabilitated in an appropriate and sustainable way regardless what after-use is implemented. Additional aspects of rehabilitation will be consideration of pre-, during and post-construction phases.

[20] It should be noted that the Bangor site is not included in the wind farm proposal and as such, rehabilitation of the Bangor site will be completed following the methods described in Part A of this document.

[21] (a) The rehabilitation measures for each bog condition and/or habitat type, (b) the approach to SAC areas, (c) remediation of watercourses and (b) silt control measures are the same.

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8.2 Integrating the Rehabilitation Plan and the Wind Farm Development: *Phase 1*

The first step in describing the rehabilitation of that part of the Oweninny wind farm involved in *Phase 1* was to consider the original design, and based on the guidelines developed as part of the rehabilitation plan, design an alternative road and turbine network. This updated *Phase 1* of the wind farm proposal is outlined in Fig.22.

A number of features can be identified:

- The road network follows the high points and there are a number of blind roads. This minimises impact on low areas and reduces fragmentation of the bog drainage network.
- Bog remnants have been avoided.
- Turbines located in lowest points and in environmentally sensitive areas (e.g. adjacent streams) have been re-located or eliminated. Where they are located close to low points the method of construction will involve building a causeway. This will lead to the turbine being elevated from the surrounding area and allow for the establishment of replacement siltation areas in the area around the causeway.
- The design will have minimal impact on the rehabilitation plan – the main outfalls can be blocked, and the road re-alignment minimises the excavation and disturbance of peat.

This new design will have minimal impact on the rehabilitation plan, while maximising the value of the land.

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8.3 Rehabilitation of the Oweninny Boglands: modifications to the timeframe of rehabilitation as a result of the wind farm development

In order for the rehabilitation programme to be tailored to incorporate the Oweninny wind farm proposal, the plan must be broken into three distinct phases:

- Pre-construction
- During construction
- Post-construction

The criteria for successful rehabilitation remain the same, i.e. stabilisation of the remaining peat by revegetation of the substrates, mitigation of silt run-off and re-instatement of replacement wetland communities where possible.

8.3.1 Pre-construction

This phase essentially relates to the time period from present to initiation of wind farm construction and largely follows that proposed timeframe for activities set out in **Part A.** Rehabilitation of cutaway areas was initiated in March 2001, and is still underway. This has focused primarily on hydrologically isolatable areas of cutaway and exposed gravel hills. Rehabilitation of gravel areas should be completed by January 2004. Also, a general clean up and removal of recyclable materials from the bog areas will be initiated in spring 2003. Peat extraction is due to cease in September 2003, although based on recent climatic trends, production may be ongoing for a period in 2004 to make up production targets. Once peat extraction ceases further rehabilitation and decommissioning measures will be initiated, including lifting of the railway networks and continuation of silt excavation (*see previous timeframe estimates*).

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It will be impossible to carry out any large-scale bog rehabilitation, except at the Bangor site and in areas at Bellacorick that are identified as exempt from turbine installation. These areas are readily identifiable from the wind turbine map (see aerial photograph: generally the areas adjacent to the N59 and the Srahnakilly road). Depending on planning permission and processing of the application, it is not possible at this time to say when actual construction of the Oweninny Wind Farm will commence.

A general timeframe of activities during this pre-construction phase can be outlined as follows:

March 2001 – to date	Rehabilitation of gravel areas and hydrologically isolatable areas of cutaway bog (70% gravel areas, 35% current cutaway area)
From today -Aug. 2004	Rehabilitation of gravel hills and hydrologically isolatable cutaway areas (*completed by January 2004*) General bog clean-up and removal of recyclable materials (*commencing April 2003*) Initiation of rehabilitation of O'Boyle's Bog, Loughnahelly Bogs and Bangor production areas
Sept. 2004 - construction	Rehabilitation of areas unaffected by wind turbine installation (Bangor bogs, areas adjacent roads, etc.) Continuation of silt pond excavations Decommissioning of workshops, machinery, etc. Removal of railway networks

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8.3.2 During construction

At the onset of actual construction of the wind farm a number of rehabilitation and decommissioning tasks will have been completed, including removal of the railway networks, general bog clean up, etc.

The construction period will be spread over a maximum of ten years and will take place over 6 phases. Each phase will initially involve road construction to allow for transport of wind turbine components, etc. The main features of rehabilitation at this point will be (i) rehabilitation of the bog areas outside of the road and wind-turbine network and (ii) maintenance of silt mitigation measures.

Rehabilitation of bog areas outside of the road and turbine network

The main features of the proposed wind farm development are the wind turbines and associated infrastructure. During construction, discrete areas will be successively selected for development and the prescribed work conducted. In the case of *Phase 1*, the areas under development are Areas 5, 6, 7 12, Rail D, F, G and Rail 337B (identifiable from Fig. 2). In general, until the road network and associated drainage network has been installed and proven effective in each discrete area, rehabilitation work will be limited. There will be scope however, to block field drains and main outfalls particularly in the western parts of Areas 5 and 6. It is likely that blocking of some of the outfalls in Areas 12 and 7 may proceed, but the turbines are located in greater proximity to the boundary margins and it may be impossible to flood areas until construction is completed.

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Once the construction work is completed however, the rehabilitation tools will reflect those described initially in **Part A**, working around the road and network. Where there are gravel hills exposed, these areas will be ploughed to accelerate revegetation. Where there are depressions within an area, the drainage will be manipulated, to create open water bodies. Where peat remains on a slope, embankments will be constructed sequentially along the slope to slow down the movement of water and ultimately peat. Main out-falls will ultimately be blocked and replacement siltation areas created but the timing of this is dependent on road construction.

N.B. The rehabilitation programme will be staggered with the construction programme for the wind farm development. As such, the duration will be spread over a longer period that that defined in **Part A**.

Maintenance of silt mitigation measures

Existing silt ponds will be maintained and will continue to be excavated at the current rates over the course of construction of the Oweninny Wind Farm. It has been proposed by the developers to install a silt pond at each turbine, which would capture any peat disturbed during construction and/or maintenance material used in the construction phase. Silt will continue to be excavated until there is no further silt run-off from the construction and post-peat production areas.

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8.3.3 Post construction

Once the construction phase is complete, a number of tasks will remain for completion. At this stage, most of the rehabilitation work will have been characterised and largely completed. There will however, be further remediation work to be completed as the areas are monitored to ensure rehabilitation methods have been effective, i.e. peat is stabilised, there are no breaches of embankments or dams, and the area is revegetating. Silt pond excavation will continue up until such time, as there is no further build-up of silt in ponds and therefore, no run-off of peat or other material from the construction site.

The post construction rehabilitation tasks will therefore include:

- Completion of rehabilitation measures
- Continuation of monitoring of effectiveness of rehabilitation measures to date
- Continuation of silt pond excavation until such time as there is no further build-up of silt in terminal ponds and no further threat of siltation of rivers and streams (time unknown)

The timeframe for completion of these rehabilitation/remediation tasks is as yet unknown and will be highly dependent on the rate of construction, issues arising from on-site environmental conditions and the ongoing alterations in the landscape.

8.4 Other Issues

All other aspects that were described in **Part A**, such as management of SACs, relocation of silt ponds (and possible remediation of watercourses) and rehabilitation of new development areas will proceed as outlined in **Part A** of the document. These aspects are seen as somewhat independent of the wind farm development, although silt control may be inter-linked with the wind farm construction.

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8.5 The Oweninny Wind Farm Development: General Conclusions

- The re-design of the road and turbine network to comply with the guidelines outlined in Section 7 of **Part A** is seen as an essential part of the wind farm development.
- In following these guidelines, there will be minimal environmental disturbance on site and minimal impact on the rehabilitation plan for the area.
- The rehabilitation work will involve the same procedures as outlined in **Part A**, although the timeframes of rehabilitation for during construction up until completion of the total 6 phases of the development can not be defined as yet.
- Issues of concern identified by the consultees relating to the development will be taken into consideration and the updated designs for the road and turbine networks for each phase of the development will be circulated as part of the ongoing consultation process.
- Rehabilitation of the Bangor site will proceed as outlined in **Part A** of this document.

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Appendix 3

Site descriptions of SPAs, IBAs and Ramsar sites

Source:

Blacksod Bay Special Protection Area (SPA) (4037):

This forms part of the IBA 041, which encompasses Broadhaven, Blacksod, Tullaghan Bay and parts of the Mullet Peninsula. The entire intertidal zone of this IBA is located within SPAs. Areas not included in the SPAs but included in the IBA are those important for corncrake (*Crex crex*), swan and geese grazing, and also for ground nesting waders and terns. Areas covered under the designations are outlined below,

- 683 ha of this IBA is covered by a *Ramsar* site (see below), which is also part of the Broadhaven Bay SPA.
- 7493 ha is covered by the Blacksod/Broadhaven SPA
- 109 ha is covered by the Cross Lough Mullet SPA
- 377 ha is covered by the Termoncaragh Lake SPA

The Broadhaven/Blacksod IBA:

This IBA is very large coastal complex, approximately 10,852 ha, next to Belmullet in County Mayo. The site includes intertidal mudflats, sand flats and salt marshes of several bays as well as parts of Belmullet peninsula and mainland. Habitats present are machair, lakes, marshes and non-intensive farmland. The site is an amalgamation of three sites, which were listed as separate important bird areas in the EU previous inventory (Grimmit and Jones 1989). It is selected as an important bird area because of the presence of the following species: Great Northern Diver, Whooper Swan, Barnacle Goose, Brent Goose, Corncrake, Bar Tailed Godwit, Red Necked Phalarope and Sandwich Tern.

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Ramsar Sites

Blacksod Bay and Broadhaven Ramsar Site
11/06/96; Mayo; 683 ha; 54º03'N 010º00'W.
A composite of diverse marine and coastal habitats that includes vast dune systems and extensive areas of dune grassland with saltmarshes occurring in sheltered bays and inlets. The grasslands are of considerable botanical importance. The site also includes several brackish lakes important to various species of breeding waders, large numbers of wintering water birds of various species, and internationally important numbers of Brent geese. Ramsar site no. 844.

This site equated to the Broadhaven/Blacksod SPA prior to the site review in the 1990s and subsequent SAC designations. Sections of these sites are now incorporated into three SACs namely Mullet/Blacksod Complex, Broadhaven Bay SAC and the Glenamoy Bog Complex SAC.

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Appendix 4

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TRIAL PIT LOG

Trial Pit No. 1

Sheet No. 1 of 1

Excavator Type:	Date:	Client:
HITACHI	23/10/03	Bord na Mona/Shell E&P

Grid Reference:	Elevation (mOD):	Site:
E084643, N324121		Srahmore, Bangor–Erris, Co. Mayo.

Depth m	Description of Strata	Legend	OD Level m	Samples Type	Samples Ref. No.	Water Inflows	Pit Completion Lining:	Pit Completion Backfill:
0.0								
	PEAT Soft, medium light brown to medium brown, occasional fragments of bog wood, slightly moist.			Vane Test	TP1			
2.4								
	Yellowish brown to light yellowish brown gravelly, clayey SAND, with some angular subangular cobbles of schist at base.			Disturbed Sample	TP1			
3.0								
	END OF TRIAL PIT							

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Logged by:	Job No.:	Remarks:
P.K.	1169	1. Shear vane test undertaken on peat, disturbed soil sample obtained for Particle Size Distribution testing.
Scale:	Rev.:	2. No significant groundwater inflow recorded during excavation.
1:25		3. Excavation terminated at 3m due to obtstruction/compaction of subsoil.

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Blanchardstown Corporate Park
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Dublin 15

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Trial Pit No. 2

Sheet No. 1 of 1

Excavator Type:	Date:	Client:
	23/10/03	Bord na Mona/Shell E&P
Grid Reference:	**Elevation (mOD):**	**Site:**
E084646, N323870		Srahmore, Bangor–Erris, Co. Mayo.

Depth m	Description of Strata	Legend	OD Level m	Samples Type	Samples Ref. No.	Water Inflows	Pit Completion Lining:	Pit Completion Backfill:
0.0								
	PEAT Soft, medium dark brown to dark brown, occasional fragments of bog wood.			Vane Test	TP2			
0.65	Medium light grey to light greenish grey, gravelly, clayey slightly micaceous SAND. The Gravels are platey, angular to subangular Quartzites.			Disturbed Sample	TP2			
3.0	END OF TRIAL PIT							

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Logged by:	Job No.:	Remarks:
P.K.	1169	1. Shear vane test undertaken on peat, disturbed soil sample obtained for Particle Size Distribution testing.
Scale:	Rev.:	2. No significant groundwater inflow recorded during excavation.
1:25		

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Trial Pit No. 3

Sheet No. 1 of 1

Excavator Type:	Date: 23/10/03	Client: Bord na Mona/Shell E&P
Grid Reference: E084890, N323700	Elevation (mOD):	Site: Srahmore, Bangor–Erris, Co. Mayo.

Depth m	Description of Strata	Legend	OD Level m	Samples Type	Samples Ref. No.	Water Inflows	Pit Completion Lining:	Pit Completion Backfill:
0.0								
	PEAT Soft, medium brown to light brown, fragments of bog wood and rootlets, slightly moist.			Vane Test	TP3			
1.8	Greenish grey to light greenish grey to light grey SAND, with some angular to subangular gravels and cobbles of schist.			Disturbed Sample	TP3			
3.45	END OF TRIAL PIT							

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Logged by: P.K.	Job No.: 1169	Remarks:
Scale: 1:25	Rev.:	1. Shear vane test undertaken on peat, disturbed soil sample obtained for Particle Size Distribution testing. 2. Slight to moderate groundwater inflow recorded at 2.5m during excavation. 3. Excavation terminated due to obstruction/compaction of subsoil at 3.45m.

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Trial Pit No. 4

Sheet No. 1 of 1

Excavator Type:	Date:	Client:
	23/10/03	Bord na Mona/Shell E&P
Grid Reference:	**Elevation (mOD):**	**Site:**
E084164, N323332		Srahmore, Bangor–Erris, Co. Mayo.

Depth m	Description of Strata	Legend	OD Level m	Samples Type	Samples Ref. No.	Water Inflows	Pit Completion Lining:	Pit Completion Backfill:
0.0								
	PEAT Soft to very soft, medium brown to medium dark brown, with fragments of bog wood and roolets, moist.			Vane Test	TP4			
1.1								
	Medium greenish grey to grey, clayey, fine grained SAND with occasional subrounded to rounded gravel and cobbles.			Disturbed Sample	TP4			
1.4								
	Medium grey to light brownish grey GRAVEL with some sub–rounded to subangular cobbles.							
1.65								
	END OF TRIAL PIT							

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Logged by:	Job No.:	Remarks:
P.K.	1169	1. Shear vane test undertaken on peat, disturbed soil sample obtained for Particle Size Distribution testing.
Scale:	Rev.:	2. Excavations terminated at 1.65m bgl due to unstable ground and pit wall collpase caused by water inflow.
1:25		

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Trial Pit No. 5

Sheet No. 1 of 1

Excavator Type:	Date:	Client:
	23/10/03	Bord na Mona/Shell E&P
Grid Reference:	**Elevation (mOD):**	**Site:**
E084474, N323382		Srahmore, Bangor–Erris, Co. Mayo.

Depth m	Description of Strata	Legend	OD Level m	Samples Type	Samples Ref. No.	Water Inflows	Pit Completion Lining:	Pit Completion Backfill:
0.0								
	PEAT Soft, medium dark brown fragments of bog wood and rootlets, moist.			Vane Test	TP5			
0.9								
	Yellowish brown to greyish brown, gravelly, cobbley SILT/ SAND. The gravels are subangular to subrounded.			Disturbed Sample	TP5			
3.0								
	END OF TRIAL PIT							

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Logged by:	Job No.:	Remarks:
P.K.	1169	1. Shear vane test undertaken on peat, disturbed soil sample obtained for Particle Size Distribution testing.
Scale:	Rev.:	2. Slight to moderate groundwater inflow at 2.5m bgl.
1:25		

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Trial Pit No. 6

Sheet No. 1 of 1

Excavator Type:	Date:	Client:
	23/10/03	Bord na Mona/Shell E&P
Grid Reference:	**Elevation (mOD):**	**Site:**
E084852, N323176		Srahmore, Bangor–Erris, Co. Mayo.

Depth m	Description of Strata	Legend	OD Level m	Samples Type	Samples Ref. No.	Water Inflows	Pit Completion Lining:	Pit Completion Backfill:
0.0								
	PEAT Soft, dark brown to brownish black, fragments of bog wood, moist.			Vane Test	TP6			
0.95								
	Light yellowish brown clayey, fine grained SAND with occasional gravels that are subrounded to rounded							
1.9								
	Medium brown to dark brown subangular to subrounded GRAVELS, with some Cobbles.			Disturbed Sample	TP6			
2.5								
	END OF TRIAL PIT							

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Logged by:	Job No.:	Remarks:
P.K.	1169	1. Shear vane test undertaken on peat, disturbed soil sample obtained for Particle Size Distribution testing.
Scale:	Rev.:	2. No significant groundwater inflows noted during excavation.
1:25		

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Trial Pit No. 7

Sheet No. 1 of 1

Excavator Type:	Date:	Client:
	23/10/03	Bord na Mona/Shell E&P
Grid Reference:	**Elevation (mOD):**	**Site:**
E084001, N323713		Srahmore, Bangor–Erris, Co. Mayo.

Depth m	Description of Strata	Legend	OD Level m	Samples Type	Samples Ref. No.	Water Inflows	Pit Completion Lining:	Pit Completion Backfill:
0.0								
	PEAT Soft, dark brown to brownish black, fragments of bog wood, moist. Occurance of more recent plant material and heather.							
				Vane Test	TP7			
0.85	Light yellowish brown to light yellowish grey clayey SAND with occasional gravels that are subrounded to rounded. Gravel content increases with depth and becomes angular at base.							
				Disturbed Sample	TP7			
2.5	END OF TRIAL PIT							

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Logged by:	Job No.:	Remarks:
P.K.	1169	1. Shear vane test undertaken on peat, disturbed soil sample obtained for Particle Size Distribution testing. 2. No significant groundwater inflows noted during excavation.
Scale: 1:25	Rev.:	

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TRIAL PIT LOG

Trial Pit No. 8

Sheet No. 1 of 1

Excavator Type:	Date:	Client:
	23/10/03	Bord na Mona/Shell E&P
Grid Reference:	**Elevation (mOD):**	**Site:**
E084402, N323988		Srahmore, Bangor–Erris, Co. Mayo.

Depth m	Description of Strata	Legend	OD Level m	Samples Type	Samples Ref. No.	Water Inflows	Pit Completion Lining:	Pit Completion Backfill:
0.0								
0.2	Medium dark, soft PEAT							
	Medium light grey to greenish grey, gravelly, cobbley SILT/ SAND. The gravels are subangular to subrounded and occasionally well rounded Quartzites, with occasional Red Sandstones and Slate.							
2.6	END OF TRIAL PIT							

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Logged by:	Job No.:	Remarks:
P.K.	1169	
Scale:	Rev.:	
1:25		

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TRIAL PIT LOG

Trial Pit No. 9

Sheet No. 1 of 1

Excavator Type:	Date:	Client:
	23/10/03	Bord na Mona/Shell E&P
Grid Reference:	**Elevation (mOD):**	**Site:**
E084402, N323988		Srahmore, Bangor–Erris, Co. Mayo.

Depth m	Description of Strata	Legend	OD Level m	Samples Type	Samples Ref. No.	Water Inflows	Pit Completion Lining:	Pit Completion Backfill:
0.0								
0.4	Medium dark, soft PEAT							
2.5	Medium light grey to greenish grey, gravelly, cobbley SILT/ SAND. The gravels are subangular subrounded and occasionally well rounded Quartites, with occasional Red Sandstone and Slate.							
	END OF TRIAL PIT							

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Logged by:	Job No.:	Remarks:
P.K.	1169	
Scale: 1:25	Rev.:	

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TRIAL PIT LOG

Trial Pit No. 10

Sheet No. 1 of 1

Excavator Type:	Date:	Client:
	18/11/03	Bord na Mona/Shell E&P

Grid Reference:	Elevation (mOD):	Site:
E083780, N323797		Srahmore, Bangor–Erris, Co. Mayo.

Depth m	Description of Strata	Legend	OD Level m	Samples Type	Samples Ref. No.	Water Inflows	Pit Completion Lining:	Pit Completion Backfill:
0.0								
0.1	Dark brown, peaty GRAVEL, with many cobbles and boulders. Gravels subangular to subrounded Quartzite, Schist, Slate and Red Sandstone							
0.7	Medium brown, clayey, gravelly, fine grained SAND. Gravels are subangular to subrounded							
1.45	Medium grey to greenish grey to light brownish grey, clayey, gravelly, fine to medium grained SAND, with occasional subangular to subrounded cobbles.			Bulk Sample	TP10			
3.2	Medium light grey, sandy, slightly clayey, subangular GRAVEL, with occasional angular, subangular and subrounded cobbles and boulders of Quartzite, Schist and Red Sandstone.							
	END OF TRIAL PIT							

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Logged by:	Job No.:	Remarks:
P.K.	1169	1. Surface water running into pit excavation because of heavy rain
Scale: 1:25	Rev.:	

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TRIAL PIT LOG

Trial Pit No. 11

Sheet No. 1 of 1

Excavator Type:	Date:	Client:
	18/11/03	Bord na Mona/Shell E&P

Grid Reference:	Elevation (mOD):	Site:
E083837, N323823		Srahmore, Bangor–Erris, Co. Mayo.

Depth m	Description of Strata	Legend	OD Level m	Samples Type	Samples Ref. No.	Water Inflows	Pit Completion Lining:	Pit Completion Backfill:
0.0								
0.2	Medium brown, sandy, slightly clayey, peaty GRAVEL, with some cobbles. Gravel is subangular to angular Quartzite, with occasional Schist and Sandstone							
	Light brown to yellowish grey, slightly clayey, gravelly, fine SAND. Subangular gravels of Quartzite and occasional angular boulders of banded Gneiss			Bulk Sample	TP11			
3.0	END OF TRIAL PIT							

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Logged by:	Job No.:	Remarks:
P.K.	1169	1. No water inflows to pit, dry.
Scale: 1:25	Rev.:	

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TRIAL PIT LOG

Trial Pit No. 12

Sheet No. 1 of 1

Excavator Type:	Date:	Client:
	18/11/03	Bord na Mona/Shell E&P
Grid Reference:	**Elevation (mOD):**	**Site:**
E083925, N323806		Srahmore, Bangor–Erris, Co. Mayo.

Depth m	Description of Strata	Legend	OD Level m	Samples Type	Samples Ref. No.	Water Inflows	Pit Completion Lining:	Pit Completion Backfill:
0.0								
0.3	Medium brown, slightly clayey fine grained SAND, with thin layers of peat on top							
	Medium light grey, gravelly, slightly clayey, slightly micaceous SAND with some subangular cobbles and occasional subangular boulders. Gravels are subangular to subrounded Quartzite.							
				Bulk Sample	TP12A			
	Medium grey to medium light grey gravelly, fine grained SAND with some cobbles and some blocky boulders of Gneiss. Gravels are subrounded and occasionally well rounded							
3.0				Bulk Sample	TP12B			
	END OF TRIAL PIT							

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Logged by:	Job No.:	Remarks:
P.K.	1169	1. Increae in moisture content at 3m bgl.
Scale: 1:25	Rev.:	

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TRIAL PIT LOG

Trial Pit No. 13

Sheet No. 1 of 1

Excavator Type:	Date:	Client:
	18/11/03	Bord na Mona/Shell E&P

Grid Reference:	Elevation (mOD):	Site:
E084417, N324002		Srahmore, Bangor–Erris, Co. Mayo.

Depth m	Description of Strata	Legend	OD Level m	Samples Type	Samples Ref. No.	Water Inflows	Pit Completion Lining:	Pit Completion Backfill:
0.0								
	Medium dark brown to brownish black, soft PEAT, with angular and subrounded gravels and boulders of Quartzite and Schist							
0.25								
	Medium dark brown to medium brown, Firm CLAY							
0.75								
	Light grey to medium light grey and light greyish brown, gravelly, silty, fine grained SAND with occasional subangular to subrounded blocky boulders of Gneiss. Gravels are subangular to subrounded, occasionally well rounded, composed of Quartzite Schist, Red Sandstone and Slate.			Bulk Sample	TP13A			
				Bulk Sample	TP13B			
3.2								
	END OF TRIAL PIT							

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Logged by:	Job No.:	Remarks:
P.K.	1169	
Scale: 1:25	Rev.:	

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TRIAL PIT LOG

Trial Pit No. 14

Sheet No. 1 of 1

Excavator Type:	Date:	Client:
	18/11/03	Bord na Mona/Shell E&P

Grid Reference:	Elevation (mOD):	Site:
E084647, N324207		Srahmore, Bangor–Erris, Co. Mayo.

Depth m	Description of Strata	Legend	OD Level m	Samples Type	Samples Ref. No.	Water Inflows	Pit Completion Lining:	Pit Completion Backfill:
0.0								
	Medium brown, gravelly, slightly clayey, fine grained SAND, with some angular cobbles and boulders of Quartzite. Gravels are subangular to angular.							
0.75								
	Light grey to light yellowish grey, gravelly, cobbley, slightly clayey SAND with some angular boulders of Gneiss. Gravels are subangular to subrounded Quartzite and Red Sandstone.							
2.0				Bulk Sample	TP14A			
	Medium grey, gravelly, slightly clayey, slightly micaceouas SAND with some subangular to subrounded cobbles of Quartzite. Gravels are subangular to subrounded Quartzite.							
3.5				Bulk Sample	TP14B			
	END OF TRIAL PIT							

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Logged by:	Job No.:	Remarks:
P.K.	1169	1. Increase in moisture content at 1.5m bgl.
Scale: 1:25	Rev.:	

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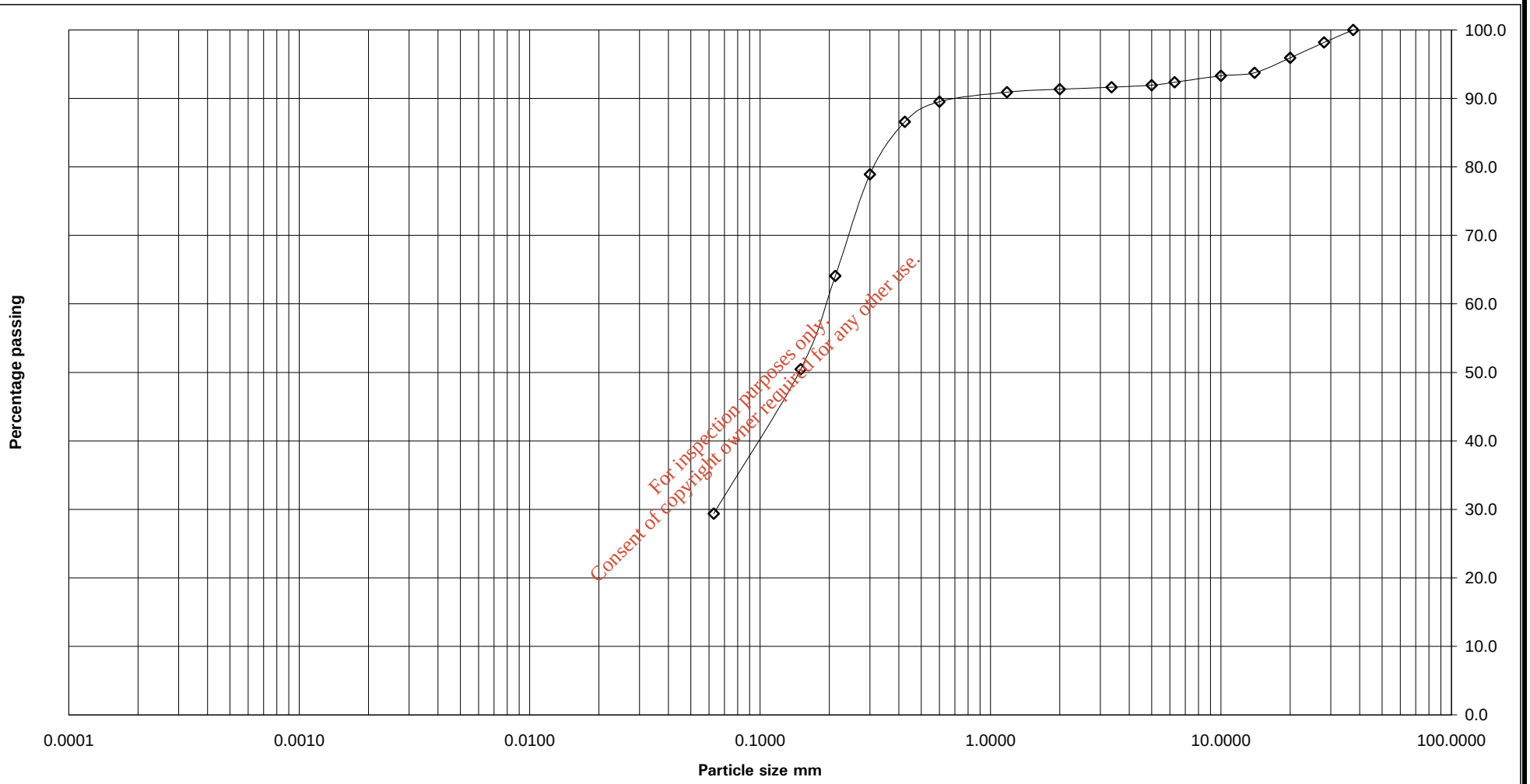
Appendix 5

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PROJECT:	Bangor Erris	Project No:	1169	**PARTICLE SIZE DISTRIBUTION**
CLIENT:	Irish Drilling	Reference:	0415	

Borehole No. TP1 Sample No. Depth 3.00 m



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	CLAY	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	COBBLES
		SILT			SAND			GRAVEL			

Visual Description: Pale grey silty SAND with little gravel

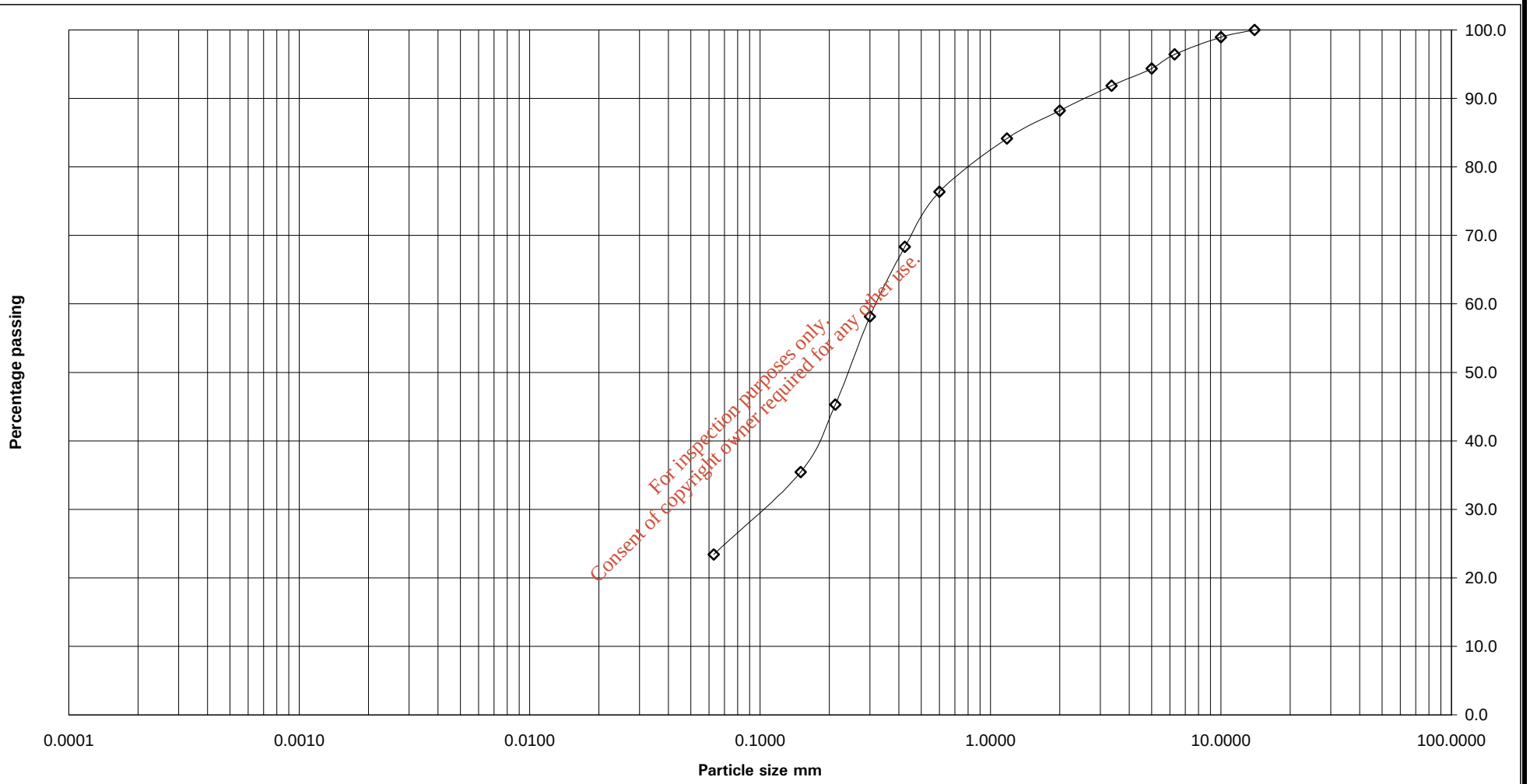
K4 SOILS LABORATORY

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PROJECT:	Bangor Erris	Project No:	1169
CLIENT:	Irish Drilling	Reference:	0415

PARTICLE SIZE DISTRIBUTION

Borehole No. TP2 Sample No. Depth 2.50 m



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CLAY	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	COBBLES
	SILT			SAND			GRAVEL			

Visual Description: Grey silty SAND with a little gravel

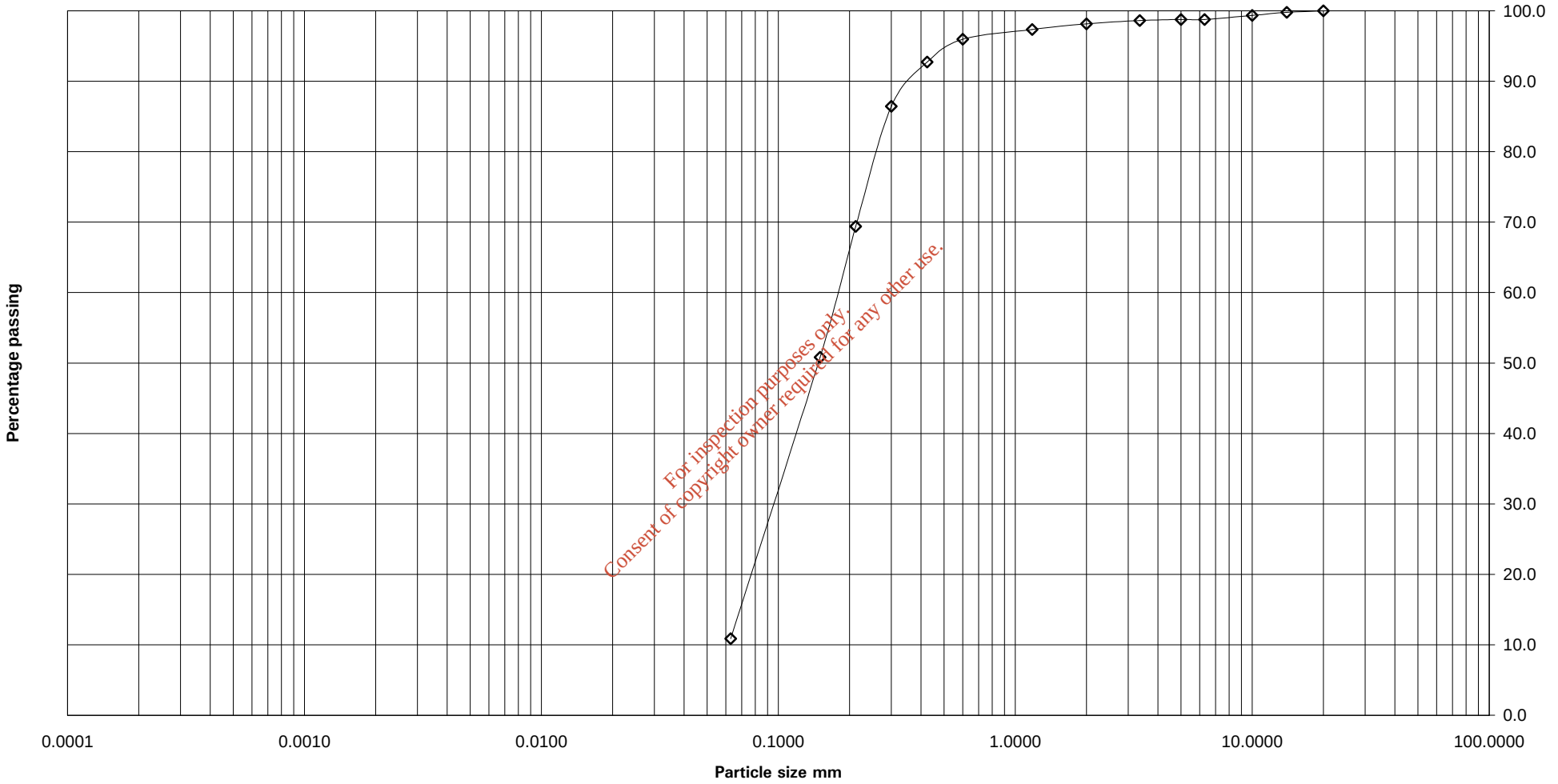
K4 SOILS LABORATORY

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PROJECT:	Bangor Erris	Project No:	1169
CLIENT:	Irish Drilling	Reference:	0415

PARTICLE SIZE DISTRIBUTION

Borehole No. TP3 Sample No. Depth 2.50 m



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CLAY	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	COBBLES
	SILT			SAND			GRAVEL			

Visual Description: Pale grey SAND with a trace of gravel

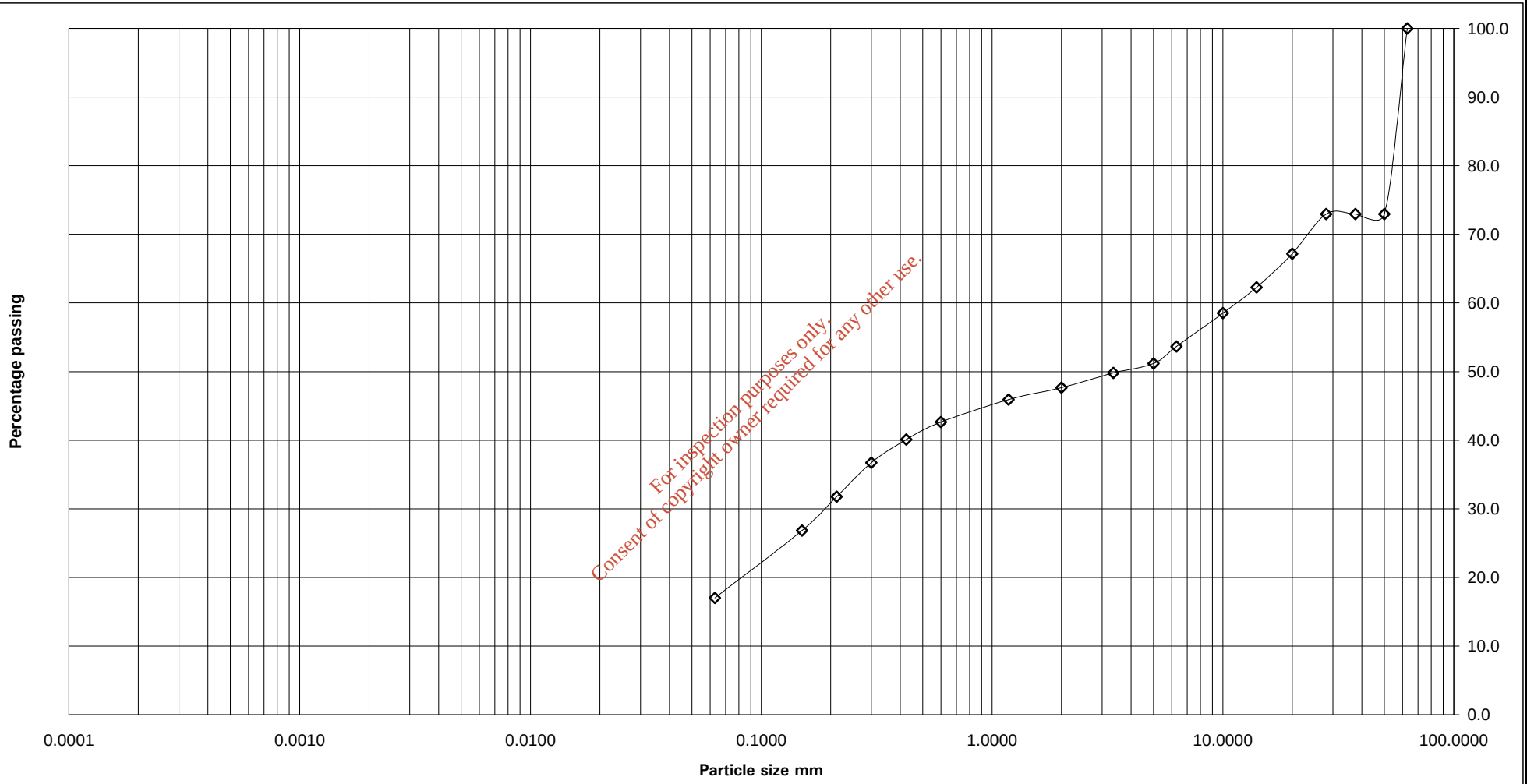
K4 SOILS LABORATORY

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PROJECT:	Bangor Erris	Project No:	1169
CLIENT:	Irish Drilling	Reference:	0415

PARTICLE SIZE DISTRIBUTION

Borehole No. TP4 Sample No. Depth 1.00 m



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CLAY	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	COBBLES
	SILT			SAND			GRAVEL			

Visual Description: Grey silty SAND and GRAVEL

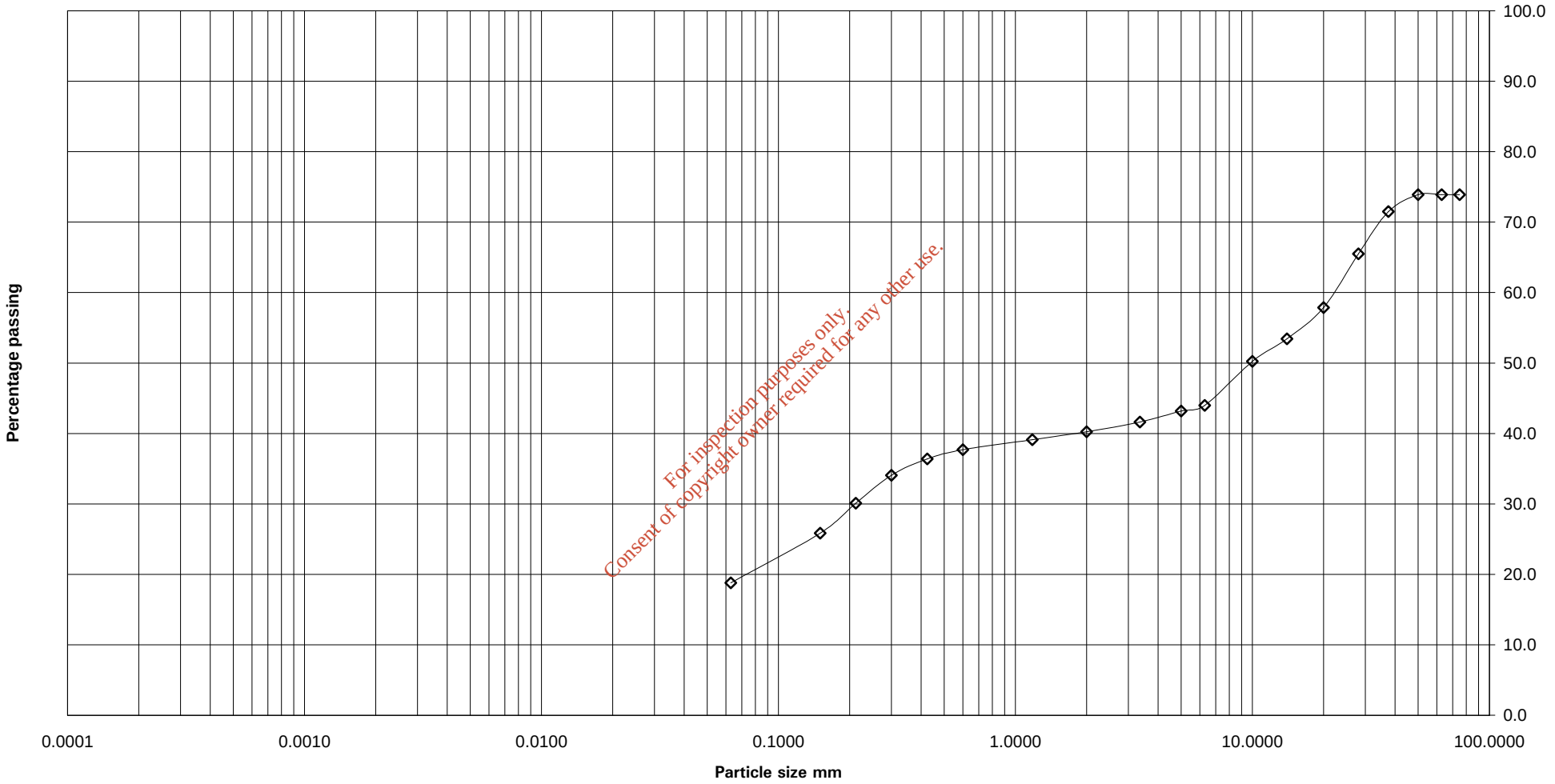
K4 SOILS LABORATORY

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PROJECT:	Bangor Erris	Project No:	1169
CLIENT:	Irish Drilling	Reference:	0415

PARTICLE SIZE DISTRIBUTION

Borehole No. TP5 Sample No. Depth 1.50 m



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CLAY	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	COBBLES
	SILT			SAND			GRAVEL			

Visual Description: Grey silty sandy GRAVEL with occasional cobbles

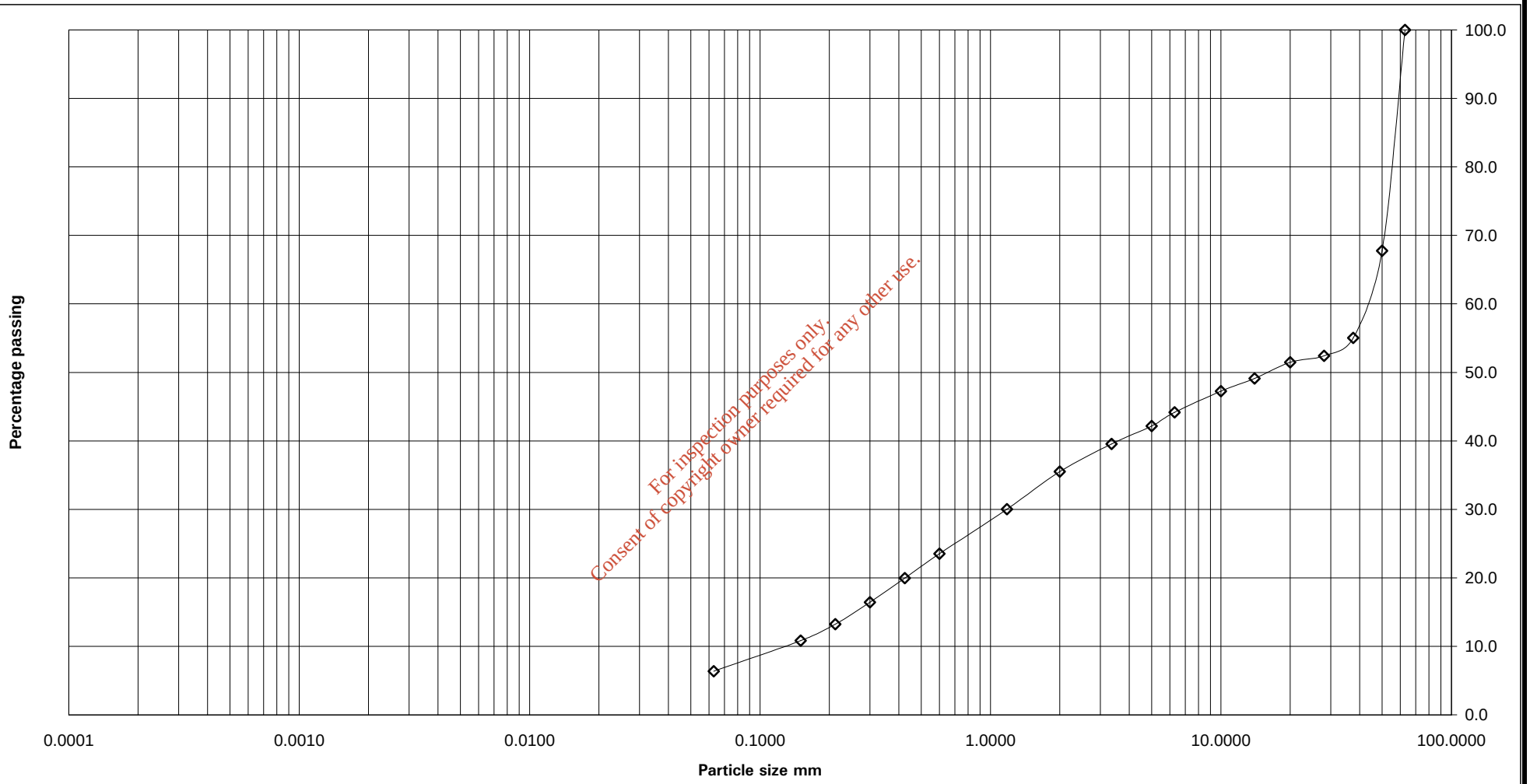
K4 SOILS LABORATORY

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PROJECT:	Bangor Erris	Project No:	1169
CLIENT:	Irish Drilling	Reference:	0415

PARTICLE SIZE DISTRIBUTION

Borehole No. TP6 Sample No. Depth 2.50 m



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CLAY	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	COBBLES
	SILT			SAND			GRAVEL			

Visual Description: Grey sandy GRAVEL

K4 SOILS LABORATORY

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Appendix 6

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BOREHOLE LOG

Borehole BH1A

Sheet No. 1 of 1

Client:	Site:	Job No.:	Scale:
Bord na Mona/Shell E&P	Srahmore, Bangor–Erris, Co. Mayo.	1169	1:50

Grid Reference			
Easting: E084463 Northing: N323049	Elevation (mOD): 17.56m Borehole Diameter (Subsoil): 65mm Borehole Diameter (Rock): 65mm Borehole Depth (m): 13.5m	Date Started: 22/10/03 Date Completed: 22/10/03	Drill Contractor: Irish Drilling Ltd. Drill Method: Coring Logged by: P.K.

Depth m	Description of Strata	Legend	OD Level m	Static Water Level 4/11/03	Samples Type	Samples Ref. No.	BH Tests Type & Ref.	Completion Details Lining:	Completion Details Backfill:
GL									
0.55	PEAT							50MM uPVC CASING	CEMENT
				▼					BENT ONITE
			15.09						
	Fine grained SAND, with clay/silt matrix, medium light grey to greenish grey.							50MM uPVC SCREEN	3–7mm Pea Gravel
12.5								END OF CASING	
	SAND with fragments of Schist and Quartzite. Light grey to light greenish grey.								
13.5	END OF BOREHOLE								
18									

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Remarks:

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BOREHOLE LOG

Borehole BH1B

Sheet No. 1 of 2

Client:	Site:	Job No.:	Scale:
Bord na Mona/Shell E&P	Srahmore, Bangor–Erris, County Mayo.	1169	1:50

Grid Reference	Elevation (mOD): 17.524	Date Started: 23/10/03	Drill Contractor: Irish Drilling Ltd.
Easting: 084463	Borehole Diameter (Subsoil): 65mm	Date Completed: 24/10/03	Drill Method: Coring
Northing: 323049	Borehole Diameter (Rock): 65mm		Logged by: PK
	Borehole Depth (m): 23.7m		

Depth m	Description of Strata	Legend	OD Level m	Static Water Level 4/11/03	Samples Type	Samples Ref. No.	BH Tests Type & Ref.	Completion Details Lining:	Completion Details Backfill:
GL									
0.65	PEAT								
	Fine grained SAND with clay/silt matrix. Medium light grey to greenish grey.		15.09m	▼				50mm uPVC CASING	BENTONITE
12.7									
13.7	SAND with fregments of Schist and Quartzite. Light grey to light greenish grey.								
	Moderately weak to moderately strong narrowly banded, schistose (dipping 75 degrees), greenish brown, coarsely to medium grained and frequently flaky, extremely micaceous, haematitic, PSAMMITE, moderately weathered. Large (2mm) flaky, specular micas, exhibiting pronounced schistosity–parallel preferred orientation								
	Discontinuities: Closely spaced, mainly schistosity paraller, sub–planar to undulose, rough surfaced, tight to moderately open.								
18									

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Remarks:

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BOREHOLE LOG

Borehole BH1B

Sheet No. 2 of 2

Client:	Site:	Job No.:	Scale:
Bord na Mona/Shell E&P	Srahmore, Bangor–Erris, County Mayo.	1169	1:50

Grid Reference			
Easting: 084463 Northing: 323049	Elevation (mOD): 17.254 Borehole Diameter (Subsoil): 65mm Borehole Diameter (Rock): 65mm Borehole Depth (m): 23.7m	Date Started: 23/10/03 Date Completed: 24/10/03	Drill Contractor: Irish Drilling Ltd. Drill Method: Coring Logged by: PK

Depth m	Description of Strata	Legend	OD Level m	Water Inflows	Samples Type	Samples Ref. No.	BH Tests Type & Ref.	Completion Details Lining:	Completion Details Backfill:
18m 18.5	As above						Packet Test Ref.: BH1B Test section: 15.5–23.7m bgl	50mm uPVC Screen	3–7mm Pea Gravel
	Strong to very strong, faintly narrowly banded, (dipping 60 degrees), white to very pale grey, fine to medium grained, micaceous QUARTZITE, fresh to slightly weathered. Mica occurs as strong orientated flakes, producing previously described narrow banding. Discontinuities: Closely to medium spaced, generally banding parallel (but also steeply dipping in at least 2 other orientations), generallly planar, slightly rough surfaced, tight and clean.								
23.7	END OF BOREHOLE								

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BOREHOLE LOG

Borehole BH2A

Sheet No. 1 of 1

Client:	Site:	Job No.:	Scale:
Bord na Mona/Shell E&P	Srahmore, Bangor–Erris, Co. Mayo.	1169	1:50

Grid Reference			
Easting: E083092 Northing: N323519	Elevation (mOD): 17.20m Borehole Diameter (Subsoil): 65mm Borehole Diameter (Rock): 65mm Borehole Depth (m): 6.1m	Date Started: 28/10/03 Date Completed: 28/10/03	Drill Contractor: Irish Drilling Ltd. Drill Method: Coring Logged by: P.K.

Depth m	Description of Strata	Legend	OD Level m	Static Water Level 4/11/03	Samples Type	Samples Ref. No.	BH Tests Type & Ref.	Completion Details Lining:	Completion Details Backfill:
GL									
0.55	PEAT								CEMENT
	Fine grained SAND, with clay/silt matrix, medium light grey to greenish grey.		14.10	▼				50MM uPVC CASING	BENTONITE
12.3								50MM uPVC SCREEN	3–7mm Pea Gravel
14.0	SAND with fragments of eroded Quartzite, Sandstone and Schist. grey.								
18	END OF BOREHOLE								

Remarks:

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BOREHOLE LOG

Borehole BH2B

Sheet No. 1 of 2

Client:	Site:	Job No.:	Scale:
Bord na Mona/Shell E&P	Srahmore, Bangor–Erris, County Mayo.	1169	1:50

Grid Reference			
Easting: 083092 Northing: 323519	Elevation (mOD): 17.17m Borehole Diameter (Subsoil): 65mm Borehole Diameter (Rock): 65mm Borehole Depth (m): 23.5m	Date Started: 27/10/03 Date Completed: 27/10/03	Drill Contractor: Irish Drilling Ltd. Drill Method: Coring Logged by: PK

Depth m	Description of Strata	Legend	OD Level m	Static Water Level 4/11/03	Samples Type	Samples Ref. No.	BH Tests Type & Ref.	Completion Details Lining:	Completion Details Backfill:
GL									
0.55	PEAT								
	Fine grained SAND with clay/silt matrix. Medium light grey to greenish grey.		14.09	▼				50mm uPVC CASING	BENTONITE
12.0									
	SAND with fragments/cobbles of eroded Quartzite, Sandstone and Schist.								
14.3									
	Moderately weak to moderately strong thinly bedded/schistose (dipping 30–45 degrees), greenish grey (changing to brown below 21.4m), fine to medium grained micaceous PSAMMITE, moderately weathered. Occasional very thin (<20mm) highly weathered zones. Discontinuities: Very closely spaced, schistosity parallel, generally planar smooth to slightly rough , thick to moderately open, strongly discoloured and clay/rock material filled.								
18									

Remarks: moderately open.

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BOREHOLE LOG

Borehole BH2B

Client:	Site:	Job No.:	Scale:
Bord na Mona/Shell E&P	Srahmore, Bangor–Erris, County Mayo.	1169	1:50

Grid Reference	Elevation (mOD): 17.17m	Date Started: 27/10/03	Drill Contractor: Iirsh Drilling Ltd.
Easting: 083092	Borehole Diameter (Subsoil): 65mm	Date Completed: 27/10/03	Drill Method: Coring
Northing: 323519	Borehole Diameter (Rock): 65mm		Logged by: PK
	Borehole Depth (m): 23.5		

Depth m	Description of Strata	Legend	OD Level m	Water Inflows	Samples Type	Samples Ref. No.	BH Tests Type & Ref.	Completion Details Lining:	Completion Details Backfill:
18m	As above						Packet Test Ref.: BH2B Test section: 15.75–23.5m	50mm uPVC Screen	3–7mm Pea Gravel
23.5	END OF BOREHOLE								

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BOREHOLE LOG

Borehole BH3A

Sheet No. 1 of 1

Client:	Site:	Job No.:	Scale:
Bord na Mona/Shell E&P	Srahmore, Bangor–Erris, Co. Mayo.	1169	1:50

Grid Reference			
Easting: E084908 Northing: N323745	Elevation (mOD): 20.29m Borehole Diameter (Subsoil): 65mm Borehole Diameter (Rock): 65mm Borehole Depth (m): 12.5m	Date Started: 28/10/03 Date Completed: 28/10/03	Drill Contractor: Irish Drilling Ltd. Drill Method: Coring Logged by: P.K.

Depth m	Description of Strata	Legend	OD Level m	Static Water Level 4/11/03	Samples Type	Samples Ref. No.	BH Tests Type & Ref.	Completion Details Lining:	Completion Details Backfill:
GL									
	PEAT							50MM uPVC CASING	CEMENT
1.55			18.52	▼					BENT ONITE
	Fine grained SAND, with clay/silt matrix, medium light grey to greenish grey.							50MM uPVC SCREEN	3–7mm Pea Gravel
5.5	END OF BOREHOLE							END OF CASING	
18									

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Second Floor, Unit 4B/5
Blanchardstown Corporate Park
Blanchardstown
Dublin 15
TEL: (01) 8030401 FAX: (01) 8030410

BOREHOLE LOG

Borehole BH3B

Sheet No. 1 of 2

Client:	Site:	Job No.:	Scale:
Bord na Mona/Shell E&P	Srahmore, Bangor–Erris, County Mayo.	1169	1:50

Grid Reference			
Easting: 084908 Northing: 323745	Elevation (mOD): 20.26m Borehole Diameter (Subsoil): 65mm Borehole Diameter (Rock): 65mm Borehole Depth (m): 16m	Date Started: 29/10/03 Date Completed: 29/10/03	Drill Contractor: Irish Drilling Ltd. Drill Method: Coring Logged by: PK

Depth m	Description of Strata	Legend	OD Level m	Static Water Level 4/11/03	Samples Type	Samples Ref. No.	BH Tests Type & Ref.	Completion Details Lining:	Completion Details Backfill:
GL									
1.55	PEAT							50mm uPVC CASING	BENTONITE
6.0	Fine grained SAND with clay/silt matrix. Medium light grey to greenish grey.		18.02	▼					
16	Strong to very strong, massive but locally narrowly banded (dipping 35 degrees), grey to yellowish grey, fine grained micaceous QUARTZITE, fresh to slightly weathered. Mica locally occurring as close to very closely spaced bands/laminae dipping circa 35 degrees. Discontinuities: Between non–intact zones, fractures are closely to very closely spaced, bedding parallel, (dipping about 35 degrees), generally sub–planar, smooth to slightly rough, generally clean.						Packet Test Ref.: BH3B Test section: 11.75–16.0m	50mm uPVC SCREEN	3–7mm Pea Gravel
	END OF BOREHOLE								

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BOREHOLE LOG

Borehole BH3B

Sheet No. 2 of 2

Client:	Site:	Job No.:	Scale:
Bord na Mona/Shell E&P	Srahmore, Bangor–Erris, County Mayo.	1169	1:50

Grid Reference			
Easting: 084908 Northing: 323745	Elevation (mOD): 20.26m Borehole Diameter (Subsoil): 65mm Borehole Diameter (Rock): 65mm Borehole Depth (m): 23.5	Date Started: 27/10/03 Date Completed: 27/10/03	Drill Contractor: Glovers SI Ltd. Drill Method: Air Rotary Logged by: KM (TES)

Depth m	Description of Strata	Legend	OD Level m	Water Inflows	Samples Type	Samples Ref. No.	BH Tests Type & Ref.	Completion Details Lining:	Completion Details Backfill:
18m	As above						Packet Test Ref.: BH2B Test section: 15.75–23.5m	50mm uPVC Screen	3–7mm Pea Gravel
23.5									

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BOREHOLE LOG

Borehole BH4

Sheet No. 1 of 2

Client:	Site:	Job No.:	Scale:
Bord na Mona/Shell E&P	Srahmore, Bangor–Erris, County Mayo.	1169	1:50

Grid Reference			
Easting: 084489 Northing: 323373	Elevation (mOD): 17.22 Borehole Diameter (Subsoil): 65mm Borehole Diameter (Rock): 65mm Borehole Depth (m): 30m	Date Started: 01/11/03 Date Completed: 01/11/03	Drill Contractor: Irish Drilling Ltd. Drill Method: Coring Logged by: PK

Depth m	Description of Strata	Legend	OD Level m	Static Water Level 4/11/03	Samples Type	Samples Ref. No.	BH Tests Type & Ref.	Completion Details Lining:	Completion Details Backfill:
GL									
	PEAT		14.81	▼				50mm uPVC CASING	BENTONITE
3.1									
	Fine grained SAND with clay/silt matrix. Medium light grey to greenish grey.								
								50mm uPVC SCREEN	3–7mm Pea Gravel
18									

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BOREHOLE LOG

Borehole BH4

Client:	Site:	Job No.:	Scale:
Bord na Mona/Shell E&P	Srahmore, Bangor–Erris, County Mayo.	1169	1:50

Grid Reference			
Easting: 084489 Northing: 323373	Elevation (mOD): 17.22m Borehole Diameter (Subsoil): 65mm Borehole Diameter (Rock): 65mm Borehole Depth (m): 30m	Date Started: 01/11/03 Date Completed: 01/11/03	Drill Contractor: Glovers SI Ltd. Drill Method: Air Rotary Logged by: PK

Depth m	Description of Strata	Legend	OD Level m	Water Inflows	Samples Type	Samples Ref. No.	BH Tests Type & Ref.	Completion Details Lining:	Completion Details Backfill:
18m	As above							50mm uPVC Screen	3–7mm Pea Gravel
30	END OF BOREHOLE								

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Appendix 7

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Report on Groundwater Sampling and Permeability Testing at Srahmore Bog, Bangor, Co. Mayo

TES Consulting Engineers

MEL Brief 1322-Q1
MEL Doc. Ref.:1322-2546

Monday, 17 November 2003

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Confidential Report To:

Morgan Burke
TES Consulting Engineers
Unit 4B/5
Blanchardstown Corporate Park
Blanchardstown
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Report submitted by:

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Prepared by:

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Project Scientist

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Project Director

Minerex Environmental Limited

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1. INTRODUCTION 1

2. WORK SPECIFICATION 1

3. GROUNDWATER SAMPLING 1

3.1 Purpose 1
3.2 Locations 1
3.3 Methods and Materials 1

4. PERMEABILITY TESTING 2

4.1 Purpose 2
4.2 Locations 2
4.3 Methods and Materials 2

5. RESULTS 2

6. REFERENCES 3

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Appendices

Appendix	Title	Pages	MEL Doc. Ref.
Appendix A	Summary of Pre-Sampling Borehole Purging Results	1 x A4	1322-028.xls
Appendix B	Summary of Permeability Test Results	1 x A4	1322-019.xls
Appendix C	Aqtesolv Curve Fitted Graphs	12 x A4	1322-2548.aqt

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1. Introduction

On 30th October 2003 Minerex Environmental Limited (MEL) were commissioned by Morgan Burke of TES Consulting Engineers to undertake groundwater sampling and permeability testing at Srahmore Bog, Bangor, Co Mayo. A detailed work specification was drafted up and agreed. The main elements of this specification are outlined below. MEL carried out site work over a three day period from the 4th to the 6th of November 2003. This report outlines the methodologies and equipment used, the results obtained and the software used for data analysis and presentation.

2. Work Specification

The following outlines the main elements of the site work undertaken at Srahmore Co. Mayo. The work is subdivided into two sections.

A. Water sampling:
A total of seven (7) monitoring wells (four overburden and three bedrock) were purged and sampled. The samples were analysed by Alcontrol Laboratories Limited.

B. Permeability testing:
Permeability tests were undertaken following sampling of the four overburden boreholes. Field data was used to determine K-values for the overburden sands and gravels.

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3. Groundwater Sampling

3.1 Purpose

The installation of monitoring points allows for water levels and water samples to be taken. Seven (7) monitoring wells were drilled and installed in the week prior to sampling. The wells were drilled in four nested couples; the first three (1A/1B, 2A/2B, 3A/3B) consisting of a shallow overburden well and a deep bedrock well; and the fourth consisting of a deep overburden well (4A). The purpose of the sampling is to provide baseline data with respect to the investigation area.

3.2 Locations

Water samples were taken from the following boreholes: 1A, 1B, 2A, 2B, 3A, 3B and 4A. The locations of these boreholes were supplied to MEL by TES prior to fieldwork. MEL does not possess a map in electronic format for the site, and the production / reproduction of same is not included in the scope of this work item.

3.3 Methods and Materials

In the context of MEL's investigations, static water levels were taken in both wells within each couple prior to any purging of the groundwater. Borehole volumes were calculated to include the annulus volume and assuming an annulus porosity of 35%. At least 2 borehole volumes were removed from each monitoring point prior to sampling. Appendix A outlines a summary of borehole volumes removed prior to sampling.

A standard dipmeter was used to record water levels. All measurements were recorded in metres to the top of steel plinth (tosp) which is MEL's reference point. It should be noted that MEL was not commissioned to survey the monitoring points installed at Srahmore and does not possess reduced levels for any of the investigation points. A 2" Honda pump was used to purge the monitoring points. Due to adverse weather conditions and poor access to the monitoring points at the site, it was not possible to purge and sample all monitoring wells within one working day. 1A and 1B were purged on the 4th of November, while 2A, 2B, 3A, 3B and 4A were purged on the morning of 5th of

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November. During purging of the first borehole volume an attempt made to remove silt from the bottom of the overburden wells using the Honda pump. This was unsuccessful as the purged water continued to have a high silt content throughout purging. All monitoring wells except 4A were sampled on the evening of the 5th of November using a 1litre designated, disposable bailer. Borehole 4A was subsequently sampled on the morning of the 6th of November. Before sampling, one borehole volume was removed from each overburden well using a disposable bailer and 5 litres were removed from each of the bedrock wells. This was undertaken to remove any stagnant water within the well 24 hours post-purging, prior to sampling. Samples taken from overburden wells had a high silt content and the laboratory was requested to filter as required for analysis.

Sample containers were supplied by Alcontrol Laboratories Ltd. These were filled directly from the disposable bailer without filtering. The samples were then placed in a battery operated coolbox for transportation to the Laboratory. The samples were received by the laboratory on the evening of the 6th of November. A chain of custody was completed during the transport of the samples to the laboratory.

4. Permeability Testing

4.1 Purpose

Permeability tests were undertaken at Srahmore to produce K-values (hydraulic conductivity) for each of the overburden monitoring points installed.

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4.2 Locations

The permeability tests were carried out at each of the established overburden wells: 1A, 2A, 3A and 4A. Four tests were undertaken in total.

4.3 Methods and Materials

Both rising head permeability tests and single post-purging recovery tests were undertaken on the four overburden boreholes. The methodology for rising head tests involves the sudden removal of a small volume of water "slug" from the well after which the rise in recovering water level is measured. This displacement of water should not exceed 10% of the equilibrium piezometric head (Ref. 1). MEL used a bailer to perform these slug tests.

A second method of permeability testing was undertaken on most of the overburden boreholes on site. This involved the manipulation of the borehole purging procedure prior to sampling. Immediately after the purging was completed (by means of a 2" Honda pump) borehole water level recovery was monitored. This recovery data was used to provide a K-value for the aquifer and is likely to represent a larger volume of aquifer around the monitoring well than for the slug test results (scale factor). A summary of all permeability testing is provided in Appendix B.

The data collected was processed using aquifer analysing software, AQTESOLV. This software provides a suite of analytical solutions for determining aquifer properties from pumping tests and slug tests. From the data supplied on borehole installation design and from the static water levels recorded during fieldwork, an unconfined sands and gravel aquifer is identified at the site. In this context, two analytical solutions were used to derive K-values for the overburden aquifer. These are Hvorslev (1951) and Bouwer-Rice (1976) (Ref. 2).

5. Results

Results of the MEL's investigation work are presented in the Appendices A (summary of pre-sampling borehole purging results), Appendix B (summary of permeability test results), Appendix C (aqtesolv cuve fitted graphs) at the back of this report.

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6. References

1. British Standards Institution (1999). *Code of Practice for Site Investigations - BS 5930.*

2. Kruseman, G. P., and de Ridder, N. A., (1992). *Analysis and Evaluation of Pumping Test Data*. ILRI Publication 47, The Netherlands.

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Appendix A

Summary of Pre-Sampling Borehole Purging Results

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VARIABLE DATA

Seasonal monitoring data

General				Water levels		Pre-Sampling Purging			
Site ID	Weather	MEL operatives	**Date** (dd/mm/yy)	Static Water level (mbRef)	Measured Depth (mbRef)	One (1) borehole volume (BHV) (Litres)	Three (3) borehole volume for purging (Litres)	Volume withdrawn (Litres)	BHV's withdrawn
BH 1A	Wet and Windy	LD	11/04/2003	2.57	8.40	24.8	74.25	103.00	4.16
BH 1B	Wet and Windy	LD	11/04/2003	2.85	23.65	79.5	238.41	275.00	3.46
BH 2A	Wet and Windy	LD	11/05/2003	3.25	6.04	10.6	31.74	42.00	3.97
BH 2B	Wet and Windy	LD	11/05/2003	3.23	23.50	78.0	234.00	165.00	2.12
BH 3A	Wet and Windy	LD	11/05/2003	2.02	5.56	11.5	34.38	52.00	4.54
BH 3B	Wet and Windy	LD	11/05/2003	2.24	15.78	53.0	158.85	155.00	2.93
BH 4A	Wet and Windy	LD	11/05/2003	2.51	29.00	105.8	317.37	384.00	3.63

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Appendix B

Summary of Permeability Test Results

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Appendix B

Summary of Permeability Tests

Borehole & Aquifer Details		*[2] K Values according to Methodology Used (up to 3 types)				
Borehole ID	Aquifer*[1]	Rising Head Test (Hvorslev)	Rising Head Test (Bouwer-Rice)	Recovery (Hvorslev)	Recovery (Bouwer-Rice	Average
BH-1/A	Unconfined	N/a	N/a	3.654E-07	2.553E-07	3.104E-07
BH-2/A	Unconfined	2.030E-07	1.143E-07	7.092E-07	4.130E-07	3.599E-07
BH-3/A	Unconfined	1.210E-06	7.194E-07	N/a	N/a	9.647E-07
BH-4/A	Unconfined	2.632E-06	2.273E-06	N/a	N/a	2.453E-06
Average		1.348E-06	1.036E-06	5.373E-07	3.342E-07	1.022E-06
Max		2.632E-06	2.273E-06	7.092E-07	4.130E-07	2.453E-06
Min		2.030E-07	1.143E-07	3.654E-07	2.553E-07	3.104E-07

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*[1] The aquifer is identified as being unconfined based on well installation data supplied (MEL Doc. Ref. 1322-2543) and from water levels recorded on 04-06/11/03.

*[2] Where duplicate tests were undertaken, an average is provided per analytical solution

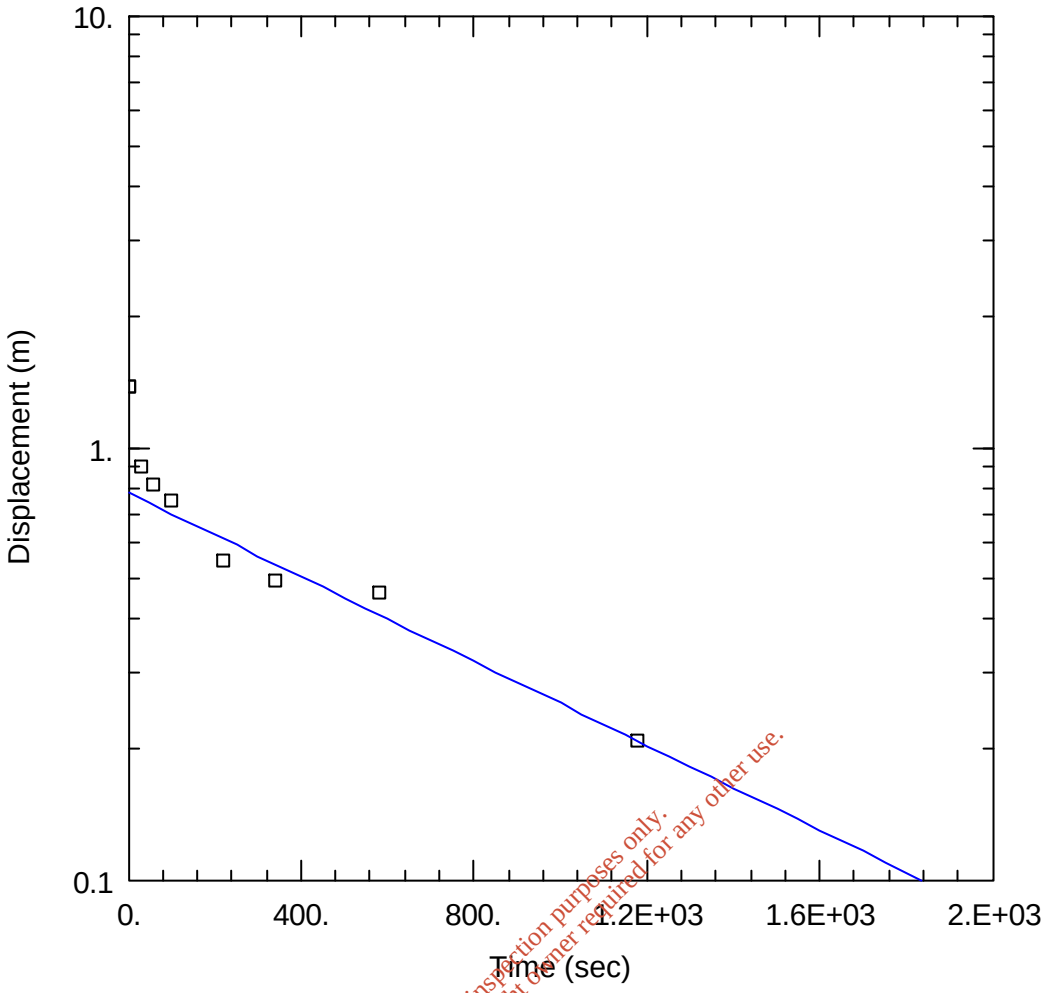
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Appendix C

Aqtesolv Curve Fitted Graphs

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1A - RECOVERY TEST 1

Data Set: P:\1322 (Shell)\aqt\1322-2548\1A\1A data Recovery.aqt
Date: 11/18/03 Time: 16:55:53

PROJECT INFORMATION

Company: Minerex Environmental Limited
Client: TES Consulting Engineers
Project: 1322-Q1
Test Location: Srahmore, Bangor, Co. Mayo
Test Well: 1A
Test Date: 04-11-03

AQUIFER DATA

Saturated Thickness: 10. m
Anisotropy Ratio (Kz/Kr): 1.

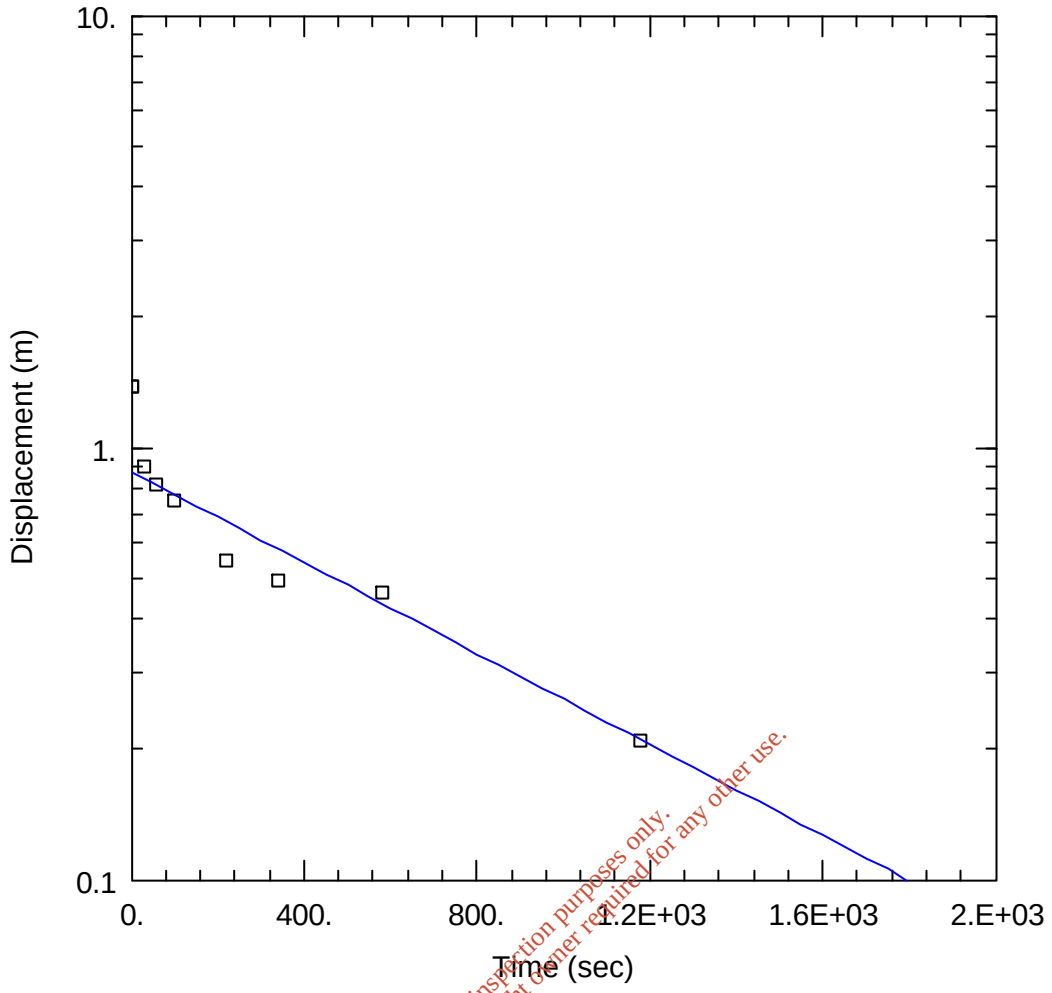
WELL DATA (1A)

Initial Displacement: 1.38 m
Water Column Height: 6.28 m
Casing Radius: 0.026 m
Wellbore Radius: 0.05 m
Screen Length: 8. m
Gravel Pack Porosity: 0.35

SOLUTION

Aquifer Model: Unconfined
Solution Method: Hvorslev
K = 4.687E-07 m/sec
y0 = 0.7864 m

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1A - RECOVERY TEST 1

Data Set: P:\1322 (Shell)\aqt\1322-2548\1A Data Recovery 1.aqt
Date: 11/18/03 Time: 17:00:02

PROJECT INFORMATION

Company: Minerex Environmental Limited
Client: TES Consulting Engineers
Project: 1322-Q1
Test Location: Srahmore, Bangor, Co. Mayo
Test Well: 1A
Test Date: 04-11-03

AQUIFER DATA

Saturated Thickness: 10. m
Anisotropy Ratio (Kz/Kr): 1.

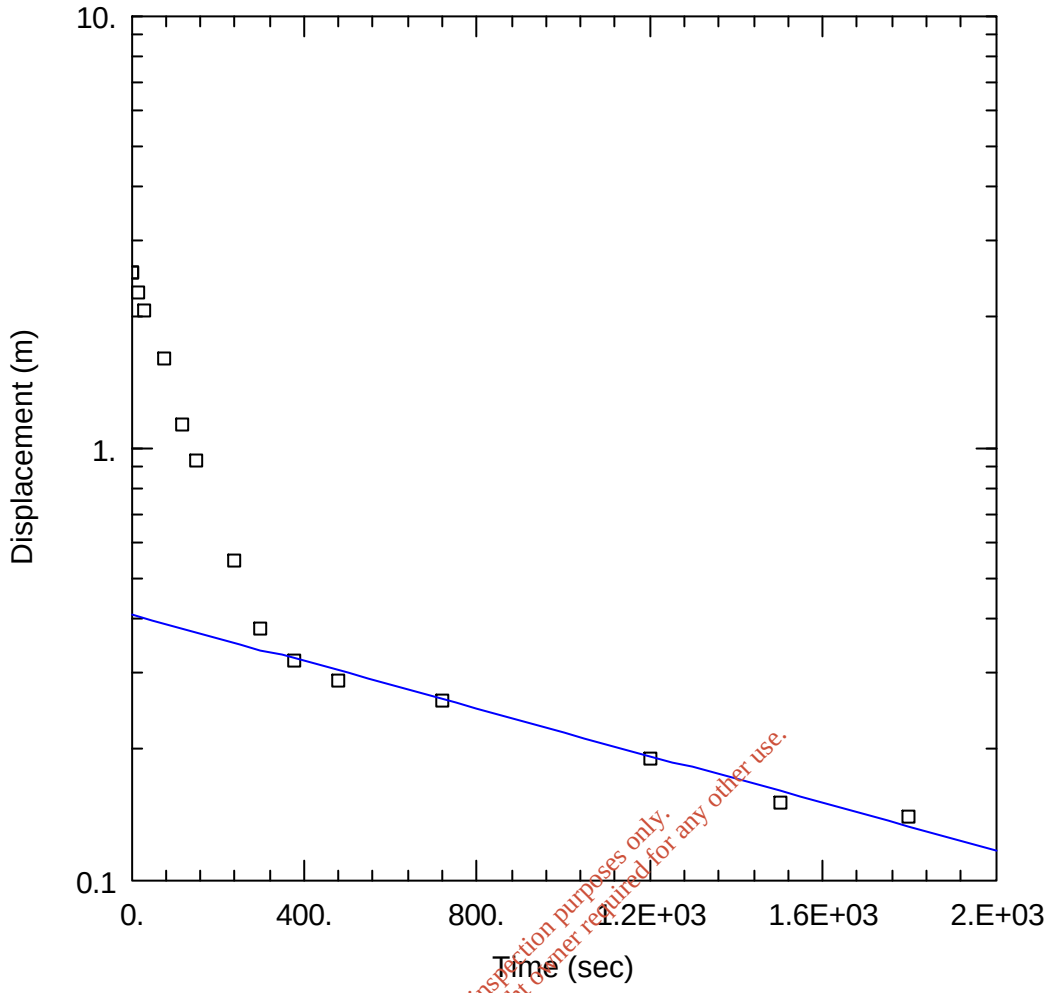
WELL DATA (1A)

Initial Displacement: 1.38 m
Water Column Height: 6.28 m
Casing Radius: 0.026 m
Wellbore Radius: 0.05 m
Screen Length: 8. m
Gravel Pack Porosity: 0.35

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 3.443E-07 m/sec
y0 = 0.8784 m

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1A - RECOVERY TEST 2

Data Set: P:\1322 (Shell)\aqt\1322-2548\1A - FINAL\1A Data Recovery 2.aqt
Date: 11/18/03 Time: 17:05:15

PROJECT INFORMATION

Company: Minerex Environmental Limited
Client: TES Consulting Engineers
Project: 1322-Q1
Test Location: Srahmore, Bangor, Co. Mayo
Test Well: 1A
Test Date: 04-11-03

AQUIFER DATA

Saturated Thickness: 10. m
Anisotropy Ratio (Kz/Kr): 1.

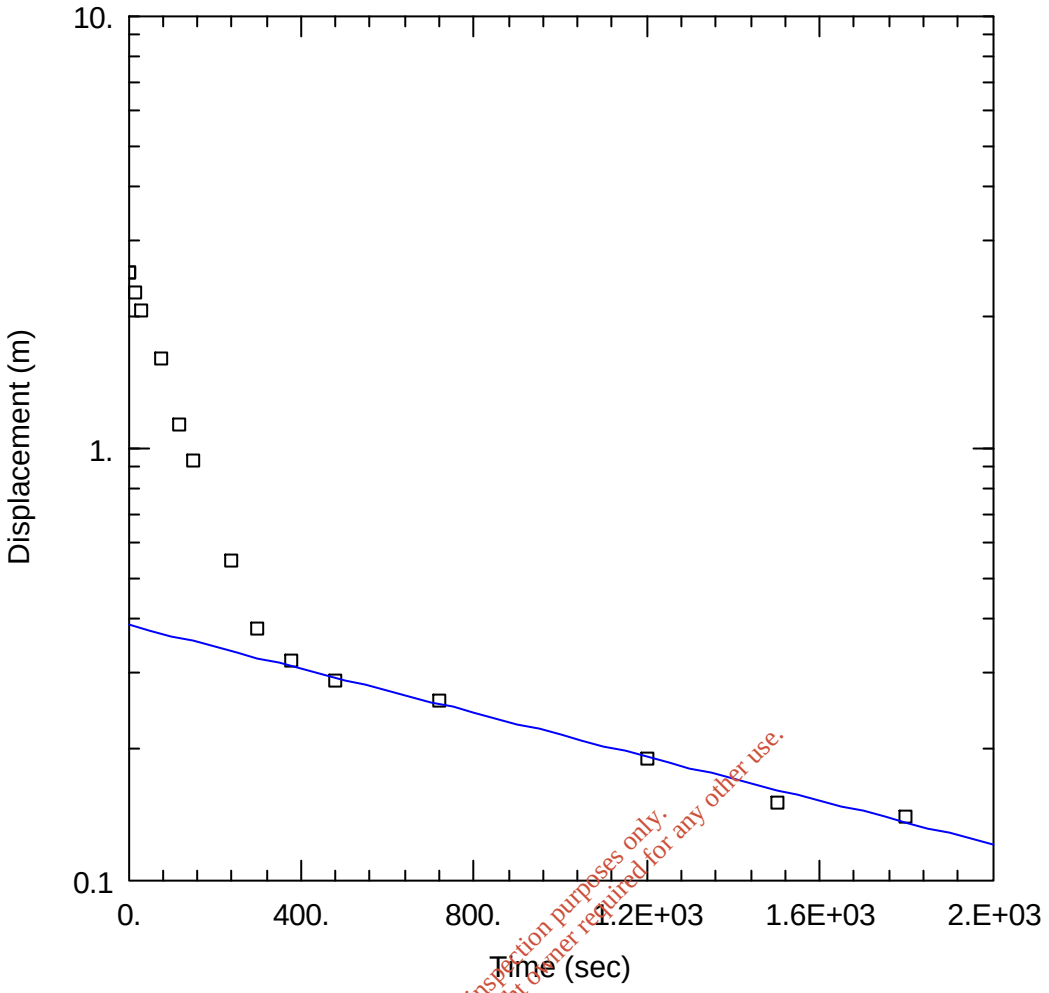
WELL DATA (1A)

Initial Displacement: 2.53 m
Water Column Height: 6.28 m
Casing Radius: 0.026 m
Wellbore Radius: 0.05 m
Screen Length: 8. m
Gravel Pack Porosity: 0.35

SOLUTION

Aquifer Model: Unconfined
Solution Method: Hvorslev
K = 2.621E-07 m/sec
y0 = 0.4114 m

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1A - RECOVERY TEST 2

Data Set: P:\1322 (Shell)\aqt\1322-2548\1A - FINAL\1A Data Recovery 2.aqt
Date: 11/18/03 Time: 17:04:50

PROJECT INFORMATION

Company: Minerex Environmental Limited
Client: TES Consulting Engineers
Project: 1322-Q1
Test Location: Srahmore, Bangor, Co. Mayo
Test Well: 1A
Test Date: 04-11-03

AQUIFER DATA

Saturated Thickness: 10. m
Anisotropy Ratio (Kz/Kr): 1.

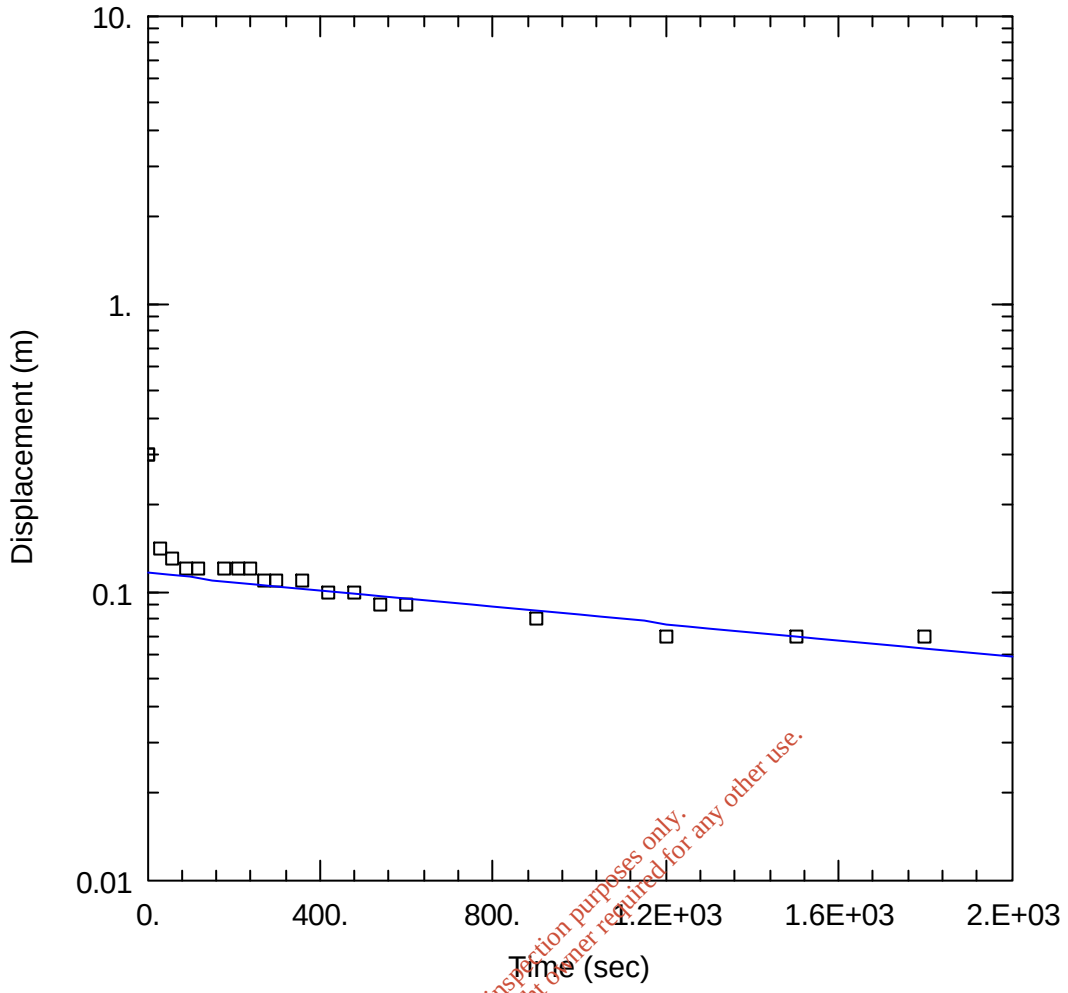
WELL DATA (1A)

Initial Displacement: 2.53 m
Water Column Height: 6.28 m
Casing Radius: 0.026 m
Wellbore Radius: 0.05 m
Screen Length: 8. m
Gravel Pack Porosity: 0.35

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 1.663E-07 m/sec
y0 = 0.3884 m

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2A - SLUG TEST

Data Set: P:\1322 (Shell)\aqt\1322-2548\1A - FINAL\2A SLUG.aqt
Date: 11/18/03 Time: 17:17:45

PROJECT INFORMATION

Company: Minerex Environmental Limited
Client: TES Consulting Engineers
Project: 1322-Q1
Test Location: Srahmore, Bangor, Co. Mayo
Test Well: 2A
Test Date: 04-11-03

AQUIFER DATA

Saturated Thickness: 7. m Anisotropy Ratio (Kz/Kr): 1.

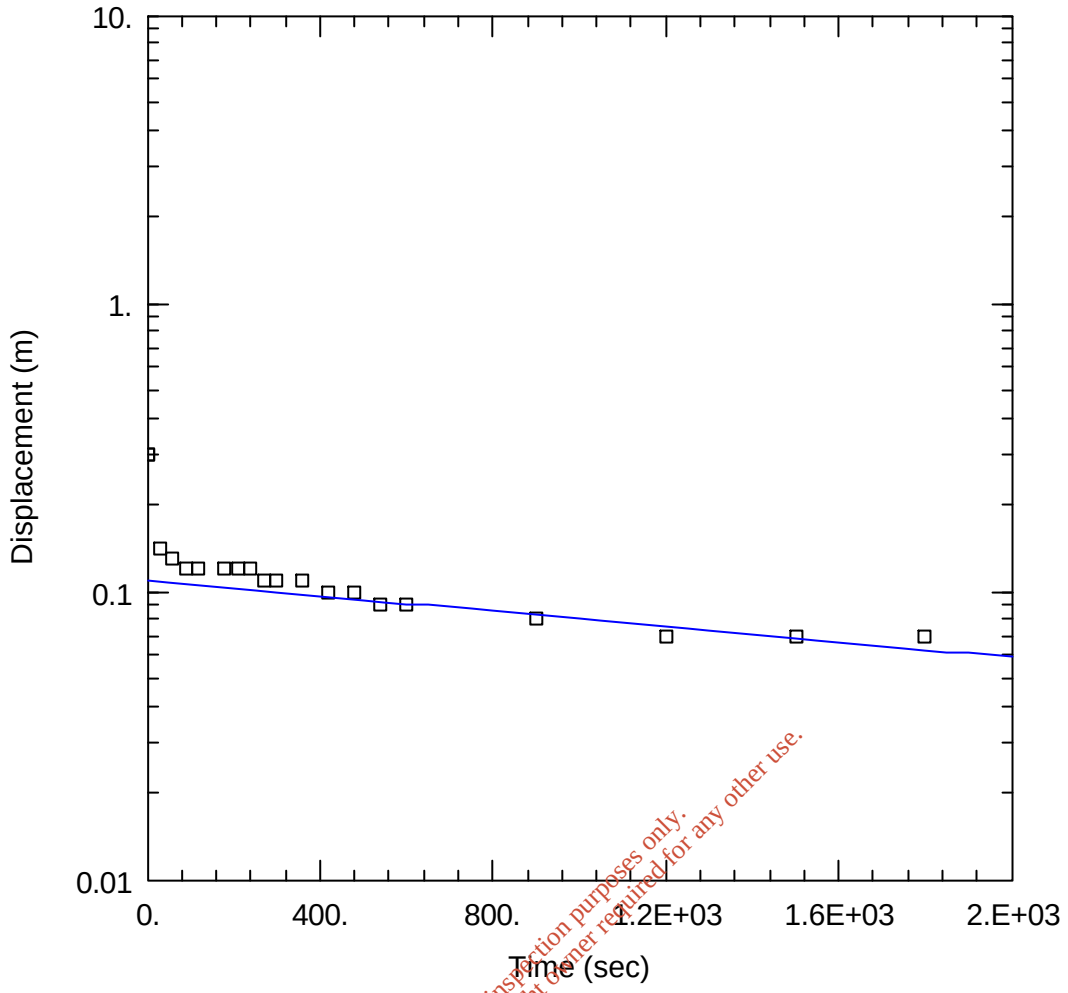
WELL DATA (2A)

Initial Displacement: 0.3 m Water Column Height: 2.64 m
Casing Radius: 0.026 m Wellbore Radius: 0.05 m
Screen Length: 5. m Gravel Pack Porosity: 0.35

SOLUTION

Aquifer Model: Unconfined Solution Method: Hvorslev
K = 2.03E-07 m/sec y0 = 0.1157 m

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2A - SLUG TEST

Data Set: P:\1322 (Shell)\aqt\1322-2548\1A - FINAL\2A SLUG.aqt
Date: 11/18/03 Time: 17:18:43

PROJECT INFORMATION

Company: Minerex Environmental Limited
Client: TES Consulting Engineers
Project: 1322-Q1
Test Location: Srahmore, Bangor, Co. Mayo
Test Well: 2A
Test Date: 04-11-03

AQUIFER DATA

Saturated Thickness: 7. m Anisotropy Ratio (Kz/Kr): 1.

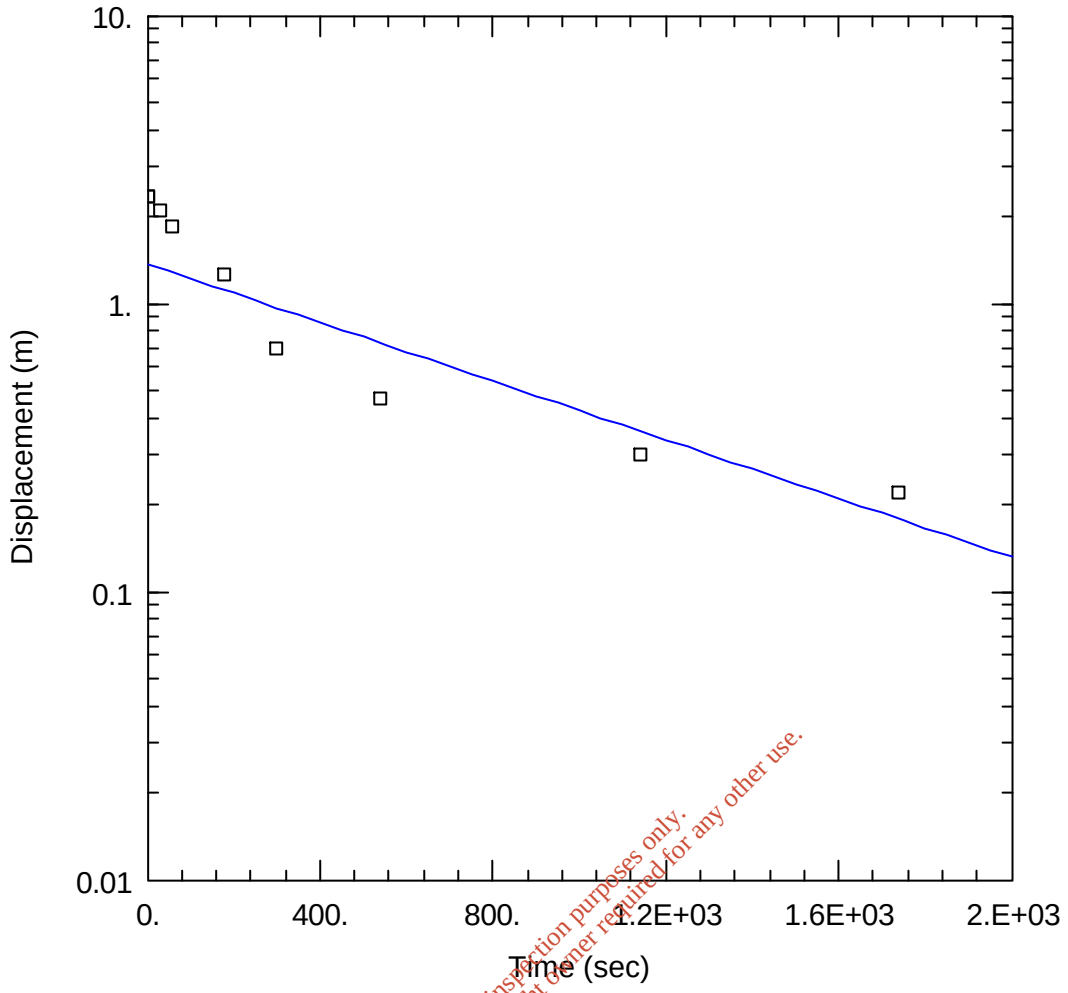
WELL DATA (2A)

Initial Displacement: 0.3 m Water Column Height: 2.64 m
Casing Radius: 0.026 m Wellbore Radius: 0.05 m
Screen Length: 5. m Gravel Pack Porosity: 0.35

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice
K = 1.143E-07 m/sec y0 = 0.1093 m

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2A - RECOVERY

Data Set: P:\1322 (Shell)\aqt\1322-2548\1A - FINAL\2A Recovery.aqt
Date: 11/18/03 Time: 17:24:58

PROJECT INFORMATION

Company: Minerex Environmental Limited
Client: TES Consulting Engineers
Project: 1322-Q1
Test Location: Srahmore, Bangor, Co. Mayo
Test Well: 2A
Test Date: 04-11-03

AQUIFER DATA

Saturated Thickness: 7. m Anisotropy Ratio (Kz/Kr): 1.

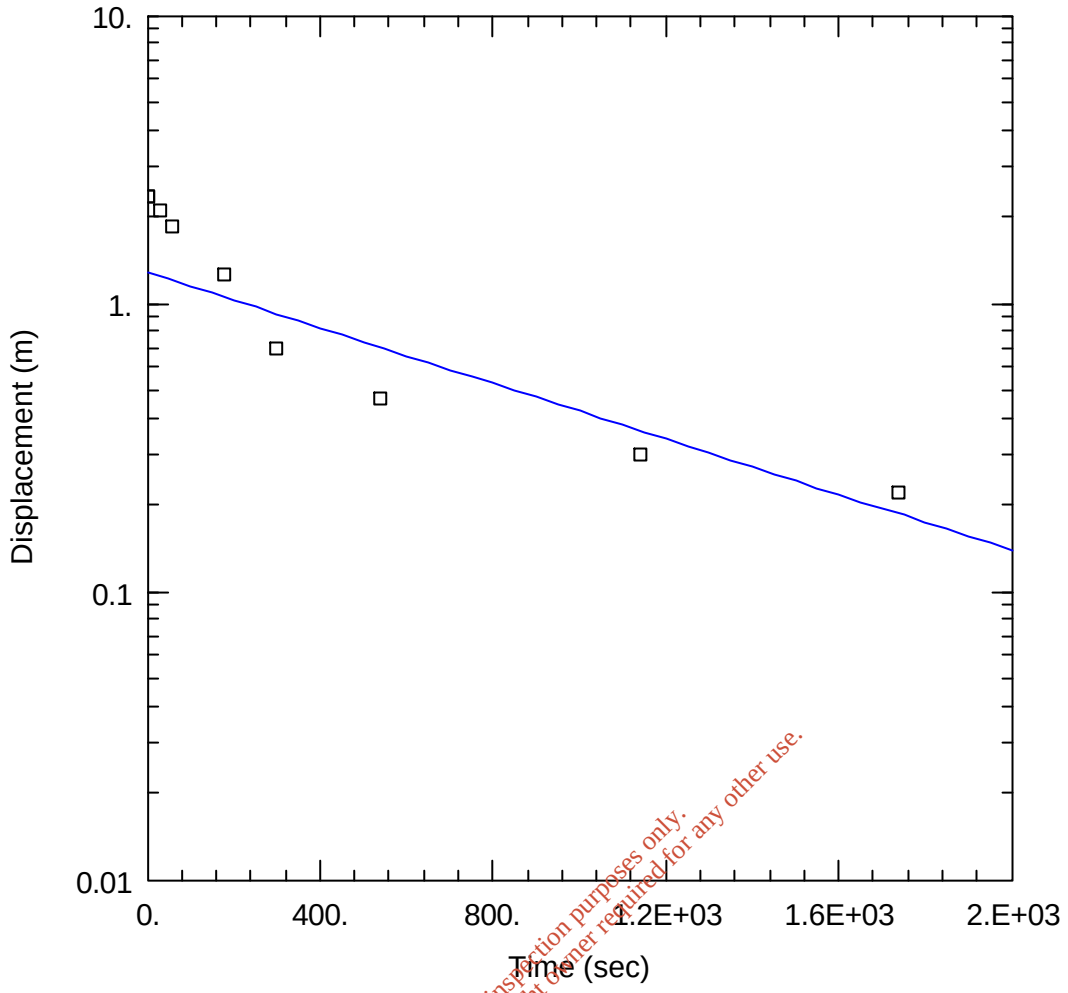
WELL DATA (2A)

Initial Displacement: 2.34 m Water Column Height: 2.64 m
Casing Radius: 0.026 m Wellbore Radius: 0.05 m
Screen Length: 5. m Gravel Pack Porosity: 0.35

SOLUTION

Aquifer Model: Unconfined Solution Method: Hvorslev
K = 7.092E-07 m/sec y0 = 1.371 m

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2A - RECOVERY

Data Set: P:\1322 (Shell)\aqt\1322-2548\1A - FINAL\2A Recovery.aqt
Date: 11/18/03 Time: 17:24:19

PROJECT INFORMATION

Company: Minerex Environmental Limited
Client: TES Consulting Engineers
Project: 1322-Q1
Test Location: Srahmore, Bangor, Co. Mayo
Test Well: 2A
Test Date: 04-11-03

AQUIFER DATA

Saturated Thickness: 7. m
Anisotropy Ratio (Kz/Kr): 1.

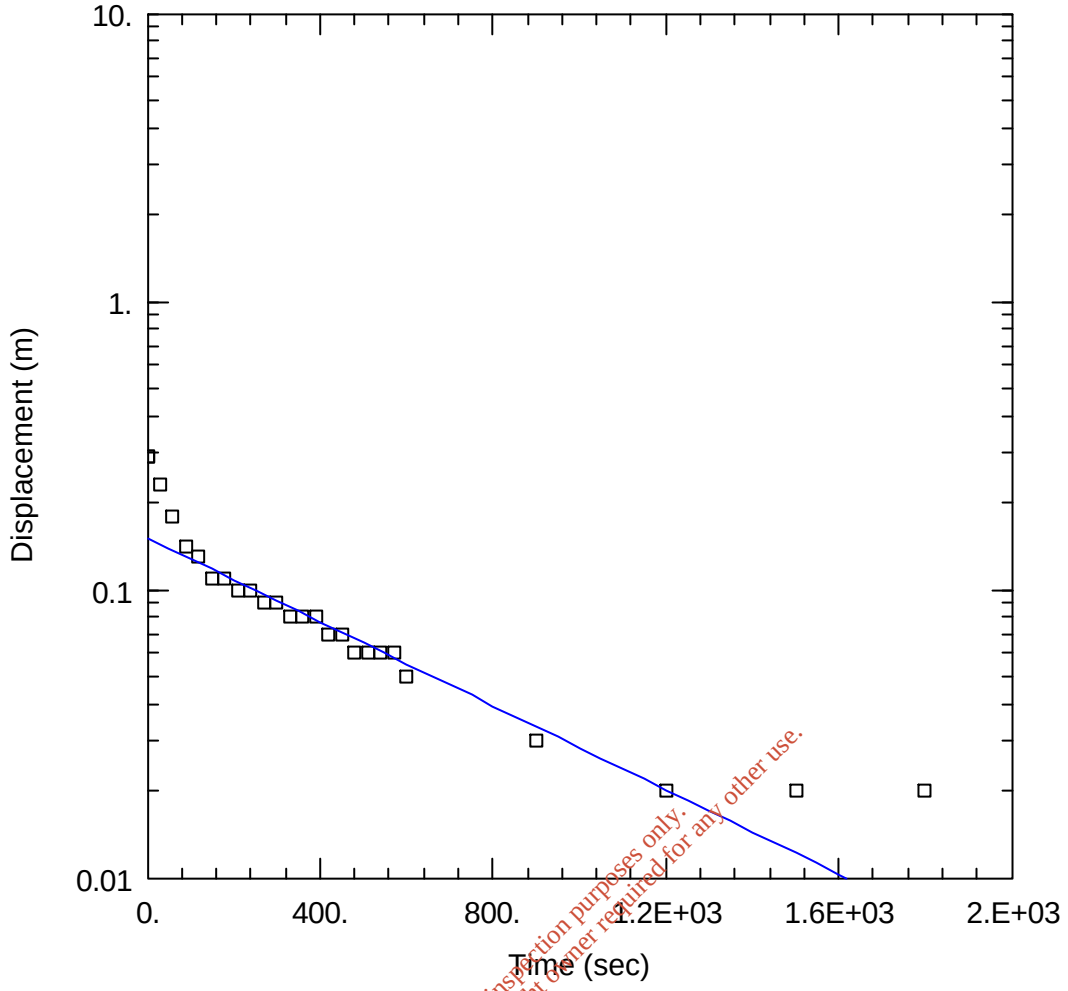
WELL DATA (2A)

Initial Displacement: 2.34 m
Water Column Height: 2.64 m
Casing Radius: 0.026 m
Wellbore Radius: 0.05 m
Screen Length: 5. m
Gravel Pack Porosity: 0.35

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 4.13E-07 m/sec
y0 = 1.284 m

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3A - SLUG

Data Set: P:\1322 (Shell)\aqt\1322-2548\1A - FINAL\3A SLUG.aqt
Date: 11/18/03 Time: 17:33:49

PROJECT INFORMATION

Company: Minerex Environmental Limited
Client: TES Consulting Engineers
Project: 1322-Q1
Test Location: Srahmore, Bangor, Co. Mayo
Test Well: 3A
Test Date: 04-11-03

AQUIFER DATA

Saturated Thickness: 5. m Anisotropy Ratio (Kz/Kr): 1.

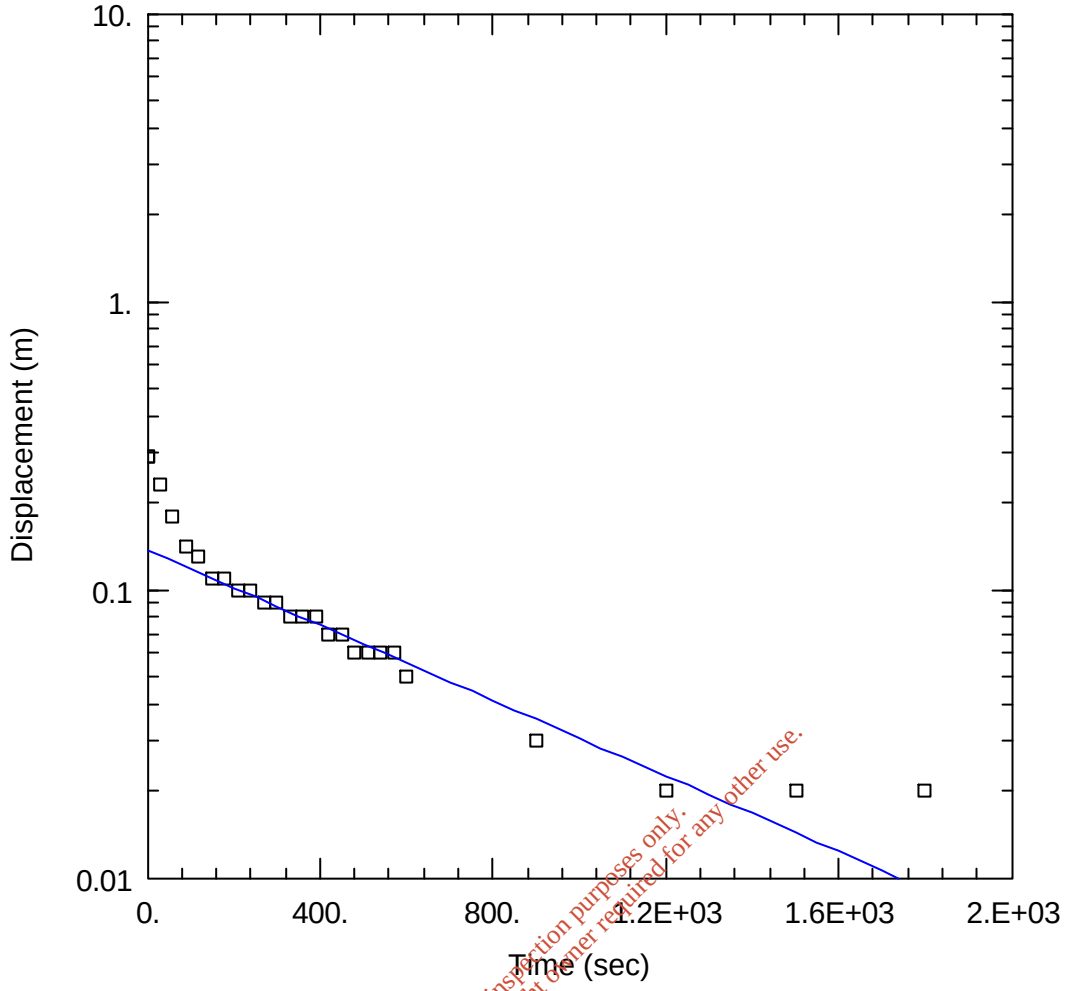
WELL DATA (3A)

Initial Displacement: 0.29 m Water Column Height: 3.12 m
Casing Radius: 0.026 m Wellbore Radius: 0.05 m
Screen Length: 4. m Gravel Pack Porosity: 0.35

SOLUTION

Aquifer Model: Unconfined Solution Method: Hvorslev
K = 1.21E-06 m/sec y0 = 0.1515 m

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3A - SLUG

Data Set: P:\1322 (Shell)\aqt\1322-2548\1A - FINAL\3A SLUG.aqt
Date: 11/18/03 Time: 17:34:25

PROJECT INFORMATION

Company: Minerex Environmental Limited
Client: TES Consulting Engineers
Project: 1322-Q1
Test Location: Srahmore, Bangor, Co. Mayo
Test Well: 3A
Test Date: 04-11-03

AQUIFER DATA

Saturated Thickness: 5. m
Anisotropy Ratio (Kz/Kr): 1.

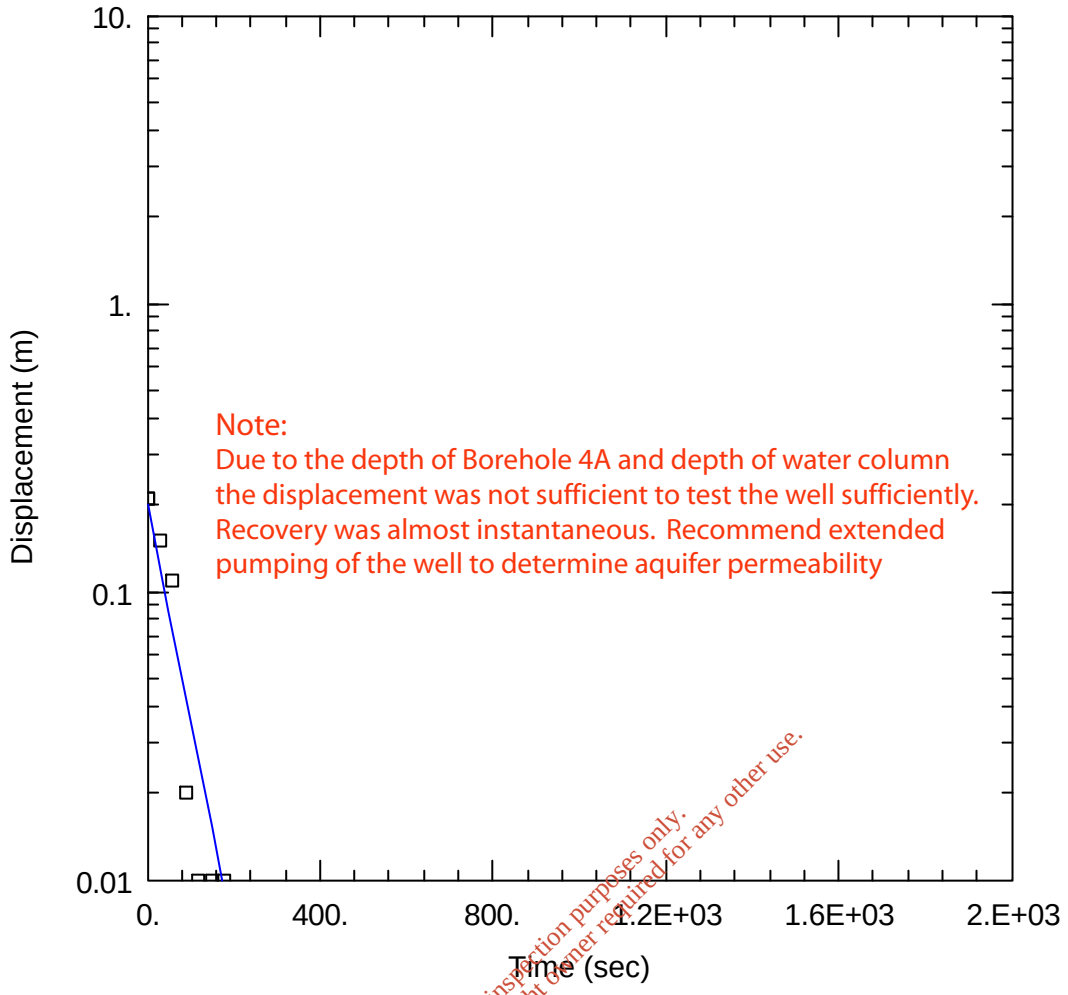
WELL DATA (3A)

Initial Displacement: 0.29 m
Water Column Height: 3.12 m
Casing Radius: 0.026 m
Wellbore Radius: 0.05 m
Screen Length: 4. m
Gravel Pack Porosity: 0.35

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 7.194E-07 m/sec
y0 = 0.1373 m

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4A - SLUG

Data Set: P:\1322 (Shell)\aqt\1322-2548\1A - FINAL\4A SLUG (erroneous).aqt
Date: 11/18/03 Time: 18:00:36

PROJECT INFORMATION

Company: Minerex Environmental Limited
Client: TES Consulting Engineers
Project: 1322-Q1
Test Location: Srahmore, Bangor, Co. Mayo
Test Well: 4A
Test Date: 04-11-03

AQUIFER DATA

Saturated Thickness: 28. m
Anisotropy Ratio (Kz/Kr): 1.

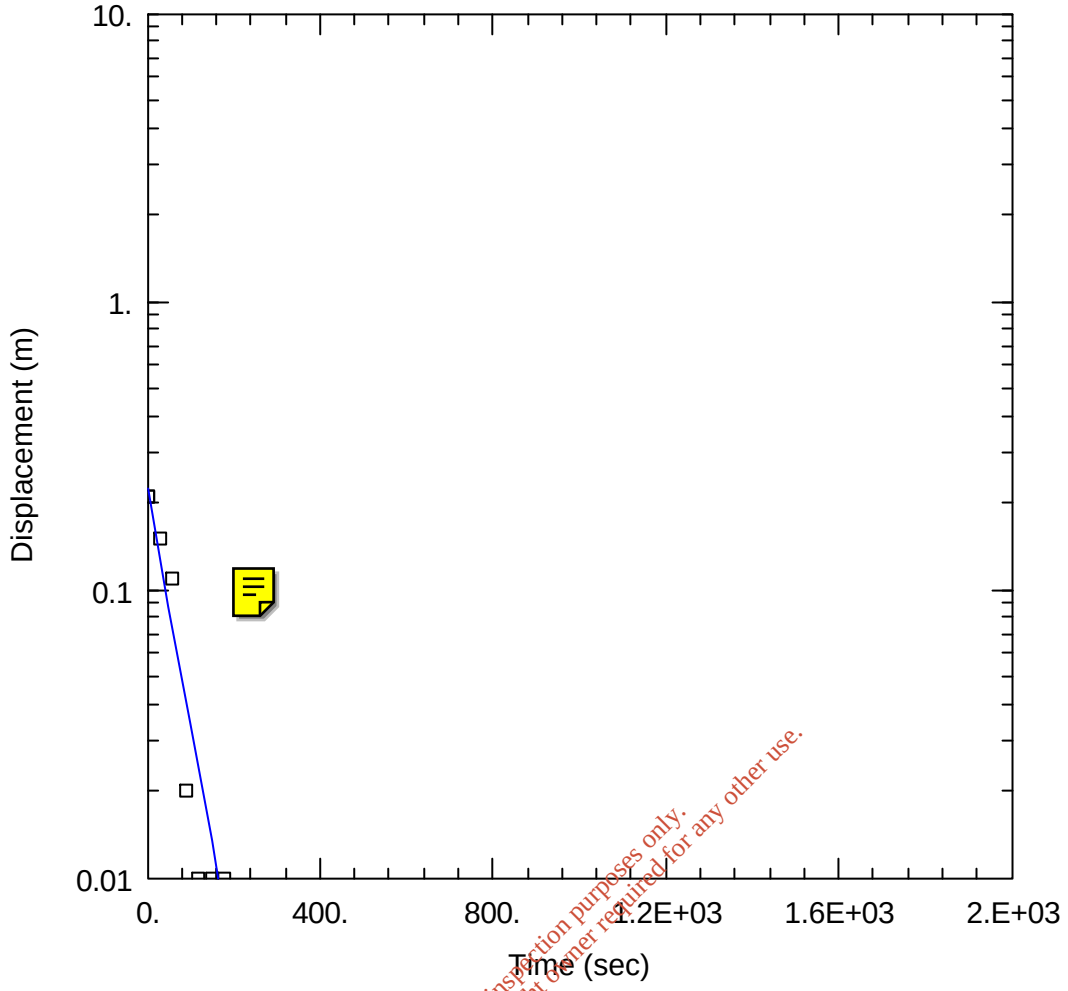
WELL DATA (4A)

Initial Displacement: 0.21 m
Casing Radius: 0.026 m
Screen Length: 27. m
Water Column Height: 27.3 m
Wellbore Radius: 0.05 m
Gravel Pack Porosity: 0.35

SOLUTION

Aquifer Model: Unconfined
Solution Method: Hvorslev
K = 2.632E-06 m/sec
y0 = 0.2015 m

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4A - SLUG

Data Set: P:\1322 (Shell)\aqt\1322-2548\1A - FINAL\4A SLUG (erroneous).aqt
Date: 11/18/03 Time: 17:58:52

PROJECT INFORMATION

Company: Minerex Environmental Limited
Client: TES Consulting Engineers
Project: 1322-Q1
Test Location: Srahmore, Bangor, Co. Mayo
Test Well: 4A
Test Date: 04-11-03

AQUIFER DATA

Saturated Thickness: 28. m
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (4A)

Initial Displacement: 0.21 m
Water Column Height: 27.3 m
Casing Radius: 0.026 m
Wellbore Radius: 0.05 m
Screen Length: 27. m
Gravel Pack Porosity: 0.35

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 2.273E-06 m/sec
y0 = 0.2239 m

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Appendix 8

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PACKER TEST RESULTS

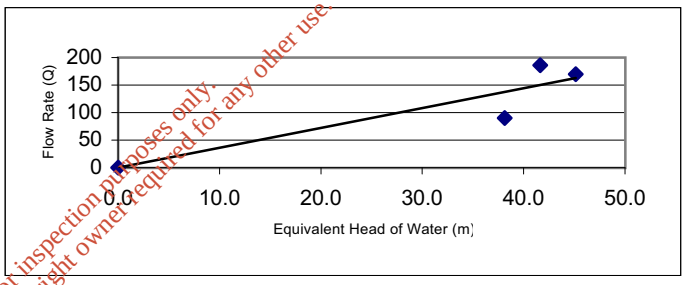
Contract:	Peat Deposit site at Bangor Erris	Top of test section (m bgl)	15.5
Client:	Enterprise Oil	Bottom of test section (m bgl)	23.7
Engineer:	TES	Centre of test section (m bgl)	19.6
Borehole:	**1B**	Length of test section (m bgl)	8.2
Bh. size:	HQ	Pressure gauge height (m agl)	0.95
Date:	24.10.'03	Initial depth to G.W. (m bgl)	19.6
		Packer inflation pressure (psi)	120

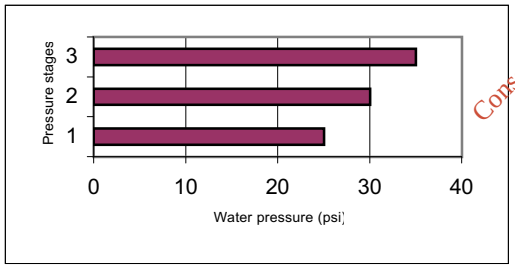
1. Site Records

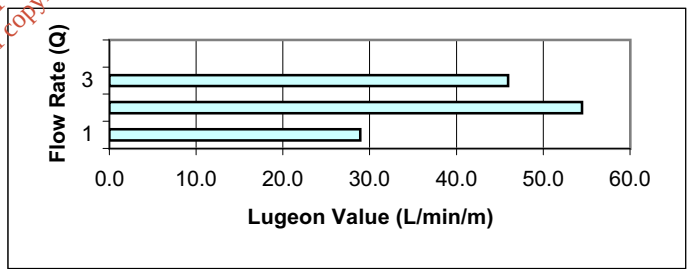
Pressure stage	Water pressure (psi)	Flow meter readings				Water taken over time period (gal)			
		start	5 min	10 min	15 min	0-5 min	5-10 min	10-15 min	0-15 min gals
1	25	157265	157377	157468	157563	112	91	95	298
2	30	157563	157838	158010	158176	275	172	166	613
3	35	158176	158388	158563	158737	212	175	174	561

2. Calculations

Pressure stage	Equiv. head of water (m)	Flow rate (Q) l/min	Lugeon Value l/min/m
1	38.1	90.3	*28.9*
2	41.6	185.8	*54.4*
3	45.1	170.0	*45.9*
5	0	0	0







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3. Permeability (k) analysis

Lugeon Value Used (l/min)	32.3
k (m/sec)	3.23E-06
k (m/day)	2.79E-01

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PACKER TEST RESULTS

Contract:	Peat Deposit site at Bangor Erris
Client:	Enterprise Oil
Engineer:	TES
Borehole:	**2B**
Bh. size:	HQ
Date:	31.10.'03

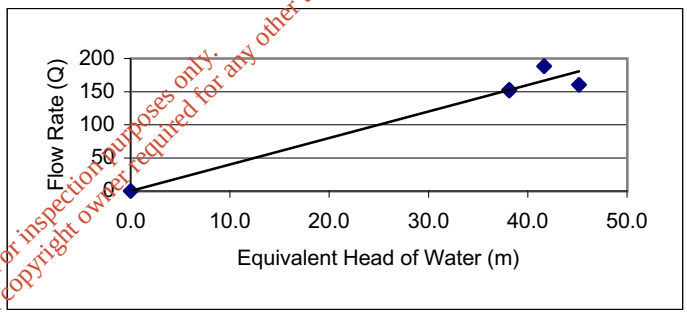
Top of test section (m bgl)	15.75
Bottom of test section (m bgl)	23.5
Centre of test section (m bgl)	19.625
Length of test section (m bgl)	7.75
Pressure gauge height (m agl)	0.95
Initial depth to G.W. (m bgl)	19.625
Packer inflation pressure (psi)	150

1. Site Records

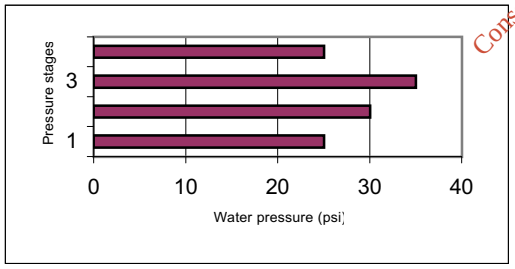
Pressure stage	Water pressure (psi)	Flow meter readings				Water taken over time period (gal)			
		start	5 min	10 min	15 min	0-5 min	5-10 min	10-15 min	0-15 min gals
1	25	159215	159382	159550	159718	167	168	168	503
2	30	159718	159925	160133	160340	207	208	207	622
3	35	160430	160546	160753	160960	116	207	207	530
4	25	160960	161128	161295	161461	168	167	166	501

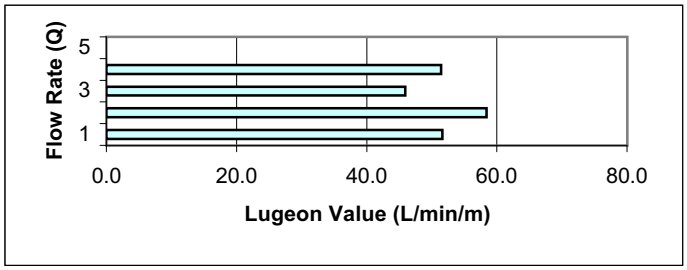
2. Calculations

Pressure stage	Equiv. head of water (m)	Flow rate (Q) l/min	Lugeon Value l/min/m
1	38.1	152.4	*51.6*
2	41.7	188.5	*58.4*
3	45.2	160.6	*45.9*
4	38.1	151.8	*51.4*
5	0	0	0



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3. Permeability (k) analysis

Lugeon Value Used (l/min)	51.8
k (m/sec)	5.18E-06
k (m/day)	4.48E-01

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PACKER TEST RESULTS

Contract:	Peat Deposit site at Bangor Erris
Client:	Enterprise Oil
Engineer:	TES
Borehole:	**3B**
Bh. size:	HQ
Date:	31.10.'03

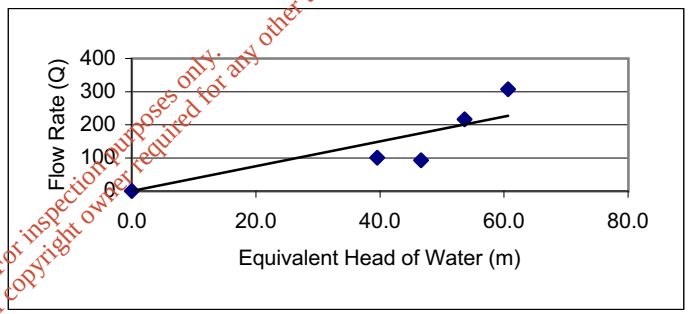
Top of test section (m bgl)	11.75
Bottom of test section (m bgl)	16
Centre of test section (m bgl)	13.875
Length of test section (m bgl)	4.25
Pressure gauge height (m agl)	1.1
Initial depth to G.W. (m bgl)	13.875
Packer inflation pressure (psi)	190

1. Site Records

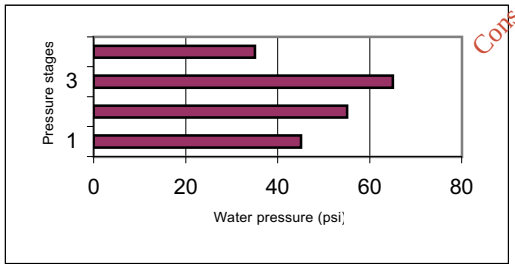
Pressure stage	Water pressure (psi)	Flow meter readings				Water taken over time period (gal)			
		start	5 min	10 min	15 min	0-5 min	5-10 min	10-15 min	0-15 min gals
1	45	162315	162402	162511	162621	87	109	110	306
2	55	162621	162851	163091	163334	230	240	243	713
3	65	163582	163929	164206	164596	347	277	390	1014
4	35	164596	164708	164820	164928	112	112	108	332

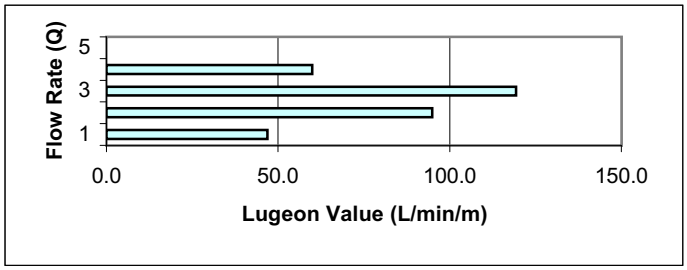
2. Calculations

Pressure stage	Equiv. head of water (m)	Flow rate (Q) l/min	Lugeon Value l/min/m
1	46.6	92.7	*46.8*
2	53.6	216.1	*94.8*
3	60.7	307.3	*119.2*
4	39.6	100.6	*59.8*
5	0	0	0



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3. Permeability (k) analysis

Lugeon Value Used (l/min)	80.1
k (m/sec)	8.01E-06
k (m/day)	0.69

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Appendix 9

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CORRIB FIELD DEVELOPMENT

PRELIMINARY GEOTECHNICAL DESIGN FOR SRAHMORE PEAT DEPOSITION SITE

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Prepared for:

TES Consulting Engineers

AGEC Ltd

5 Kilcarrig Street

Bagenalstown

Co. Carlow

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DOCUMENT APPROVAL FORM

Document title:	Preliminary Geotechnical Design for Srahmore Peat Deposition Site		
File reference Number:	382_044	Document Revision No.	2
Note: Amendments marked with line in right-hand margin			

File Reference Number	Document Revision No.	Amendment/Comment

Task	Nominated authority	Approved (signature and date)
Prepared by	Authors: Paul Jennings	Paul Jennings 11.12.03
Checked by	Geotechnical Project Manager: Peter Rutty	P. Rutty 4/12/03
Approved by	Geotechnical Project Director: Turlough Johnston	T. Johnston 11-12-03
Quality check	Quality Manager: Marion English	M. English 11/12/03

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Table 2 Adopted Design Parameters for Ex Situ Peat
Table 3 Adopted Design Parameters for Mineral Soil
Table 4 Summary of Slope Factor of Safety in Area 6

FIGURES (at end of text)

Figure 1 Site Location
Figure 2 Site Layout Plan
Figure 3 Profile of Undrained Shear Strength (c_u) of Peat with Depth from CPT Results
Figure 4 Factor of Safety for Global Stability - Case (1)
Figure 5 Factor of Safety for Localised Stability - Case (2)

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APPENDICES

Appendix A Phase 1 Ground Investigation Results
Appendix B Phase 2 Ground investigation Results
Appendix C Review of Effective Stress Parameters for Peat
Appendix D Risk Register

DRAWINGS

Drawing No. 382_001 Preliminary Design Ground Profile for Areas 5 & 6 – Section 1-1
Drawing No. 382_002 Preliminary Design Ground Profile for Areas 5 & 6 – Section 2-2
Drawing No. 382_003 Preliminary Design Ground Profile for Areas 5 & 6 – Section 3-3

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1 INTRODUCTION

The Srahmore Peat Deposition Area is located about 1 km west of Bangor, County Mayo. The site is situated between the R313 and Bangor to Gweesalia roads in an area formerly used for peat harvesting by Bórd na Mona (Figure 1).

It is proposed to use the site as a deposition area for peat arisings from the excavation for the proposed gas terminal platform located at Bellanaboy, County Mayo.

Applied Ground Engineering Consultants Ltd (AGEC) was engaged in November 2003 by Shell E&P Ireland Ltd to carry out a preliminary geotechnical design of the site, which included the following.

(1) Procurement of ground investigation data at site for design.

(2) Interpretation of ground investigation data and selection of appropriate design parameters.

(3) Assess and clearly demonstrate that the following elements of the proposed works have an acceptable factor of safety with respect to global and local stability in the temporary as well as permanent condition.

   (a) Access Roads
   (b) Deposition Areas
   (c) Peat Transfer Area and Car park

(4) A geotechnical risk register prepared for all activities relating to the site and the deposition activities envisaged, with the appropriate corrective and control features identified.

(5) Observation and instrumentation requirements. The long and short-term requirements, if any, for observation and instrumentation of the site.

Details of site hydrology and drainage together with a summary of soils and geology are addressed in the main Environmental Impact Statement (TES, 2003).

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2 SITE DESCRIPTION

The proposed Srahmore Peat Deposition Site (SPDS) is located to the south of the R313 (Figure 1) in an area of relatively flat to gently sloping ground. The natural ground surface at the site slopes gently from northeast to southwest with a fall about 0.2˚, that is 5m fall over a distance of 1500m.

Several minor streams drain the site. These streams feed into the Munkin River to the west and the Owenmore River to the south.

The SPDS is in two parts, referred to as Area 5 and Area 6 (Figure 2). Each of these areas originally comprised natural blanket peat which has since been largely cutaway. The depth of peat cutting is some 1.5 to 2.5m.

Peat has been cutaway from Area 5 and 6 leaving a series of high- and lowfields.

(1) Lowfields comprise areas where peat has been cut-away to near the top of the underlying mineral soil, typically a depth of 1.5 to 2.5m. In places the mineral soil can be seen exposed in the base of the low field. Lowfields are typically 120 to 150m wide and are separated by high fields.

(2) Highfields comprise a strip of intact peat that has been left upstanding between low fields. The strip is some 15m wide, and has typically been used to facilitate vehicular and train access during peat harvesting operations.

The cutaway areas form an excavated basin within and surrounded by existing peat land. The highfields form internal divides within the cutaway areas which further compartmentalise the cutaway areas into rectangular excavated basins (Figure 2).

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3 PROPOSED WORKS

Within the SPDS it is proposed to use Area 5 as a reception area for peat arriving on site. The proposed work in Area 5 will include an access road from the R313. A hardstanding for peat transfer will be constructed at the end of the access road for peat handling and car parking.

Area 6 is proposed to be used as the deposition area for peat excavated from the proposed gas terminal site at Bellanaboy. The proposed average depth of placed peat within the deposition area is given as 1.04m.

The proposed sequence of placing peat in Area 6 is given in the main Environmental Impact Statement (TES, 2003). A summary is given below.

(1) Low ground bearing pressure (Haku) trailers will transport the peat from the reception area to highfields in Area 6 via internal haul roads constructed on existing peat.

(2) Haku trailers will travel along internal roadways which will be constructed on highfields in Area 6 and empty the peat by tipping onto the side of the highfield.

(3) Excavators will remove the peat from the highfield and place the peat onto the lowfield. Peat will then be bulldozed towards the centre of the lowfield to create a cambered surface with highest point in the centre sloping back toward the highfields.

(4) The height of placed peat will generally be of the order of 1.4 to 1.8m at the highest point in the centre above the existing ground levels, with a fall towards the highfields. The edge of the placed peat will be offset from the bottom toe of each of the highfields where drainage ditches are to be constructed.

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4 SUPERFICIAL DEPOSITS

The superficial deposits within the SPDS can be briefly classified into the following main types.

(1) Peat
(2) Glacial Till
(3) Weathered Rock

In general terms all superficial deposit types other than peat may be referred to as mineral soils. Exposures below the base of the peat are limited to trial pits, which indicate till underlying peat. The extent of weathered rock below till is not known, as boreholes were open-holed to top of competent rock.

4.1 Peat

Blanket peat originally covered the site. Most of the peat has been removed from the lowfields, leaving typically less than 1m thickness of peat. Original peat depth was estimated as typically 3 to 4m. Locally deeper areas of peat, up to 6m adjacent to R313, were recorded.

Based on a general soil map of Ireland (An Foras Talúntais, 1980), the site is shown to be covered in low-level blanket/basin peat.

The upper about 1m of peat is generally very fibrous and possibly desiccated which results in a relatively stronger and stiffer upper layer. Peat was described using BS: 5930 (BSI, 1999) as soft slightly moist brown PEAT with occasional fragments and large pieces of bogwood. Peat appeared to lie directly on glacial till.

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4.2 Glacial Till

Till, typically derived from local bedrock, underlies the peat. The thickness of till in Area 6 is estimated to vary from 6 to 14m based on the depth of superficial deposits given in borehole logs. Borehole logs do not distinguish between till and weathered rock, and it is possible that weathered rock is present in the lower part of the superficial deposits.

Based on trial pit logs, till is present at some locations as an upper cohesive deposit underlain by a granular deposit. Till was described from trial pits using BS: 5930 as follows.

(1) Upper cohesive deposit. Described as generally firm brown sandy CLAY. Given the presence of bogwood in the peat, this suggests that prior to peat formation the site was formerly forested, and therefore a buried soil surface layer is likely present. The upper cohesive deposit possibly represents the remnants of a buried soil surface layer. This layer does not appear to be widespread.

(2) Lower granular layer. Described as generally grey to yellow/brown clayey to slightly clayey occasionally silty gravelly fine- to medium-grained SAND with occasional to some sub-angular to sub-rounded gravels, cobbles and boulders of quartzite, schist and red sandstone. The till is layered, with occasional GRAVEL layers also recorded, though no clear stratification between trial pits was recognisable. The lower granular till layer is widespread and is more commonly found immediately below peat.

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4.3 Weathered Rock

Extent and character of weathered rock is not known as borehole logs do not distinguish between till and weathered rock, and it is possible that weathered rock is present at depth. No weathered rock was identified from trial pits which were excavated to about 3m.

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5 SOLID BEDROCK GEOLOGY

The bedrock geology of the area of the SPDS consists of rocks of the Dalradian Supergroup Series (GSI, 1992), which comprises essentially metamorphosed sedimentary rock. Boreholes within Area 6 show the depth to rockhead is variable and ranged from about 6 m bgl in BH3B to 14.3m bgl (BH2B).

The dominant rock type below the site is the Inver Schist Formation, which is a pelitic to semi-pelitic schist. Several sub-ordinate rock types also crop below the site along a northwest to southeast axis. These rock types are generally separated by a fault line and include marble, quartzite and psammitic schist.

Borehole records identified both psammite and quartzite bedrock. Psammite was described as moderately weak to moderately strong, narrowly banded, schistose (dipping 75˚), fine- to coarse-grained micaceous to extremely micaceous PSAMMITE. In places the psammite was underlain by quartzite (BH1B) or quartzite was recorded at the top of rockhead (BH3B). Quartzite was described as strong to very strong, massive to narrowly banded (dipping 35˚ and 60˚), fine- to medium-grained micaceous QUARTZITE.

Minor folding has been identified within the schists, with cleavage/schistocity dipping towards the northeast at between 35˚ and 75˚.

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6 GROUND INVESTIGATION

6.1 Fieldwork

Ground investigation work at the SPDS was carried out in 2 phases. Phase 1 was carried out in October/November 2003 on behalf of TES Consulting Engineers (TES) to determine the nature and extent of geological and hydrological characteristics at the site. Phase 2 was carried out in November/December 2003 on behalf of TES by AGEC to provide further information for a geotechnical assessment of the site.

Ground investigation works were carried out by Irish Drilling Ltd (IDL) and Fugro Engineering Services Ltd.

The following ground investigation has been carried out at the SPDS.

(1) Boreholes (7 nos.),
(2) Trial pits (14 nos.),
(3) In situ shear vane testing using handheld vane (7 nos.),
(4) In situ shear vane using rig-mounted mechanical vane, (up to 40 nos.), and
(5) Cone penetration testing (CPT) (up to 80 nos.).

The above boreholes, and some trial pits, together with permeability/pumping tests within rock were carried out in Phase 1 (Appendix A). The results of permeability/pumping tests are not included in this report.

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Trial pits were carried out to a depth of typically 3m using a tracked excavator.

Hand-held shear vanes were generally carried out in trial pits by IDL using a Geonor H-60, 50.8mm diameter vane.

Cone penetration testing (CPT) was carried out by Fugro Ltd using both a 3 tonne mini crawler and 15 tonne mounted CPT rig. The rigs were also used to carry out shear vane testing using a mechanical Geonor H-10, 55mm diameter vane.

Ground investigation results for Phase 1 and 2 are given in Appendix A and B respectively.

6.2 Laboratory Testing

Phase 1 laboratory test results included particle size distribution, five-point compaction and index testing (Appendix A).

Previous experience of laboratory strength testing for peat using a range of triaxial, simple and direct simple shear (DSS) testing apparatus has shown that results can be scattered and difficult to interpret. This is due to the excessive deformations that peat undergoes and the difficulty in defining the resulting failure limit. In situ strength testing possibly provides the most realistic indication of peat strength.

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7 TOPOGRAPHIC SURVEY

A topographic survey of the SPDS was carried out on behalf of TES by Bórd na Mona as part of the Phase 1 investigation. This survey has been used to generate the elevation contours used to generate the geological cross-sections (See Drawing Nos. 382_001 to 003).

Additional detailed level survey was carried out by AGEC at specific locations to supplement the topographic survey.

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8 GEOTECHNICAL ASSESSMENT

8.1 General

A preliminary geotechnical design and assessment of the following elements of the SPDS has been carried out.

(1) Global stability of the deposition area (Area 6) prior to and following peat placement,

(2) Local stability of highfield/lowfield in deposition area (Area 6), and

(3) Assessment of access road, peat transfer area and car park in Area 5

8.2 Factor of Safety for Earthworks Stability

The code of practice for earthworks BS 6031:1981 (BSI, 1981) provides advice on design of both temporary and permanent earthworks. It states that for a first time failure with a good standard of site investigation the design factor of safety (FoS) of should be 1.3 to 1.4.

For the purpose of peat stability a minimum FoS of 1.3 is required.

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8.3 Stability Analysis

Stability analysis was carried out using slope stability computer program Talren (Terrasol, 1997) applying Bishop's rigorous method.

Both total and effective stress analyses were examined. Total stress analysis applies to short-term conditions occurring during construction and for a time following construction until construction induced pore water pressures dissipate. Undrained shear strength values, c_u are used for total stress analysis. Effective stress analysis applies to long-term conditions where construction induced excess pore water pressure has dissipated. Effective strength parameters, c' and ϕ', are used together with assessed groundwater conditions.

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9 DESIGN PARAMETERS

9.1 Peat

Undrained shear strength (c_u) of in situ peat was determined using cautious estimates of c_u. Vane results are presented in Appendix A. The following sources were used to assess c_u for peat:

(1) In situ vane testing using both hand-held and mechanical,
(2) In situ cone penetration testing (CPT), and
(3) Results from neighbouring sites.

In situ vane test results are included in Appendix A. Results indicate that strength ranges typically from about $c_{u\ vane}$ of 10 to 23kPa for unfactored vane results.

Vane results from several works on Irish peat have used unfactored vanes (see for example Hanrahan, 1964, Piggott et al., 1992 and AGEC, 2002). These works back-analysed failures and found that unfactored vane results provided a reasonable estimate of the operating shear strength. Furthermore several of the highfields in Area 6 are upstanding by 1.5m to 2.0m with a sub-vertical face. Back-analysis of these faces shows that a minimum $c_{u\ back}$ of about 10kPa is required for stability.

CPT's were carried out across the site to establish cone resistance (q_c) and hence undrained strength ($c_{u\ CPT}$) with depth in peat (Appendix B). The relationship between $c_{u\ CPT}$ and q_c is based on an approximation of the bearing capacity equation (Sanglerat, 1972) which requires cone factor (N_k) to be determined.

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Based on previous experience, N_k = 15 was adopted. Previous work (AGEC, 2002 and 2003) indicates that, whilst there is a scatter of data, this provides a reasonable cautious estimate of undrained strength of peat.

Depth profile of peat c_u with depth using CPT results is shown in Figure 3. This shows a stronger and stiffer layer within the upper 1m associated with more fibrous material overlying weaker more amorphous peat. At greater depth, the profile indicates little strength gain with depth. Inspection of exposed peat in the low field areas by AGEC estimated c_u of 10 to 15kPa.

Previous work on blanket peat in North Mayo (AGEC, 2002) determined effective strength parameters (c' and ϕ') for peat from DSS and DS tests. Results showed a lower bound c' = 3kPa and ϕ' = 32°. A review of effective strength parameters for peat from Irish and international publications showed that these results are comparative to values used elsewhere (Appendix C).

Adopted design parameters for in situ peat are given in Table 1. These parameters are based on site specific results or results from neighbouring peat sites. In general, the design parameters for peat are within the range reported in the literature.

Parameter/Characteristic	Design Value	Comments

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Bulk unit weight, γ (kN/m^3)	10	-
Effective friction angle, ϕ' (degrees)	32	-
Effective cohesion, c' (kN/m^2)	3	-
Undrained shear strength	Highfield Upper 1m: 15kPa Peat below 1m: 5kPa Lowfield Upper 1m: 10kPa Peat below 1m: 5kPa	-

Table 1 Adopted Design Parameters for In Situ Peat

9.2 Ex situ Peat

The parameters for peat excavated from the gas terminal site are based on several previous site investigations (AGEC, 2002). All peat beneath the terminal is to be removed and placed at the SPDS.

Adopted design parameters for ex situ peat are given in Table 2. These parameters are based on site specific results or results from neighbouring peat sites

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Parameter/Characteristic	Design Value	Comments
Bulk unit weight, γ (kN/m^3)	10	-
Effective friction angle, ϕ' (degrees)	-	Not used
Effective cohesion, c' (kPa)	-	Not used
Undrained shear strength, c_u (kPa)	2	Remoulded strength. Based on investigations results presented in AGEC (2002)
Slope inclination	>1v:10h	For long-term stability surface profile of peat to be constructed with the shallowest gradients practicable based on previous experience.

Table 2 Adopted Design Parameters for Ex Situ Peat

9.3 Mineral Soil (Glacial Till)

Mineral soil considered to be glacial till underlies the peat and has a variable thickness. Till consists of two layers, an upper cohesive layer and a lower granular layer. The upper layer is not always present and for preliminary design till is modelled as a granular layer only.

Adopted design parameters are given in Table 3.

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Parameter/Characteristic	Design Value	Comments
Bulk unit weight, γ (kN/m^3)	20	-
Effective friction angle, ϕ' (degrees)	32	Assumed medium dense
Effective cohesion, c' (kPa)	0	-
Undrained shear strength, c_u (kPa)	0	-

Table 3 Adopted Design Parameters for Mineral Soil

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10 PRELIMINARY DESIGN GROUND PROFILE

10.1 General

Preliminary design ground profile Area 6 is presented in Drawings Nos. 382_001 and 382_002, and preliminary design profile for Area 5 is presented in Drawing No. 382_003.

The drawings show both an exact scaled profile and a profile with an exaggerated vertical scale which highlights more clearly the geometry.

10.2 Peat Layer

Bórd na Mona undertook a peat depth survey of the Srahmore site in 1998, using a 'Hiller Borer' sampler, which is a hollow stem sampler. This sampler was pushed into the peat material and the hollow stem used to indicate depth to mineral soil.

Within Area 5, the survey indicated peat thickness varied from about 0.34m to 0.7m in the zone where it is proposed to construct the peat reception hardstand. The peat thickness along the access road from the R313 to the reception hardstand varied from 0.34m to 6m. The peat thickness being greatest immediately adjacent to the R313, where no peat extraction has been undertaken.

With respect to Area 6, the Hiller Borer survey indicates that between 0.1m and 2.16m of peat overlies the mineral subsoil in the lowfields.

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10.3 Mineral Soil (Glacial Till) Layer

Mineral soil underlies the peat. The top surface of the mineral soil is variable with ground investigation results indicating a depth varying between about 3 and 6m. The thickness of mineral soil is estimated as between 6 and 14 m bgl.

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11 GEOTECHNICAL DESIGN AND STABILITY RESULTS

11.1 Area 6

Peat is to be placed within the lowfields of Area 6. Stability of lowfields during and following placement of peat has been assessed for the following cases.

(1) Global stability of the deposition area (Area 6) prior to and following peat placement.

(2) Local stability of highfield/lowfield in deposition area (Area 6).

Stability results are presented in Table 4 and Figures 4 and 5. A surcharge of 10 kPa is assumed to represent construction traffic for Case (2).

Case	Minimum Factor of Safety				Comments
	Total Stress Analysis		Effective Stress Analysis		
	Existing	Filled	Existing	Filled	
(1)	5.76	>20	3.21	>20	See Figure 4
(2)	1.39	4	1.37	1.46	See Figure 5

Table 4 Summary of Slope Factor of Safety in Area 6

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For Case (1) the FoS is high, as would be expected given the geometry of the area. The minimum FoS of 3.21 is prior to filling for global failure along perimeter of deposition (Figure 4a and b). This is greater than the required minimum of 1.3.

Where peat is placed within Area 6, global stability analyses were carried out assuming potential translational failure below deposition area. Stability along Section 2-2 (Drawing No. 382_002) was examined together with stability along the lowfield to the south of Section 1-1 (Drawing No. 382_001). The calculated FoS is greater than 20 (Figure 4c to h). The high FoS indicates that such a failure mode is inapplicable.

Case (2) examined local stability within Area 6. The minimum FoS of 1.37 for local stability was found for potential side-slope failure of highfield (Figure 5a and b). Where a surcharge load is placed up to the edge of the highfield the FoS reduces to less than 1.3 within about 2m of the edge of the highfield. Siting of concentrated loads close to the edge of the highfield, may result in localised side slope failure of highfield, and is to be avoided.

Local stability of placed peat in the western end of the lowfield was examined. This shows a minimum FoS of 1.46 (Figure 5d) and assumes failure surface passes through intact peat below placed peat. Some minor slippage of placed peat may occur from the face of the peat until such time as plant cover can be established on the placed peat surface.

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Further analyses examined potential failure of placed peat between highfields (Figure 5e and f). This shows minimum FoS of 11. 62.

11.2 Area 5

Within Area 5 it is proposed to construct an access road from the R313 to a hardstanding area for peat transfer. The hardstanding will be used for transferring peat received from the Bellanaboy site on to onto specialist low ground bearing machinery for transport to deposition in Area 6.

A geotechnical assessment of access road and peat transfer area was carried out.

11.2.1 Access Road from R313

The peat thickness along the access road from the R313 to the reception hardstand varies from 0.34m to 6m based on Bórd na Mona's peat depth survey. The peat thickness is greatest immediately adjacent to the R313, where no peat extraction took place (Drawing No. 382_003).

Where peat is to remain below the access road, then estimated settlements up to 1m would be expected. This settlement is likely to be differential varying with applied loading and thickness of peat.

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Bearing failure of the road has been assessed. This indicates that where peat is left below the road, the road foundation requires a biaxial geotextile, such as Tensar SS30/40 or similar, laid within a suitable granular fill. Whilst this may reduce the potential for bearing failure and limit localised differential settlement, the total predicted settlement is likely to disrupt the running surface.

Preliminary design options are as follows.

(1) Peat should be removed from below the road where it is proposed to construct a metalled road surface. Where there is significant depth of peat then excavations need to be fully supported. Partial removal of peat may be a viable option where it can be shown that significant settlement and bearing failure do not adversely affect the road. Alternatively stabilising peat in situ is an option, see below

(2) Where there is a significant depth of peat, modification of peat in situ can be carried out using for example vibro-compacted concrete columns, stone columns, in situ mixing of peat with cement and lime.

(3) Where no metalled road surface is required then peat can be left in place. Road construction would then consist of a suitable granular fill reinforced with a biaxial geogrid, such as Tensar SS30/40 or similar. This construction would require periodic re-levelling and grading to maintain an acceptable running surface.

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11.2.2 Peat Transfer Area

Trial pit (TP2) was excavated in the area of the proposed hardstanding for the peat transfer area (Drawing No. 382_003). The depth of peat encountered was 0.65m underlain by mineral soil. These ground conditions do not represent any great difficulty with respect the proposed construction.

Where peat is to remain below the hardstanding, then settlements of the order of about 200mm would be expected. This settlement is likely to be differential varying with applied loading and thickness of peat.

Preliminary design options are as follows.

(1) Peat should be removed from below the hardstanding where it is proposed to construct a metalled surface to the hardstanding.

(2) Where no surface to the hardstanding is proposed then a suitable granular fill reinforced with a biaxial geogrid, such as Tensar SS30/40 or similar, would suffice. This construction would require periodic re-levelling and grading of hardstanding surface.

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12 CONSTRUCTION

12.1 General

An assessment of geotechnical hazard and associated risk for the proposed construction is presented in Appendix D. The risk assessment identified no significant risks with respect to major failure or instability associated with the proposed works.

All geotechnical hazards were classified as trivial risk. Of the 6 likely geotechnical hazards identified for the works (see Table in Appendix D), 5 of these hazards affect the site work only and have no impact beyond the site boundary. The highest risk is associated with possible settlement and bearing failure of the access road from the R313. Where this road is constructed on peat then monitoring of road performance is required. Disruption of this road would have a high impact on the works.

12.2 Geotechnical Instrumentation

Geotechnical instrumentation is required to monitor key performance criteria and validate the design. Instrumentation is usually required to monitor horizontal and vertical displacement of the ground or construction access road embankments.

Given the low geotechnical risk associated with the proposed works, at the preliminary stage no requirement for geotechnical monitoring is envisaged.

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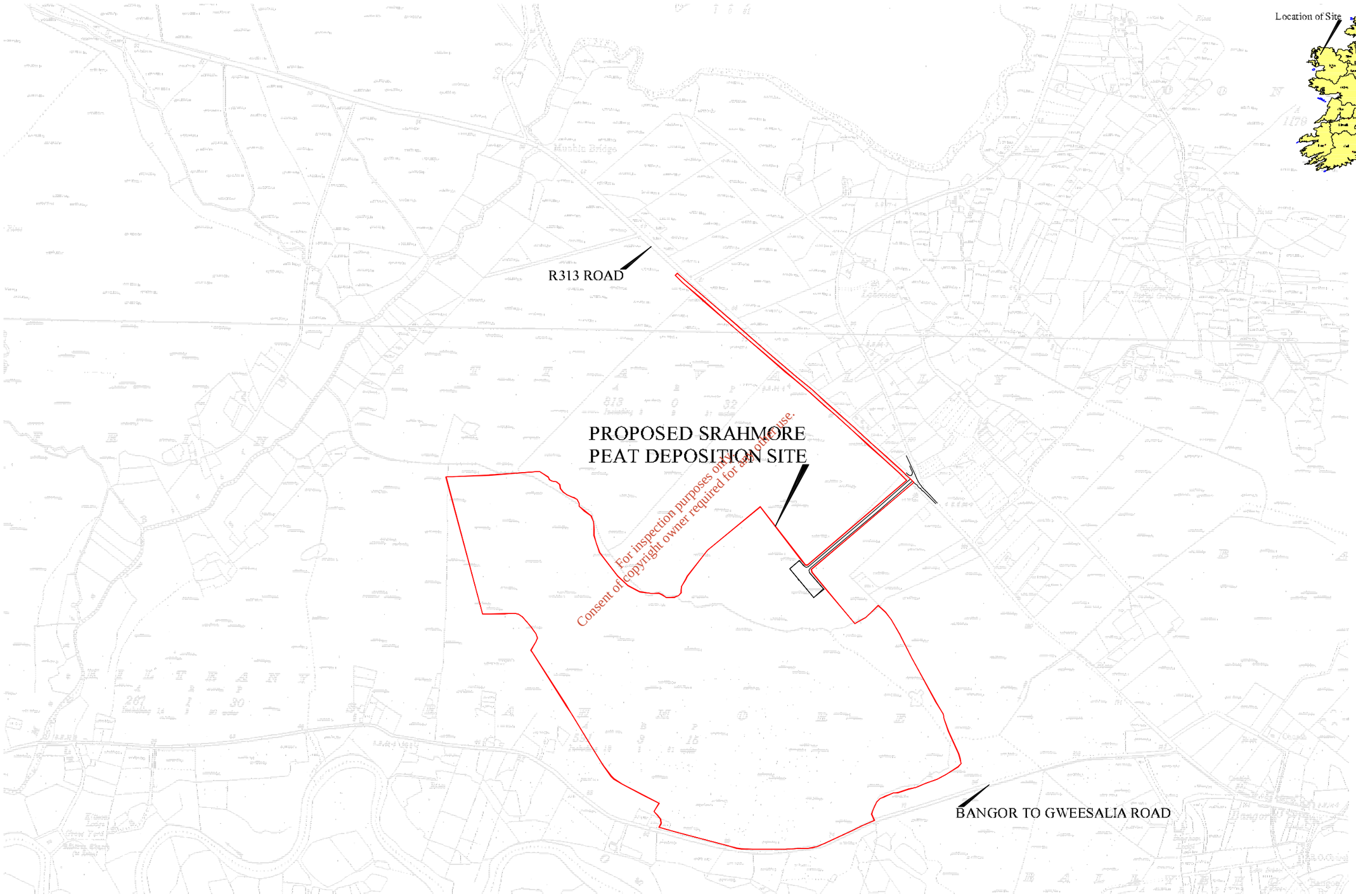
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FIGURES

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Notes:		Client: Shell E&P Ireland Limited	Job: Preliminary Geotechnical Design for Srahmore Peat Deposition Site	Figure 1 Title: Site Location	AGEC Ltd 5 Kilcarrig Street Bagenalstown Carlow Ireland Tel: +353 503 23800 Fax: +353 503 23793 www.agec.ie info@agec.ie
Scale: 1:12500	Checked: P.J.				
Date: 09/12/03	Revision: A				
Drawn: P.O.R.	Based on: 382_018				

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AREA 7

AREA 5

AREA 6

BOUNDARY OF PROPOSED SRAHMORE PEAT DEPOSITION SITE

PEAT TRANSFER HARDSTANDING

ACCESS ROAD

R313 ROAD

STREAM

LOWFIELD (LF)

HIGHFIELD (HF1)

ROAD

RIVER

TP1
TP2
TP3
TP4
TP5
TP6
TP7
TP8
TP10
TP11
TP12
TP14

BH 1A/B
BH 2A/B
BH 3A/B
BH 4

HF1
HF2
HF3
HF4
HF5
HF6

HF1 CP1
HF1 CP4
HF1 CP6
HF1 CP8
HF1 CP10
HF2 CP2
HF2 CP4
HF2 CP6
HF2 CP8
HF2 CP10
HF3 CP2
HF3 CP4
HF3 CP5
HF3 CP6
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HF5 CP6

1
2
3

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NOTES:
(1) PROPOSED AND COMPLETED (5 DEC. 2003) GROUND INVESTIGATION SHOWN

(2) PROPOSED GROUND INVESTIGATION TO BE COMPLETED BY END OF DEC. 2003

LEGEND:

- BHXX — BOREHOLE LOCATION
- TPXX — TRIALPIT LOCATION
- CPXXX — CONE PENETRATION TEST LOCATION
- REMAINING PROPOSED CONE PENETRATION TEST LOCATION
- X X — LOCATION CROSS SECTION

Further notes:

Notes:

Scale: 1:2500 (A1)	Checked: P.J.
Date: 09/12/03	Revision: A
Drawn: P.O.R.	Based on: 382_03,018

Client: Shell E&P Ireland Limited

Job: Preliminary Geotechnical Design for Srahmore Peat Deposition Site

Figure 2

Title: Site Layout Plan

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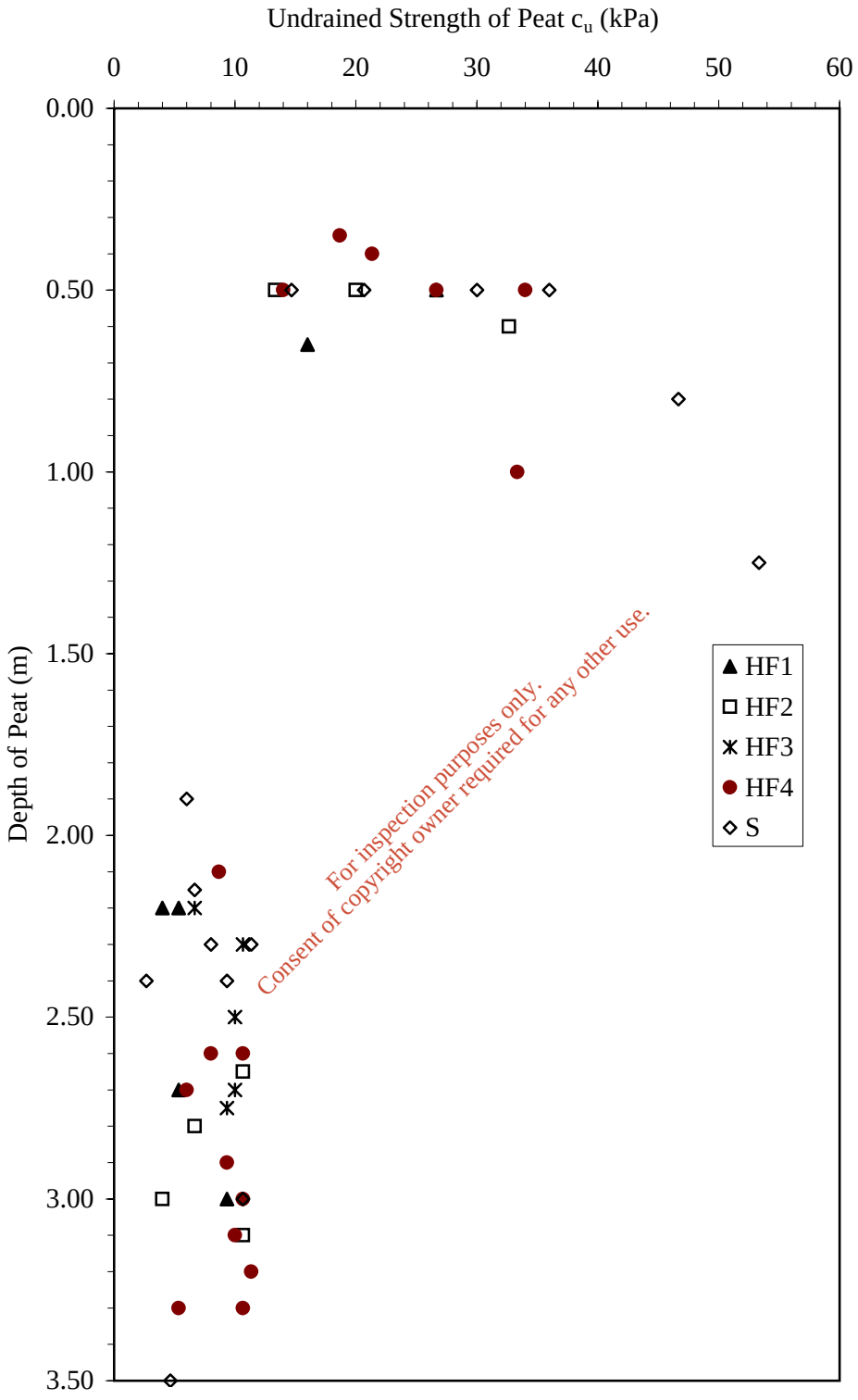


Figure 3 Profile of Undrained Shear Strength (c_u) of Peat with Depth from CPT Results

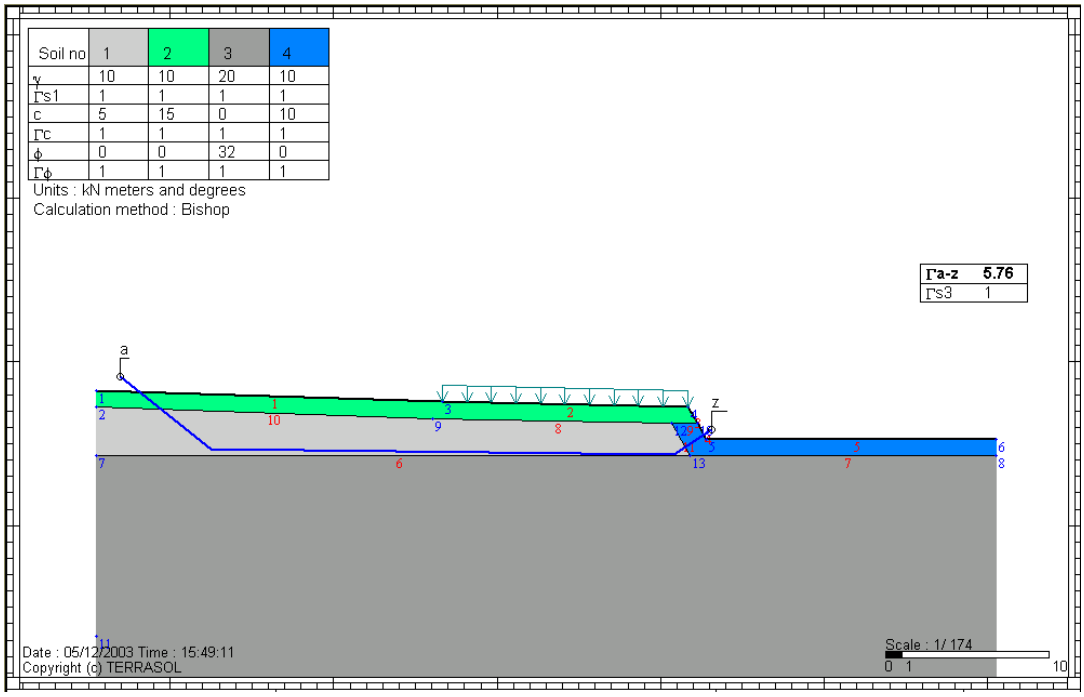
Notes

(1) Results are for highfield (HF) and southern (S) perimeter areas

(2) CPT converted to $c_{u\,CPT}$ using N_k = 15

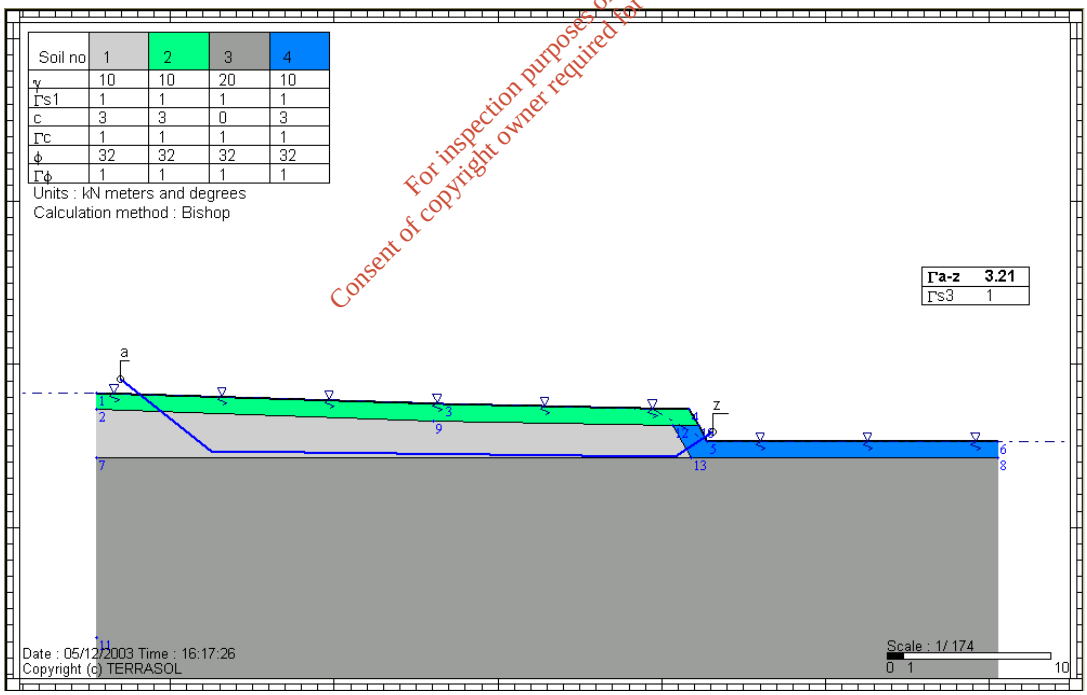
(3) Results based on 30 CPT locations throughout the site

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(a) Showing global stability of perimeter assuming translational slide for total stress (undrained) analysis

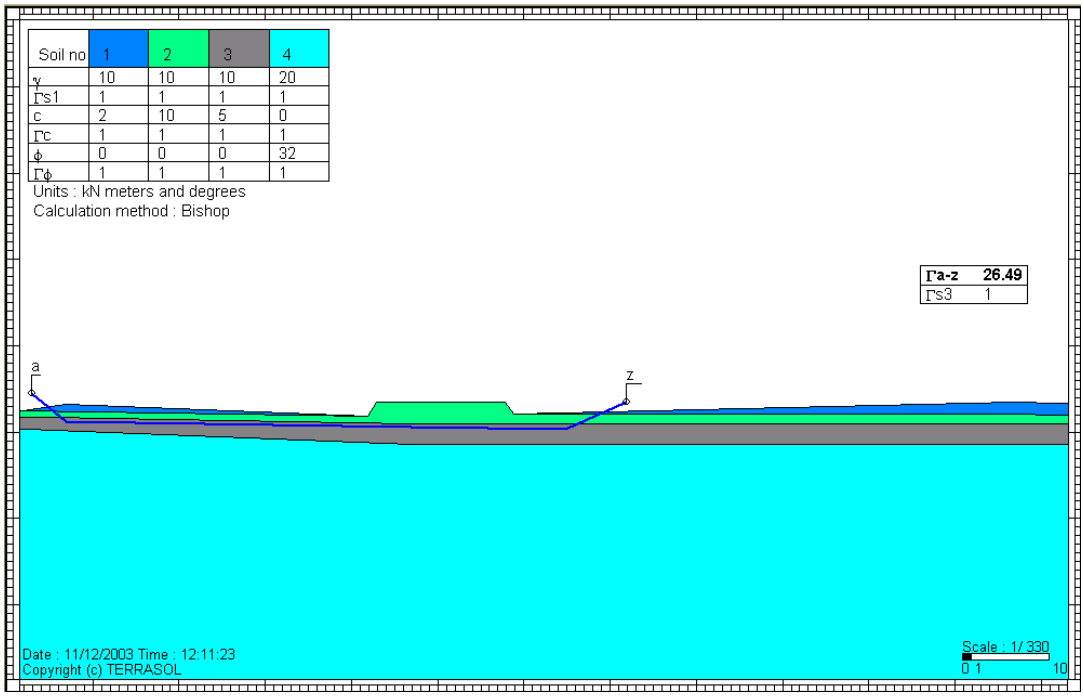
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(b) Showing global stability of perimeter assuming translational slide for drained loading condition. Groundwater assumed at peat surface.

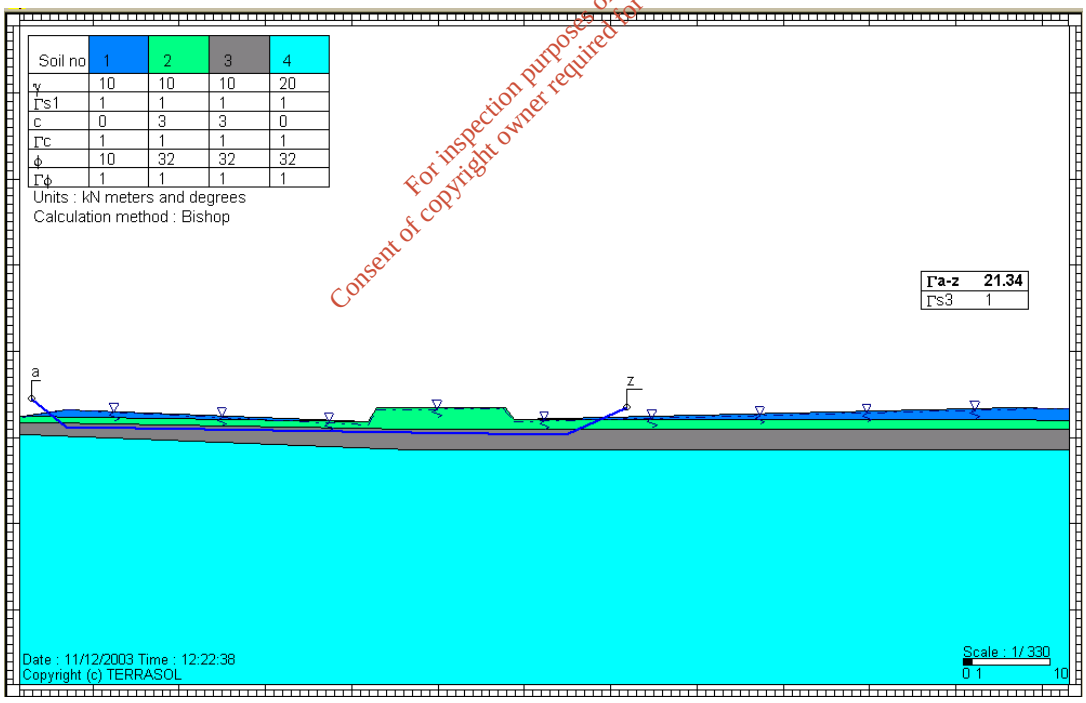
Figure 4 Factor of Safety for Global Stability - Case (1) Cont.

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(c) Example of global stability of under highfield along Section 2-2 following peat placement assuming translational slide for total stress (undrained) analysis

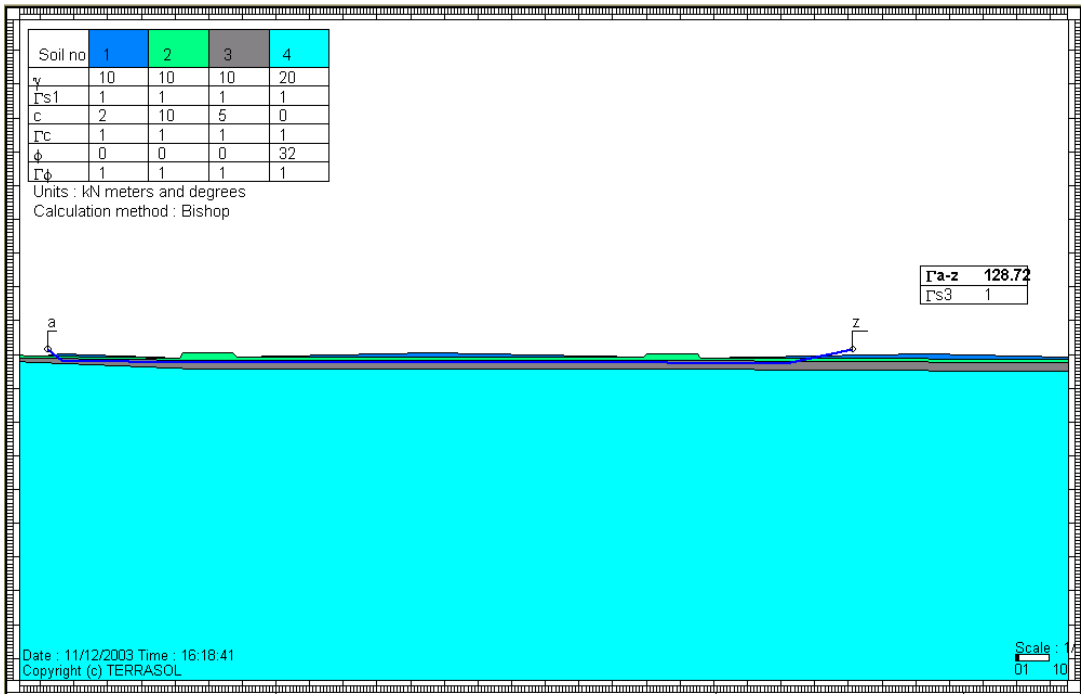
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(d) Example of global stability of under highfield along Section 2-2 following peat placement assuming translational slide for drained loading condition. Groundwater assumed at peat surface.

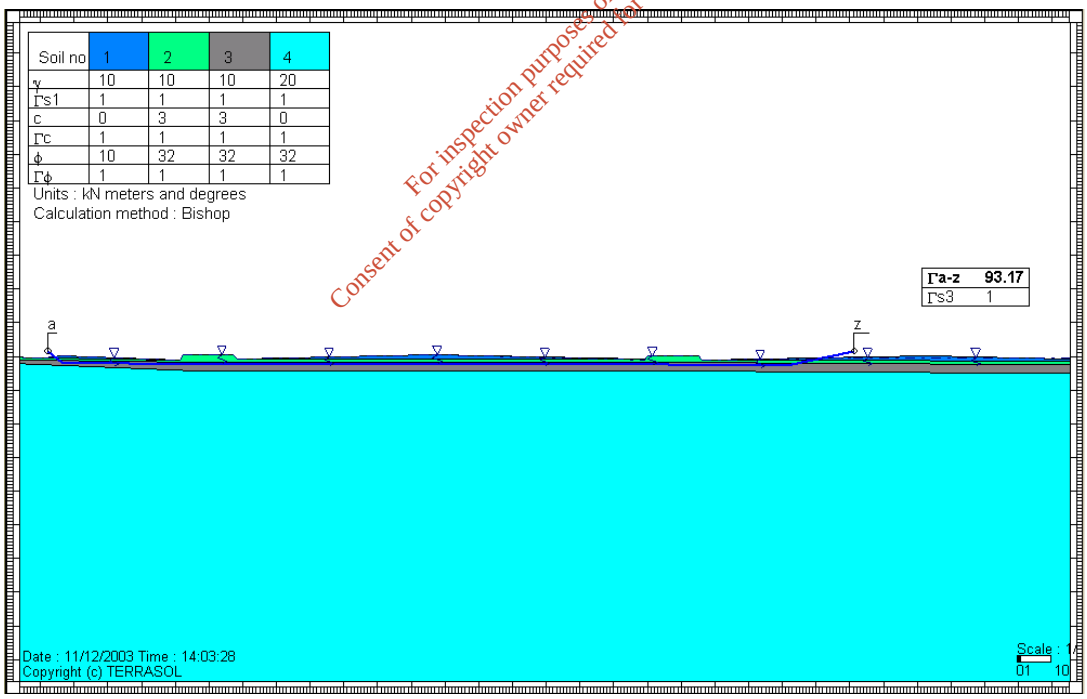
Figure 4 Factor of Safety for Global Stability - Case (1) Cont.

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(e) Example of global stability under 2 highfields along Section 2-2 following peat placement assuming translational slide for total stress (undrained) analysis

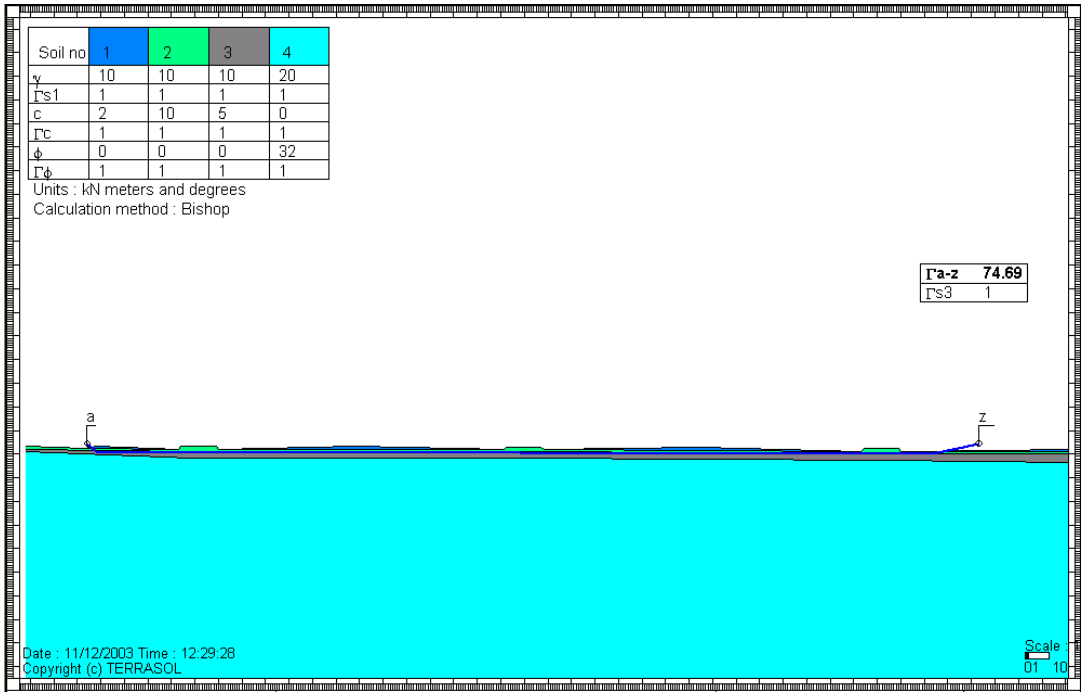
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(f) Example of global stability under 2 highfields along Section 2-2 following peat placement assuming translational slide for drained loading condition. Groundwater assumed at peat surface.

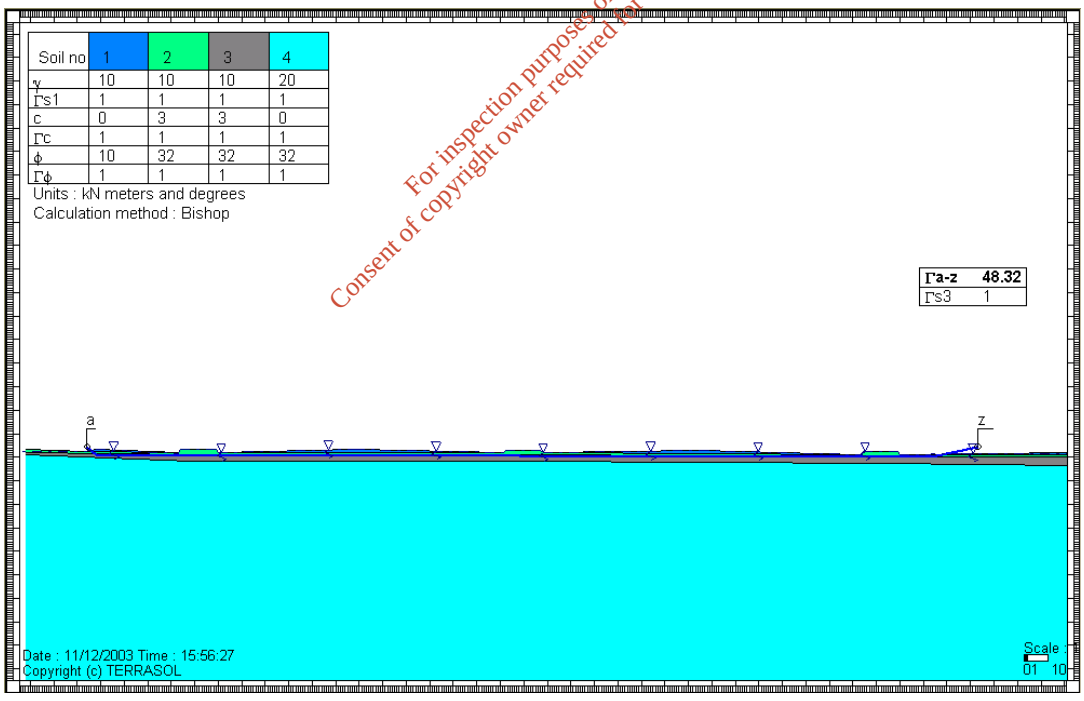
Figure 4 Factor of Safety for Global Stability - Case (1) Cont.

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(g) Example of global stability under 3 highfields along Section 2-2 following peat placement assuming translational slide for total stress (undrained) analysis

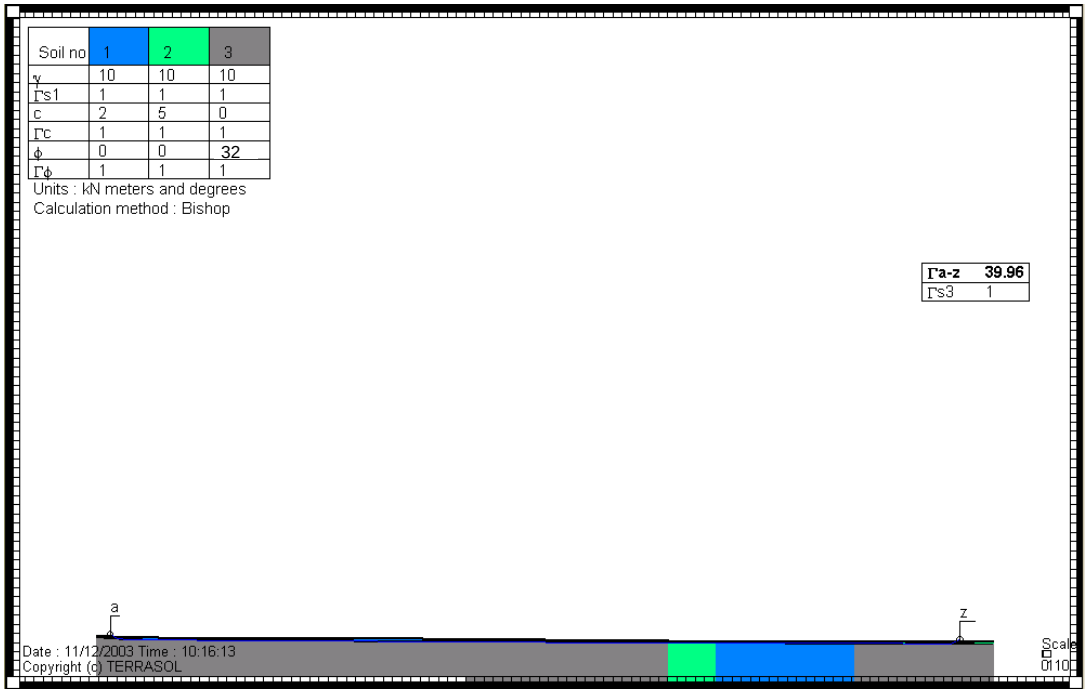
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(h) Example of global stability under 3 highfields along Section 2-2 following peat placement assuming translational slide for drained loading condition. Groundwater assumed at peat surface.

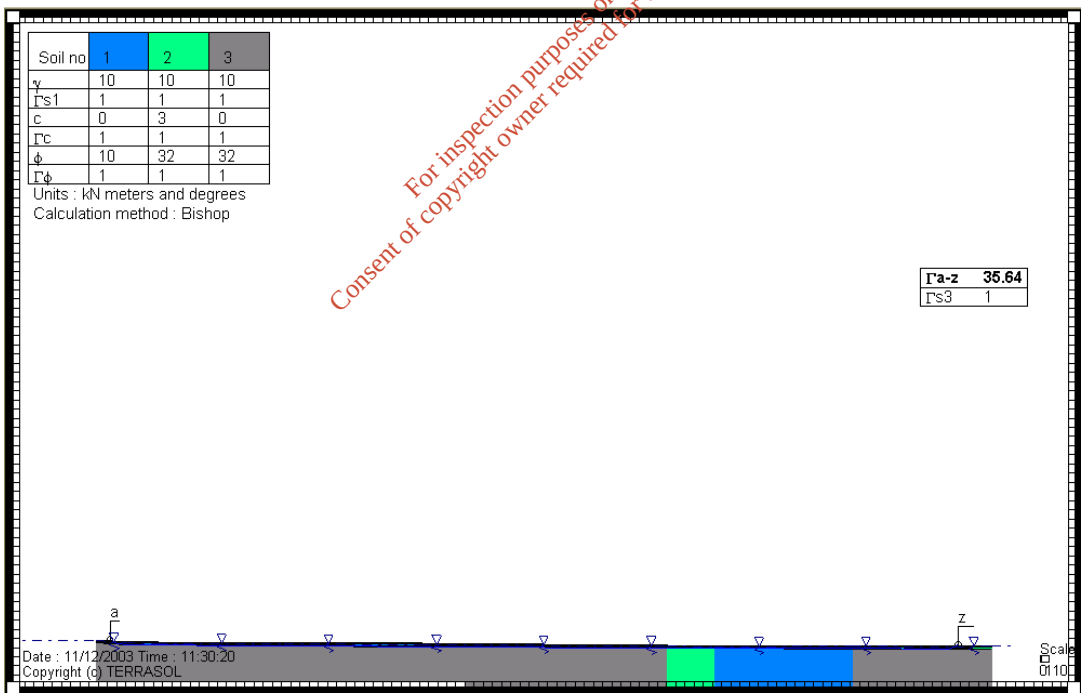
Figure 4 Factor of Safety for Global Stability - Case (1) Cont.

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(i) Example of global stability under lowfield to south of Section 1-1 following peat placement assuming translational slide for total stress (undrained) analysis

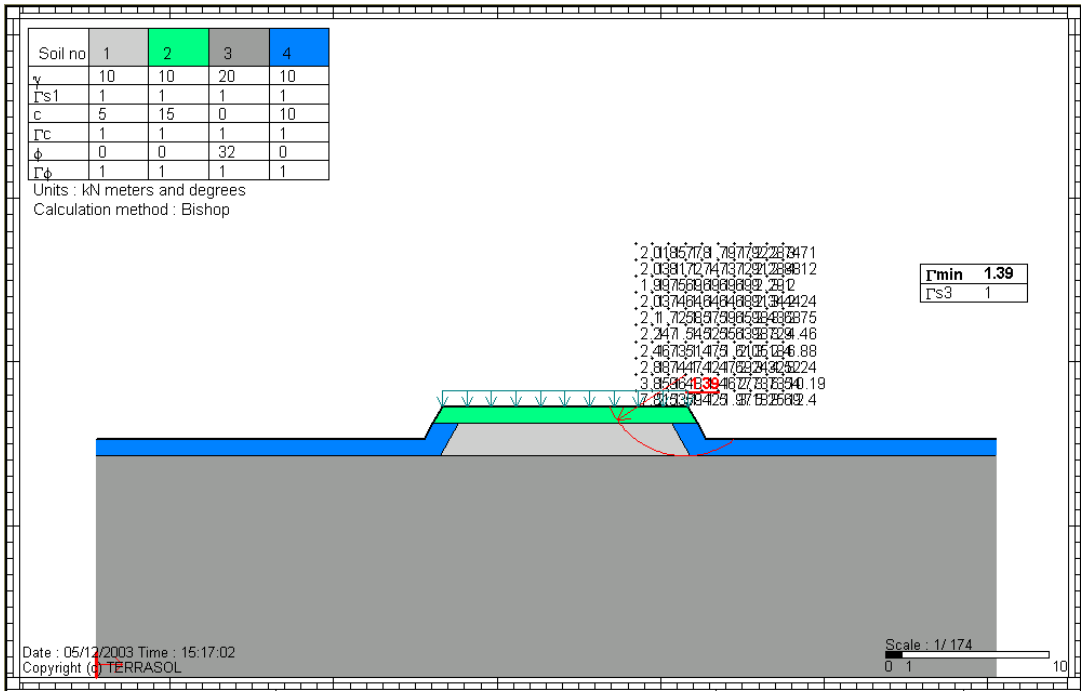
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(j) Example of global stability under lowfield to south of Section 1-1 following peat placement assuming translational slide for drained loading condition. Groundwater assumed at peat surface.

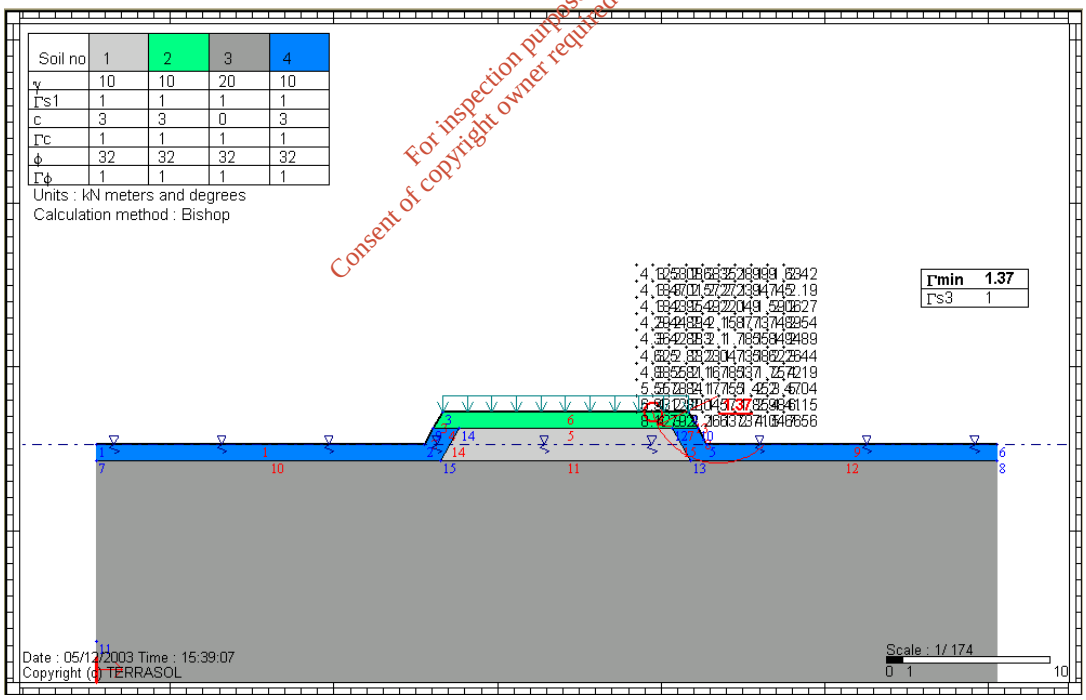
Figure 4 Factor of Safety for Global Stability - Case (1)

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(a) Showing locally stability of highfield for total stress (undrained) analysis

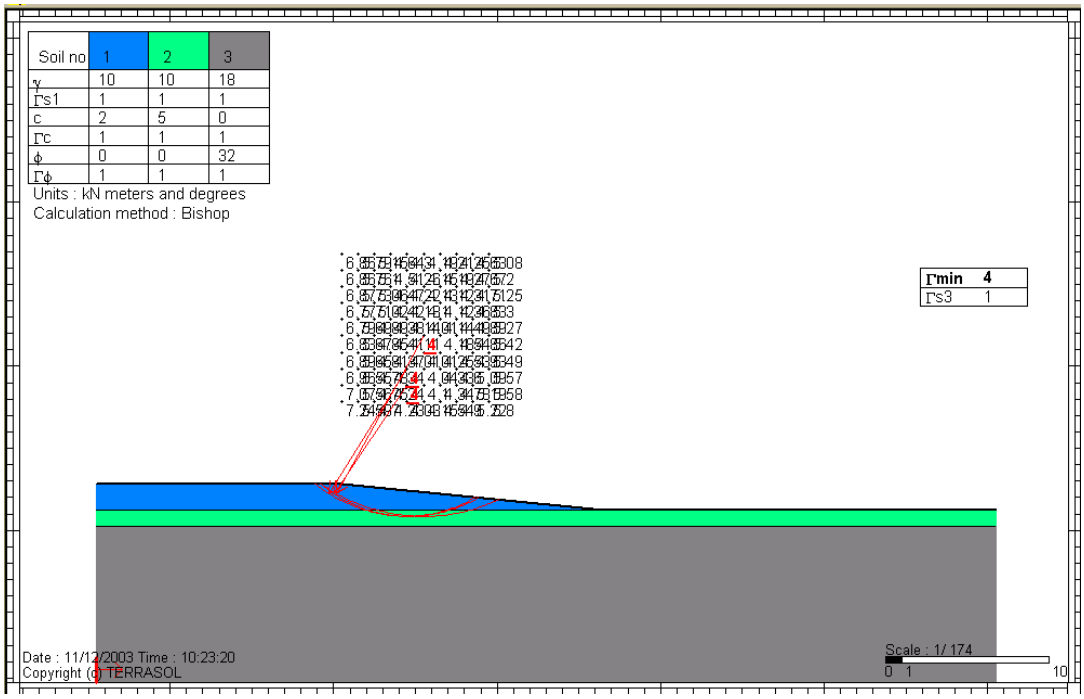
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(b) Showing locally stability of highfield for effective stress (drained) analysis

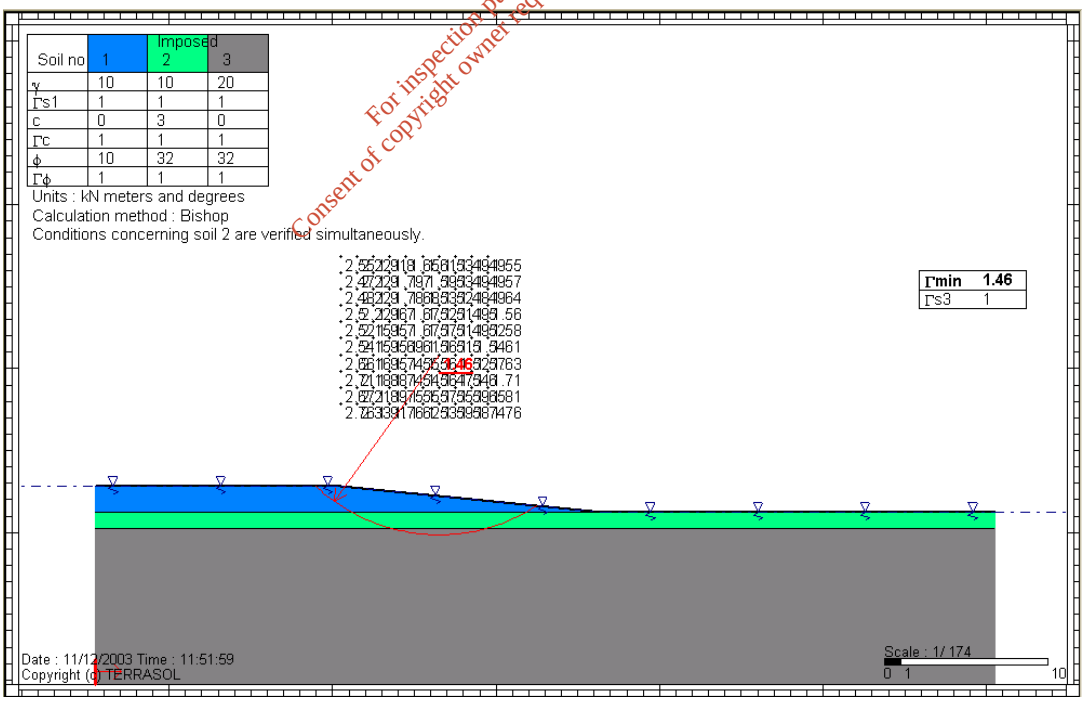
Figure 5 Factor of Safety for Localised Stability - Case (2) Cont.

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(c) Example of stability of placed peat at western end of lowfield assuming rotational slide for total stress (undrained) analysis.

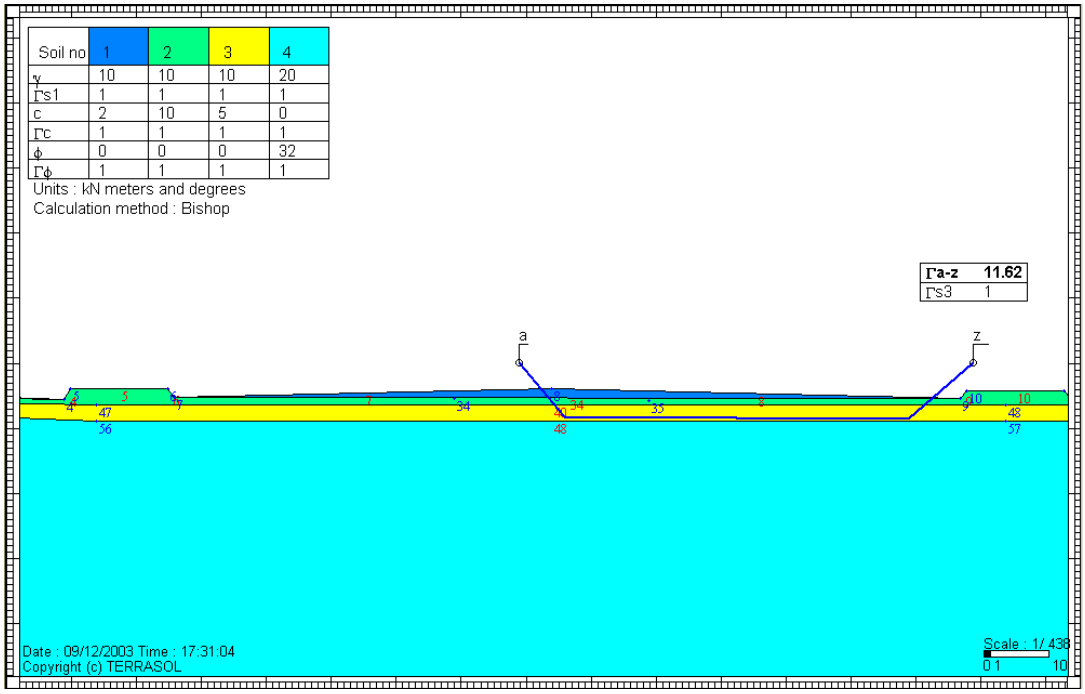
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(d) Example of stability of placed peat at western end of lowfield assuming rotational slide for drained loading condition. Groundwater assumed at peat surface.

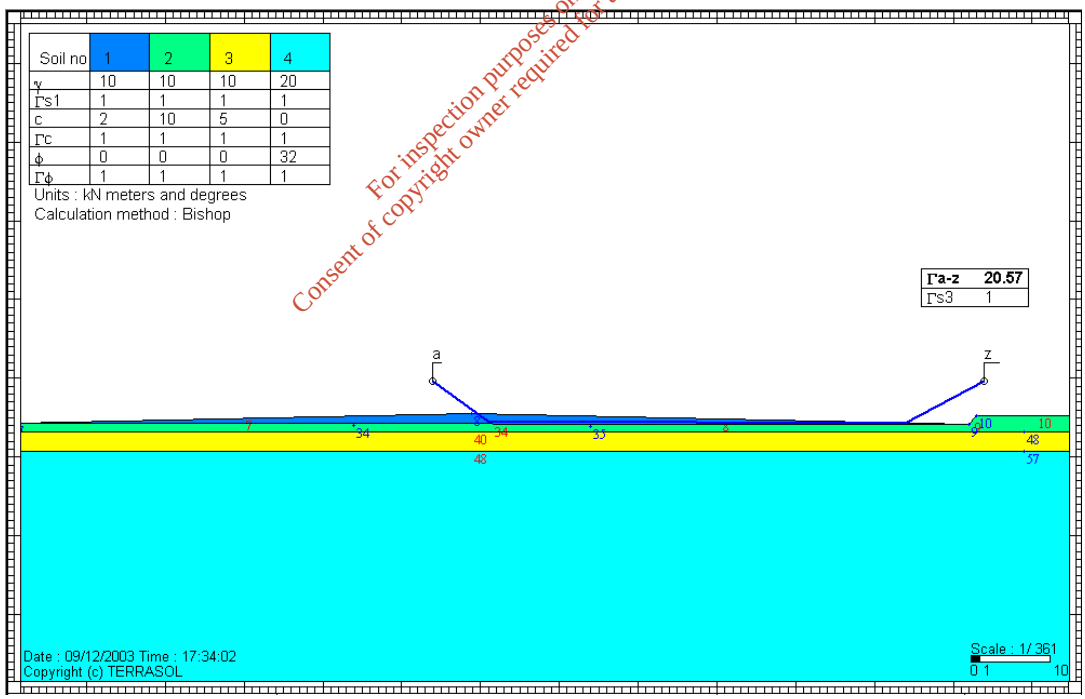
Figure 5 Factor of Safety for Localised Stability - Case (2) Cont.

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(e) Example of stability of underlying intact peat below placed peat between highfields assuming translational slide for total stress (undrained) analysis.

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(f) Example of stability within placed peat between highfields assuming translational slide for total stress (undrained) analysis.

Figure 5 Factor of Safety for Localised Stability - Case (2)

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DRAWINGS

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Legend:

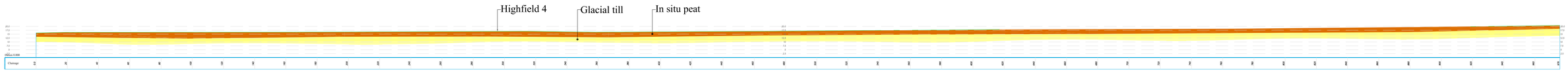
HF2 — Location of Highfield 2

CPXXX — Static Cone Penetration Location, depth to bottom of peat shown by line.

BHXXX — Location of borehole with descriptions

OH no recovery 5.8 — Open hole to 5.8 mbgl
PT 2.0 — Peat to 5.8 mbgl
SA 1.5 — Sand to 5.8 mbgl
GR 2.4 — Gravel to 5.8 mbgl

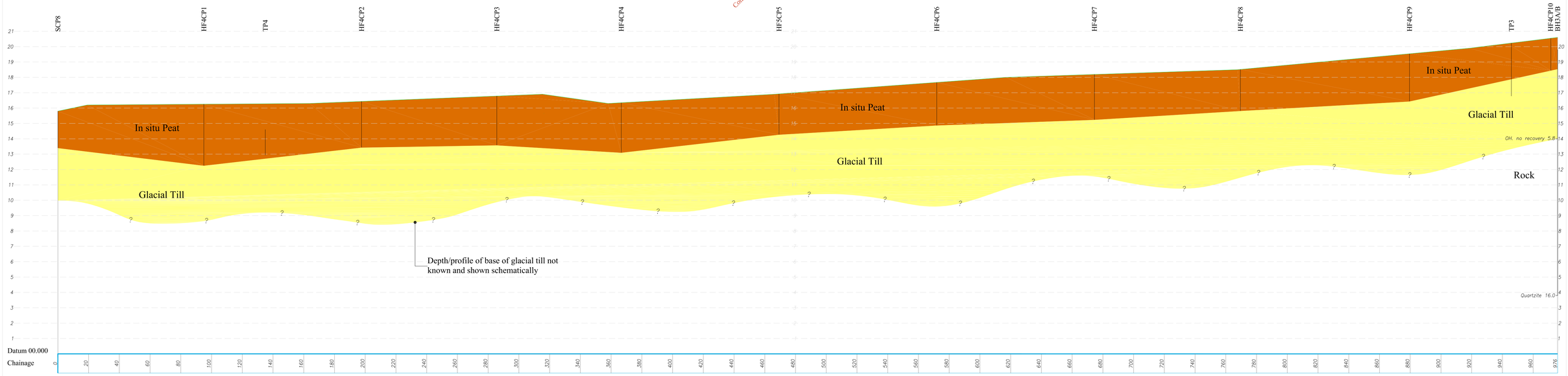
TPXXX — Location of trialpit, depth reached shown by line.



Section 1-1

Hor. Scale: 1:1250
Ver. Scale: 1:1250

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Section 1-1 with vertical scale exaggerated by 10

Hor. Scale: 1:1250
Ver. Scale: 1:125

Further notes:

Notes:

Scale: See Above	Checked: P.J.
Date: 10/12/03	Revision: A
Drawn: P.O.R.	Based on: 382_03,018

Client: Shell E&P Ireland Limited

Job: Preliminary Geotechnical Design for Srahmore Peat Deposition Site

Drg. No. - 382_001

Title: Preliminary Design Ground Profile for Areas 5 & 6 Section 1-1

AGEC Ltd
5 Kilcarrig Street
Bagenalstown
Carlow
Ireland

Tel: 353-503-23800
Fax: 353-503-23793

www.agec.ie
info@agec.ie

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Applied Ground Engineering Consultants Limited

Legend:

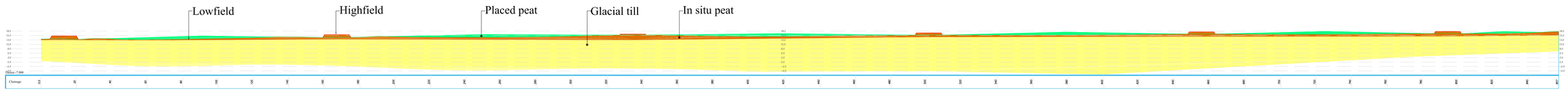
HF2 — Location of Highfield 2

CPXXX — Static Cone Penetration Location, depth to bottom of peat shown by line.

BHXXX — Location of borehole with descriptions

OH no recovery 5.8 — Open hole to 5.8 mbgl
PT 2.0 — Peat to 5.8 mbgl
SA 1.5 — Sand to 5.8 mbgl
GR 2.4 — Gravel to 5.8 mbgl

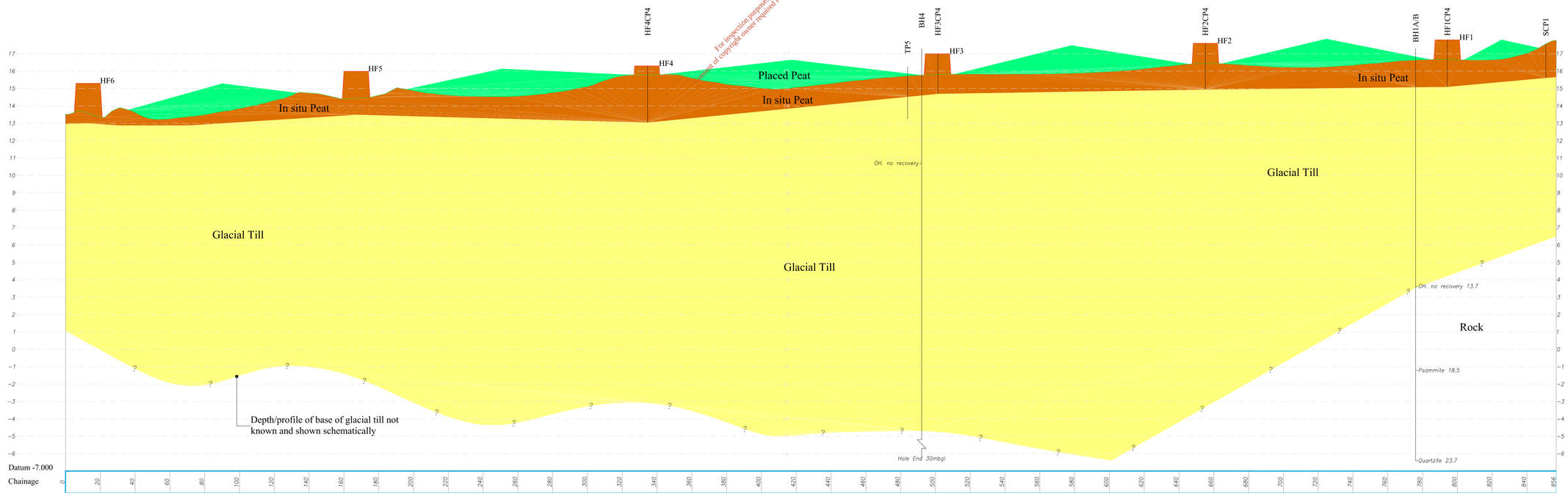
TPXXX — Location of trialpit, depth reached shown by line.



Section 2-2

Hor. Scale: 1:1250
Ver. Scale: 1:1250

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Section 2-2 with vertical scale exaggerated by 10

Hor. Scale: 1:1250
Ver. Scale: 1:125

Further notes:

Notes:

Scale: See Above | Checked: P.J.
Date: 10/12/03 | Revision: A
Drawn: P.O.R. | Based on: 382_03,018

Client: Shell E&P Ireland Limited

Job: Preliminary Geotechnical Design for Srahmore Peat Deposition Site

Drg. No. - 382_002

Title: Preliminary Design Ground Profile for Areas 5 & 6 Section 2-2

AGEC Ltd
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Tel: 353-503-23800
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www.agec.ie
info@agec.ie

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Legend:

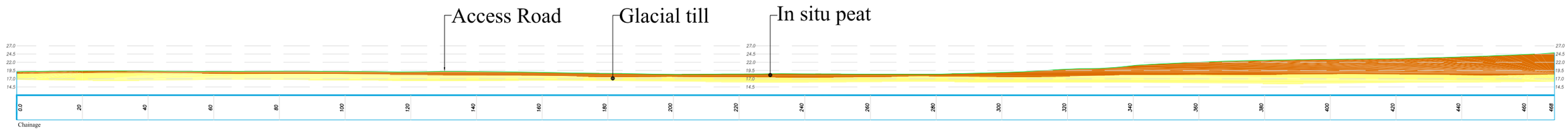
HF2 — Location of Highfield 2

CPXXX — Static Cone Penetration Location, depth to bottom of peat shown by line.

BHXXX — Location of borehole with descriptions

OH. no recovery 5.8 — Open hole to 5.8 mbgl
PT 2.0 — Peat to 5.8 mbgl
SA 1.5 — Sand to 5.8 mbgl
GR 2.4 — Gravel to 5.8 mbgl

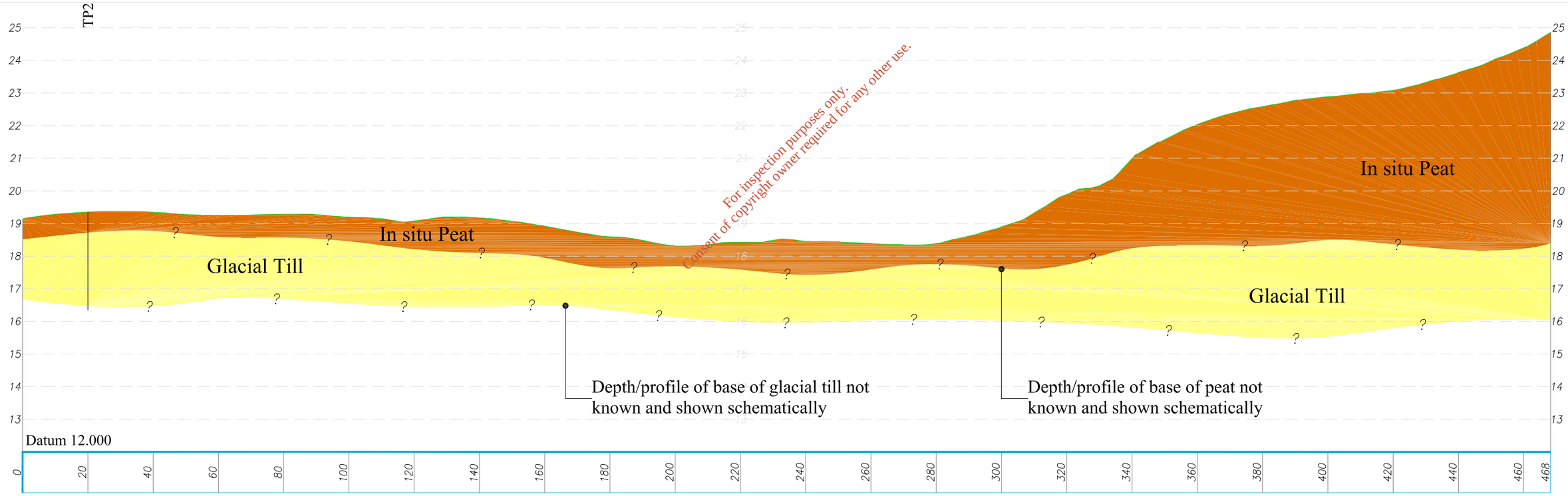
TPXXX — Location of trialpit, depth reached shown by line.



Section 3-3

Hor. Scale: 1:1250

Ver. Scale: 1:1250



Section 3-3 with vertical scale exaggerated by 10

Hor. Scale: 1:1250

Ver. Scale: 1:125

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Notes:	Client: Shell E&P Ireland Limited	Job: Preliminary Geotechnical Design for Srahmore Peat Deposition Site	Drg. No. - 382_003 Title: Preliminary Design Ground Profile for Areas 5 & 6 Section 3-3	AGEC Ltd 5 Kilcarrig Street Bagenalstown Carlow Ireland Tel: +353 503 23800 Fax: +353 503 23793 www.agec.ie info@agec.ie
Scale: See Above / Checked: P.J.				
Date: 10/12/03 / Revision: A				
Drawn: P.O.R. / Based on: 382_018				

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APPENDIX A PHASE 1 GROUND INVESTIGATION RESULTS

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BOREHOLE LOG

Borehole BH1A

Sheet No. 1 of 1

Client:	Site:	Job No.:	Scale:
Bord na Mona/Shell E&P	Srahmore, Bangor-Erris, Co. Mayo.	1169	1:50

Grid Reference			
Easting: E084463 Northing: N323049	Elevation (mOD): 17.56m Borehole Diameter (Subsoil): 65mm Borehole Diameter (Rock): 65mm Borehole Depth (m): 13.5m	Date Started: 22/10/03 Date Completed: 22/10/03	Drill Contractor: Irish Drilling Ltd. Drill Method: Coring Logged by: P.K.

Depth m	Description of Strata	Legend	OD Level m	Static Water Level 4/11/03	Samples Type	Samples Ref. No.	BH Tests Type & Ref.	Completion Details Lining:	Completion Details Backfill:
GL									
0.55	PEAT							50MM uPVC CASING	CEMENT BENTONITE
	Fine grained SAND, with clay/silt matrix, medium light grey to greenish grey.		15.09 ▼					50MM uPVC SCREEN	3-7mm Pea Gravel
12.5								END OF CASING	
	SAND with fragments of Schist and Quartzite. Light grey to light greenish grey.								
13.5	END OF BOREHOLE								
18									

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BOREHOLE LOG

Borehole BH1B

Sheet No. 2 of 2

Client:	Site:	Job No.:	Scale:
Bord na Mona/Shell E&P	Srahmore, Bangor–Erris, County Mayo.	1169	1:50

Grid Reference			
Easting: 084463	Elevation (mOD): 17.254	Date Started: 23/10/03	Drill Contractor: Irish Drilling Ltd.
Northing: 323049	Borehole Diameter (Subsoil): 65mm	Date Completed: 24/10/03	Drill Method: Coring
	Borehole Diameter (Rock): 65mm		Logged by: PK
	Borehole Depth (m): 23.7m		

Depth m	Description of Strata	Legend	OD Level m	Water Inflows	Samples Type	Samples Ref. No.	BH Tests Type & Ref.	Completion Details Lining:	Completion Details Backfill:
18m									
18.5	As above								
	Strong to very strong, faintly narrowly banded, (dipping 60 degrees), white to very pale grey, fine to medium grained, micaceous QUARTZITE, fresh to slightly weathered. Mica occurs as strong orientated flakes, producing previously described narrow banding. Discontinuities: Closely to medium spaced, generally banding parallel (but also steeply dipping in at least 2 other orientations), generally planar, slightly rough surfaced, tight and clean.						Packet Test Ref.: BH1B Test section: 15.5–23.7m bgl	50mm uPVC Screen	3–7mm Pea Gravel
23.7	END OF BOREHOLE								

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BOREHOLE LOG

Borehole BH2A

Sheet No. 1 of 1

Client:	Site:	Job No.:	Scale:
Bord na Mona/Shell E&P	Srahmore, Bangor–Erris, Co. Mayo.	1169	1:50

Grid Reference Easting: E083092 Northing: N323519	Elevation (mOD): 17.20m Borehole Diameter (Subsoil): 65mm Borehole Diameter (Rock): 65mm Borehole Depth (m): 6.1m	Date Started: 28/10/03 Date Completed: 28/10/03	Drill Contractor: Irish Drilling Ltd. Drill Method: Coring Logged by: P.K.

Depth m	Description of Strata	Legend	OD Level m	Static Water Level 4/11/03	Samples Type	Samples Ref. No.	BH Tests Type & Ref.	Completion Details Lining:	Completion Details Backfill:
GL									
0.55	PEAT								CEMENT
	Fine grained SAND, with clay/silt matrix, medium light grey to greenish grey.		14.10	▼				50MM uPVC CASING	BENTONITE
12.3								50MM uPVC SCREEN	3–7mm Pea Gravel
14.0	SAND with fragments of eroded Quartzite, Sandstone and Schist. grey.								
18	END OF BOREHOLE								

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BOREHOLE LOG

Borehole BH2B

Sheet No. 1 of 2

Client:	Site:	Job No.:	Scale:
Bord na Mona/Shell E&P	Srahmore, Bangor-Erris, County Mayo.	1169	1:50

Grid Reference			
Easting: 083092 Northing: 323519	Elevation (mOD): 17.17m Borehole Diameter (Subsoil): 65mm Borehole Diameter (Rock): 65mm Borehole Depth (m): 23.5m	Date Started: 27/10/03 Date Completed: 27/10/03	Drill Contractor: Irish Drilling Ltd. Drill Method: Coring Logged by: PK

Depth m	Description of Strata	Legend	OD Level m	Static Water Level 4/11/03	Samples Type	Samples Ref. No.	BH Tests Type & Ref.	Completion Details Lining:	Completion Details Backfill:
GL									
0.55	PEAT								
	Fine grained SAND with clay/silt matrix. Medium light grey to greenish grey.		14.09 ▼					50mm uPVC CASING	BENTONITE
12.0	SAND with fragments/cobbles of eroded Quartzite, Sandstone and Schist.								
14.3	Moderately weak to moderately strong thinly bedded/schistose (dipping 30–45 degrees), greenish grey (changing to brown below 21.4m), fine to medium grained micaceous PSAMMITE, moderately weathered. Occasional very thin (<20mm) highly weathered zones. Discontinuities: Very closely spaced, schistosity parallel, generally planar smooth to slightly rough , thick to moderately open, strongly discoloured and clay/rock material filled.								
18	moderately open.								

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BOREHOLE LOG

Borehole BH2B

Sheet No. 2 of 2

Client:	Site:	Job No.:	Scale:
Bord na Mona/Shell E&P	Srahmore, Bangor–Erris, County Mayo.	1169	1:50

Grid Reference			
Easting: 083092 Northing: 323519	Elevation (mOD): 17.17m Borehole Diameter (Subsoil): 65mm Borehole Diameter (Rock): 65mm Borehole Depth (m): 23.5	Date Started: 27/10/03 Date Completed: 27/10/03	Drill Contractor: Irish Drilling Ltd. Drill Method: Coring Logged by: PK

Depth m	Description of Strata	Legend	OD Level m	Water Inflows	Samples Type	Samples Ref. No.	BH Tests Type & Ref.	Completion Details Lining:	Completion Details Backfill:
18m	As above						Packet Test Ref.: BH2B Test section: 15.75–23.5m	50mm uPVC Screen	3–7mm Pea Gravel
23.5	END OF BOREHOLE								

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BOREHOLE LOG

Borehole BH3A

Sheet No. 1 of 1

Client:	Site:	Job No.:	Scale:
Bord na Mona/Shell E&P	Srahmore, Bangor–Erris, Co. Mayo.	1169	1:50

Grid Reference			
Easting: E084908 Northing: N323745	Elevation (mOD): 20.29m Borehole Diameter (Subsoil): 65mm Borehole Diameter (Rock): 65mm Borehole Depth (m): 12.5m	Date Started: 28/10/03 Date Completed: 28/10/03	Drill Contractor: Irish Drilling Ltd. Drill Method: Coring Logged by: P.K.

Depth m	Description of Strata	Legend	OD Level m	Static Water Level 4/11/03	Samples Type	Samples Ref. No.	BH Tests Type & Ref.	Completion Details Lining:	Completion Details Backfill:
GL									
	PEAT							50MM uPVC CASING	CEMENT
1.55			18.52	▼					BENT ONITE
	Fine grained SAND, with clay/silt matrix, medium light grey to greenish grey.							50MM uPVC SCREEN	3–7mm Pea Gravel
5.5	END OF BOREHOLE							END OF CASING	
18									

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BOREHOLE LOG

Borehole BH3B

Sheet No. 1 of 2

Client:	Site:	Job No.:	Scale:
Bord na Mona/Shell E&P	Srahmore, Bangor–Erris, County Mayo.	1169	1:50

Grid Reference	Elevation (mOD): 20.26m	Date Started: 29/10/03	Drill Contractor: Irish Drilling Ltd.
Easting: 084908	Borehole Diameter (Subsoil): 65mm	Date Completed: 29/10/03	Drill Method: Coring
Northing: 323745	Borehole Diameter (Rock): 65mm		Logged by: PK
	Borehole Depth (m): 16m		

Depth m	Description of Strata	Legend	OD Level m	Static Water Level 4/11/03	Samples Type	Samples Ref. No.	BH Tests Type & Ref.	Completion Details Lining:	Completion Details Backfill:
GL									
1.55	PEAT							50mm uPVC CASING	BENTONITE
6.0	Fine grained SAND with clay/silt matrix. Medium light grey to greenish grey.		18.02	▼					
16	Strong to very strong, massive but locally narrowly banded (dipping 35 degrees), grey to yellowish grey, fine grained micaceous QUARTZITE, fresh to slightly weathered. Mica locally occurring as close to very closely spaced bands/laminae dipping circa 35 degrees. Discontinuities: Between non–intact zones fractures are closely to very closely spaced, bedding parallel, (dipping about 35 degrees), generally sub–planar, smooth to slightly rough, generally clean.						Packet Test Ref.: BH3B Test section: 11.75–16.0m	50mm uPVC SCREEN	3–7mm Pea Gravel
	END OF BOREHOLE								

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BOREHOLE LOG

Borehole BH3B

Sheet No. 2 of 2

Client:	Site:	Job No.:	Scale:
Bord na Mona/Shell E&P	Srahmore, Bangor–Erris, County Mayo.	1169	1:50

Grid Reference Easting: 084908 Northing: 323745	Elevation (mOD): 20.26m Borehole Diameter (Subsoil): 65mm Borehole Diameter (Rock): 65mm Borehole Depth (m): 23.5	Date Started: 27/10/03 Date Completed: 27/10/03	Drill Contractor: Glovers SI Ltd. Drill Method: Air Rotary Logged by: KM (TES)

Depth m	Description of Strata	Legend	OD Level m	Water Inflows	Samples Type	Samples Ref. No.	BH Tests Type & Ref.	Completion Details Lining:	Completion Details Backfill:
18m	As above						Packet Test Ref.: BH2B Test section: 15.75–23.5m	50mm uPVC Screen	3–7mm Pea Gravel
23.5									

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BOREHOLE LOG

Borehole BH4

Sheet No. 1 of 2

Client:	Site:	Job No.:	Scale:
Bord na Mona/Shell E&P	Srahmore, Bangor–Erris, County Mayo.	1169	1:50

Grid Reference			
Easting: 084489	Elevation (mOD): 17.22	Date Started: 01/11/03	Drill Contractor: Irish Drilling Ltd.
Northing: 323373	Borehole Diameter (Subsoil): 65mm	Date Completed: 01/11/03	Drill Method: Coring
	Borehole Diameter (Rock): 65mm		Logged by: PK
	Borehole Depth (m): 30m		

Depth m	Description of Strata	Legend	OD Level m	Static Water Level 4/11/03	Samples Type	Samples Ref. No.	BH Tests Type & Ref.	Completion Details Lining:	Completion Details Backfill:
GL									
	PEAT		14.81 ▼					50mm uPVC CASING	BENTONITE
3.1	Fine grained SAND with clay/silt matrix. Medium light grey to greenish grey.							50mm uPVC SCREEN	3–7mm Pea Gravel
18									

Remarks:

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BOREHOLE LOG

Borehole BH4

Client:	Site:	Job No.:	Scale:
Bord na Mona/Shell E&P	Srahmore, Bangor-Erris, County Mayo.	1169	1:50

Grid Reference			
Easting: 084489 Northing: 323373	Elevation (mOD): 17.22m Borehole Diameter (Subsoil): 65mm Borehole Diameter (Rock): 65mm Borehole Depth (m): 30m	Date Started: 01/11/03 Date Completed: 01/11/03	Drill Contractor: Glovers SI Ltd. Drill Method: Air Rotary Logged by: PK

Depth m	Description of Strata	Legend	OD Level m	Water Inflows	Samples Type	Samples Ref. No.	BH Tests Type & Ref.	Completion Details Lining:	Completion Details Backfill:
18m	As above							50mm uPVC Screen	3-7mm Pea Gravel
30	END OF BOREHOLE								

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TRIAL PIT LOG

Trial Pit No. 1

Sheet No. 1 of 1

Excavator Type:	Date:	Client:
HITACHI	23/10/03	Bord na Mona/Shell E&P
Grid Reference:	**Elevation (mOD):**	**Site:**
E084643, N324121		Srahmore, Bangor–Erris, Co. Mayo.

Depth m	Description of Strata	Legend	OD Level m	Samples Type	Samples Ref. No.	Water Inflows	Pit Completion Lining:	Pit Completion Backfill:
0.0								
	PEAT Soft, medium light brown to medium brown, occasional fragments of bog wood, slightly moist.			Vane Test	TP1			
2.4	Yellowish brown to light yellowish brown gravelly, clayey SAND, with some angular subangular cobbles of schist at base.			Disturbed Sample	TP1			
3.0	END OF TRIAL PIT							

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Logged by:	Job No.:	Remarks:
P.K.	1169	1. Shear vane test undertaken on peat, disturbed soil sample obtained for Particle Size Distribution testing.
Scale:	Rev.:	2. No significant groundwater inflow recorded during excavation.
1:25		3. Excavation terminated at 3m due to obtstruction/compaction of subsoil.

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TRIAL PIT LOG

Trial Pit No. 2

Sheet No. 1 of 1

Excavator Type:	Date:	Client:
	23/10/03	Bord na Mona/Shell E&P
Grid Reference:	**Elevation (mOD):**	**Site:**
E084646, N323870		Srahmore, Bangor–Erris, Co. Mayo.

Depth m	Description of Strata	Legend	OD Level m	Samples Type	Samples Ref. No.	Water Inflows	Pit Completion Lining:	Pit Completion Backfill:
0.0								
	PEAT Soft, medium dark brown to dark brown, occasional fragments of bog wood.							
				Vane Test	TP2			
0.65								
	Medium light grey to light greenish grey, gravelly, clayey slightly micaceous SAND. The Gravels are platey, angular to subangular Quartzites.							
				Disturbed Sample	TP2			
3.0								
	END OF TRIAL PIT							

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Logged by:	Job No.:	Remarks:
P.K.	1169	1. Shear vane test undertaken on peat, disturbed soil sample obtained for Particle Size Distribution testing.
Scale:	Rev.:	2. No significant groundwater inflow recorded during excavation.
1:25		

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TRIAL PIT LOG

Trial Pit No. 3

Sheet No. 1 of 1

Excavator Type:	Date:	Client:
	23/10/03	Bord na Mona/Shell E&P
Grid Reference:	**Elevation (mOD):**	**Site:**
E084890, N323700		Srahmore, Bangor–Erris, Co. Mayo.

Depth m	Description of Strata	Legend	OD Level m	Samples Type	Samples Ref. No.	Water Inflows	Pit Completion Lining:	Pit Completion Backfill:
0.0								
	PEAT Soft, medium brown to light brown, fragments of bog wood and rootlets, slightly moist.			Vane Test	TP3			
1.8	Greenish grey to light greenish grey to light grey SAND, with some angular to subangular gravels and cobbles of schist.			Disturbed Sample	TP3			
3.45	END OF TRIAL PIT							

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Logged by:	Job No.:	Remarks:
P.K.	1169	1. Shear vane test undertaken on peat, disturbed soil sample obtained for Particle Size Distribution testing.
Scale:	Rev.:	2. Slight to moderate groundwater inflow recorded at 2.5m during excavation.
1:25		3. Excavation terminated due to obstruction/compaction of subsoil at 3.45m.

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TRIAL PIT LOG

Trial Pit No. 4

Sheet No. 1 of 1

Excavator Type:	Date: 23/10/03	Client: Bord na Mona/Shell E&P
Grid Reference: E084164, N323332	Elevation (mOD):	Site: Srahmore, Bangor–Erris, Co. Mayo.

Depth m	Description of Strata	Legend	OD Level m	Samples Type	Samples Ref. No.	Water Inflows	Pit Completion Lining:	Pit Completion Backfill:
0.0								
	PEAT Soft to very soft, medium brown to medium dark brown, with fragments of bog wood and roolets, moist.			Vane Test	TP4			
1.1								
	Medium greenish grey to grey, clayey, fine grained SAND with occasional subrounded to rounded gravel and cobbles.			Disturbed Sample	TP4			
1.4								
1.65	Medium grey to light brownish grey GRAVEL with some sub–rounded to subangular cobbles.							
	END OF TRIAL PIT							

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Logged by: P.K.	Job No.: 1169	Remarks: 1. Shear vane test undertaken on peat, disturbed soil sample obtained for Particle Size Distribution testing. 2. Excavations terminated at 1.65m bgl due to unstable ground and pit wall collpase caused by water inflow.
Scale: 1:25	Rev.:	

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TRIAL PIT LOG
Trial Pit No. 5
Sheet No. 1 of 1

Excavator Type:	Date: 23/10/03	Client: Bord na Mona/Shell E&P
Grid Reference: E084474, N323382	Elevation (mOD):	Site: Srahmore, Bangor–Erris, Co. Mayo.

Depth m	Description of Strata	Legend	OD Level m	Samples Type	Samples Ref. No.	Water Inflows	Pit Completion Lining:	Pit Completion Backfill:
0.0								
	PEAT Soft, medium dark brown fragments of bog wood and rootlets, moist.			Vane Test	TP5			
0.9								
	Yellowish brown to greyish brown, gravelly, cobbley SILT/ SAND. The gravels are subangular to subrounded.			Disturbed Sample	TP5			
3.0	END OF TRIAL PIT							

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Logged by: P.K.	Job No.: 1169	Remarks: 1. Shear vane test undertaken on peat, disturbed soil sample obtained for Particle Size Distribution testing. 2. Slight to moderate groundwater inflow at 2.5m bgl.
Scale: 1:25	Rev.:	

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TRIAL PIT LOG

Trial Pit No. 6

Sheet No. 1 of 1

Excavator Type:	Date: 23/10/03	Client: Bord na Mona/Shell E&P
Grid Reference: E084852, N323176	Elevation (mOD):	Site: Srahmore, Bangor–Erris, Co. Mayo.

Depth m	Description of Strata	Legend	OD Level m	Samples Type	Samples Ref. No.	Water Inflows	Pit Completion Lining:	Pit Completion Backfill:
0.0								
	PEAT Soft, dark brown to brownish black, fragments of bog wood, moist.			Vane Test	TP6			
0.95	Light yellowish brown clayey, fine grained SAND with occasional gravels that are subrounded to rounded							
1.9	Medium brown to dark brown subangular to subrounded GRAVELS, with some Cobbles.			Disturbed Sample	TP6			
2.5	END OF TRIAL PIT							

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Logged by: P.K.	Job No.: 1169	Remarks: 1. Shear vane test undertaken on peat, disturbed soil sample obtained for Particle Size Distribution testing. 2. No significant groundwater inflows noted during excavation.
Scale: 1:25	Rev.:	

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TRIAL PIT LOG

Trial Pit No. 7

Sheet No. 1 of 1

Excavator Type:	Date: 23/10/03	Client: Bord na Mona/Shell E&P
Grid Reference: E084001, N323713	Elevation (mOD):	Site: Srahmore, Bangor–Erris, Co. Mayo.

Depth m	Description of Strata	Legend	OD Level m	Samples Type	Samples Ref. No.	Water Inflows	Pit Completion Lining:	Pit Completion Backfill:
0.0								
	PEAT Soft, dark brown to brownish black, fragments of bog wood, moist. Occurance of more recent plant material and heather.			Vane Test	TP7			
0.85	Light yellowish brown to light yellowish grey clayey SAND with occasional gravels that are subrounded to rounded. Gravel content increases with depth and becomes angular at base.			Disturbed Sample	TP7			
2.5	END OF TRIAL PIT							

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Logged by:	Job No.:	Remarks:
P.K.	1169	1. Shear vane test undertaken on peat, disturbed soil sample obtained for Particle Size Distribution testing. 2. No significant groundwater inflows noted during excavation.
Scale: 1:25	Rev.:	

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TRIAL PIT LOG

Trial Pit No. 8

Sheet No. 1 of 1

Excavator Type:	Date:	Client:
	23/10/03	Bord na Mona/Shell E&P

Grid Reference:	Elevation (mOD):	Site:
E084402, N323988		Srahmore, Bangor–Erris, Co. Mayo.

Depth m	Description of Strata	Legend	OD Level m	Samples Type	Samples Ref. No.	Water Inflows	Pit Completion Lining:	Pit Completion Backfill:
0.0								
0.2	Medium dark, soft PEAT							
	Medium light grey to greenish grey, gravelly, cobbley SILT/ SAND. The gravels are subangular to subrounded and occasionally well rounded Quartzites, with occasional Red Sandstones and Slate.							
2.6	END OF TRIAL PIT							

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Logged by:	Job No.:	Remarks:
P.K.	1169	
Scale: 1:25	Rev.:	

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TRIAL PIT LOG

Trial Pit No. 9

Sheet No. 1 of 1

Excavator Type:	Date: 23/10/03	Client: Bord na Mona/Shell E&P
Grid Reference: E084402, N323988	Elevation (mOD):	Site: Srahmore, Bangor–Erris, Co. Mayo.

Depth m	Description of Strata	Legend	OD Level m	Samples Type	Samples Ref. No.	Water Inflows	Pit Completion Lining:	Pit Completion Backfill:
0.0								
	Medium dark, soft PEAT							
0.4								
	Medium light grey to greenish grey, gravelly, cobbley SILT/ SAND. The gravels are subangular subrounded and occasionally well rounded Quartites, with occasional Red Sandstone and Slate.							
2.5	END OF TRIAL PIT							

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Logged by: P.K.	Job No.: 1169	Remarks:
Scale: 1:25	Rev.:	

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TRIAL PIT LOG

Trial Pit No. 10

Sheet No. 1 of 1

Excavator Type:	Date:	Client:
	18/11/03	Bord na Mona/Shell E&P

Grid Reference:	Elevation (mOD):	Site:
E083780, N323797		Srahmore, Bangor–Erris, Co. Mayo.

Depth m	Description of Strata	Legend	OD Level m	Samples Type	Samples Ref. No.	Water Inflows	Pit Completion Lining:	Pit Completion Backfill:
0.0								
0.1	Dark brown, peaty GRAVEL, with many cobbles and boulders. Gravels subangular to subrounded Quartzite, Schist, Slate and Red Sandstone							
0.7	Medium brown, clayey, gravelly, fine grained SAND. Gravels are subangular to subrounded							
1.45	Medium grey to greenish grey to light brownish grey, clayey, gravelly, fine to medium grained SAND, with occasional subangular to subrounded cobbles.			Bulk Sample	TP10			
3.2	Medium light grey, sandy, slightly clayey, subangular GRAVEL, with occasional angular, subangular and subrounded cobbles and boulders of Quartzite, Schist and Red Sandstone.							
	END OF TRIAL PIT							

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Logged by:	Job No.:	Remarks:
P.K.	1169	1. Surface water running into pit excavation because of heavy rain
Scale: 1:25	Rev.:	

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TRIAL PIT LOG

Trial Pit No. 11

Sheet No. 1 of 1

Excavator Type:	Date:	Client:
	18/11/03	Bord na Mona/Shell E&P
Grid Reference:	**Elevation (mOD):**	**Site:**
E083837, N323823		Srahmore, Bangor–Erris, Co. Mayo.

Depth m	Description of Strata	Legend	OD Level m	Samples Type	Samples Ref. No.	Water Inflows	Pit Completion Lining:	Pit Completion Backfill:
0.0								
0.2	Medium brown, sandy, slightly clayey, peaty GRAVEL, with some cobbles. Gravel is subangular to angular Quartzite, with occasional Schist and Sandstone							
	Light brown to yellowish grey, slightly clayey, gravelly, fine SAND. Subangular gravels of Quartzite and occasional angular boulders of banded Gneiss			Bulk Sample	TP11			
3.0	END OF TRIAL PIT							

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Logged by:	Job No.:	Remarks:
P.K.	1169	1. No water inflows to pit, dry.
Scale: 1:25	Rev.:	

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TRIAL PIT LOG

Trial Pit No. 12

Sheet No. 1 of 1

Excavator Type:	Date:	Client:
	18/11/03	Bord na Mona/Shell E&P
Grid Reference:	**Elevation (mOD):**	**Site:**
E083925, N323806		Srahmore, Bangor–Erris, Co. Mayo.

Depth m	Description of Strata	Legend	OD Level m	Samples Type	Samples Ref. No.	Water Inflows	Pit Completion Lining:	Pit Completion Backfill:
0.0								
	Medium brown, slightly clayey fine grained SAND, with thin layers of peat on top							
0.3								
	Medium light grey, gravelly, slightly clayey, slightly micaceous SAND with some subangular cobbles and occasional subangular boulders. Gravels are subangular to subrounded Quartzite.							
				Bulk Sample	TP12A			
	Medium grey to medium light grey gravelly, fine grained SAND with some cobbles and some blocky boulders of Gneiss. Gravels are subrounded and occasionally well rounded							
				Bulk Sample	TP12B			
3.0	END OF TRIAL PIT							

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Logged by:	Job No.:	Remarks:
P.K.	1169	1. Increae in moisture content at 3m bgl.
Scale: 1:25	Rev.:	

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TRIAL PIT LOG

Trial Pit No. 13

Sheet No. 1 of 1

Excavator Type:	Date:	Client:
	18/11/03	Bord na Mona/Shell E&P
Grid Reference:	**Elevation (mOD):**	**Site:**
E084417, N324002		Srahmore, Bangor–Erris, Co. Mayo.

Depth m	Description of Strata	Legend	OD Level m	Samples Type	Samples Ref. No.	Water Inflows	Pit Completion Lining:	Pit Completion Backfill:
0.0								
0.25	Medium dark brown to brownish black, soft PEAT, with angular and subrounded gravels and boulders of Quartzite and Schist							
0.75	Medium dark brown to medium brown, Firm CLAY							
	Light grey to medium light grey and light greyish brown, gravelly, silty, fine grained SAND with occasional subangular to subrounded blocky boulders of Gneiss. Gravels are subangular to subrounded, occasionally well rounded, composed of Quartzite Schist, Red Sandstone and Slate.			Bulk Sample	TP13A			
				Bulk Sample	TP13B			
3.2	END OF TRIAL PIT							

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Logged by:	Job No.:	Remarks:
P.K.	1169	
Scale: 1:25	Rev.:	

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TRIAL PIT LOG

Trial Pit No. 14

Sheet No. 1 of 1

Excavator Type:	Date: 18/11/03	Client: Bord na Mona/Shell E&P
Grid Reference: E084647, N324207	Elevation (mOD):	Site: Srahmore, Bangor–Erris, Co. Mayo.

Depth m	Description of Strata	Legend	OD Level m	Samples Type	Samples Ref. No.	Water Inflows	Pit Completion Lining:	Pit Completion Backfill:
0.0								
	Medium brown, gravelly, slightly clayey, fine grained SAND, with some angular cobbles and boulders of Quartzite. Gravels are subangular to angular.							
0.75								
	Light grey to light yellowish grey, gravelly, cobbley, slightly clayey SAND with some angular boulders of Gneiss. Gravels are subangular to subrounded Quartzite and Red Sandstone.							
2.0				Bulk Sample	TP14A			
	Medium grey, gravelly, slightly clayey, slightly micaceouas SAND with some subangular to subrounded cobbles of Quartzite. Gravels are subangular to subrounded Quartzite.							
3.5				Bulk Sample	TP14B			
	END OF TRIAL PIT							

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Logged by: P.K.	Job No.: 1169	Remarks: 1. Increase in moisture content at 1.5m bgl.
Scale: 1:25	Rev.:	

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TEST RESULTS

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IRISH DRILLING LTD. Loughrea Co. Galway Tel: (091) 841274 Fax: (091) 847687	Contract: Peat Deposit Site at Bangor Erris		
	Date: Eng.:	23.10.'03 DJ	

In-situ Shear Vane

Trial Pit	Depth m	Co-ordinates	Undrained Shear strength Uncorrected kN/m^2	Undrained Shear strength *Corrected (based on plasticity) kN/m^2
1	1.5	84643, 24121	12	6
2	0.5	84646, 23870	12	6
3	1.0	84890, 23700	23	12
4	0.9	84164, 23332	10	5
5	0.7	84474, 23382	10	5
6	0.6	84852, 23173	19	9.5
7	0.8	84001, 23713	14	7

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* Correction factor based on Bjerrum's (1972,1973) correction factor for field vane strength as a function of Plasticity Index

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IRISH DRILLING LTD.
Loughrea Co. Galway.

Tel: (091)841274 Fax: (091) 847687

Contract: Peat deposit site at Bangor Erris
Client: Enterprise Oil
Engineer: TES

Date: 20/11/2003
Tested By: DD Checked: DJ

Summary of Soil Classification Tests

BS1377: Part 2: 1990

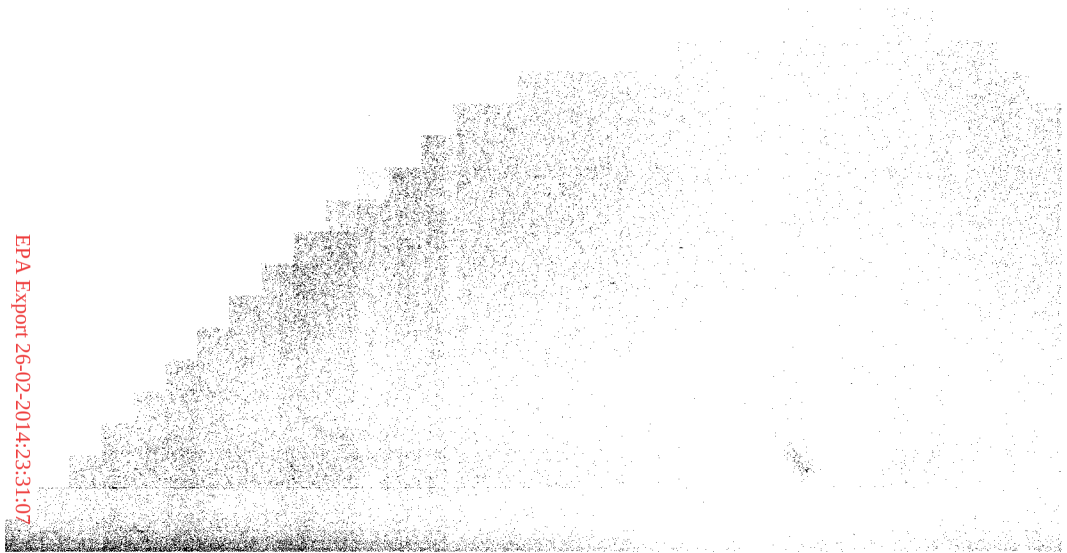
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Borehole/ Trialpit	Type	Depth m	Bulk Density Mg/m3	Moisture Content %	Particle Density Mg/m3	Liquid Limit %	Plastic Limit %	Plasticity Index %	% passing 425 micron %		Description of fraction passing 425 micron sieve.
TP 1		1.0		840							
		2.0		877.8							
		3.0		20.8			Non plastic		93		
TP 2		0.5		448.1							
		1.5		14			Non plastic		94		
		2.5		14.3							
TP 3		1.0		343.6							
		2.5		23.8			Non plastic		95		
		3.5		23.7							

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Borehole/ Trialpit	Type	Depth m	Bulk Density Mg/m3	Moisture Content %	Particle Density Mg/m3	Liquid Limit %	Plastic Limit %	Plasticity Index %	% passing 425 micron %		Description of fraction passing 425 micron sieve.
TP 4		0.5		205							
		1.0		12.5			Non plastic		32		
		1.5		16.1							
TP 5		0.5		984.1							
		1.5		39.2			Non plastic		40		
		2.5		10							
TP 6		0.0		1005.9							
		1.5		14.7			Non plastic		20		
		2.5		19							
TP 7		0.5		286.1							
		1.5		19							
		2.5		23.2			Non plastic		75		

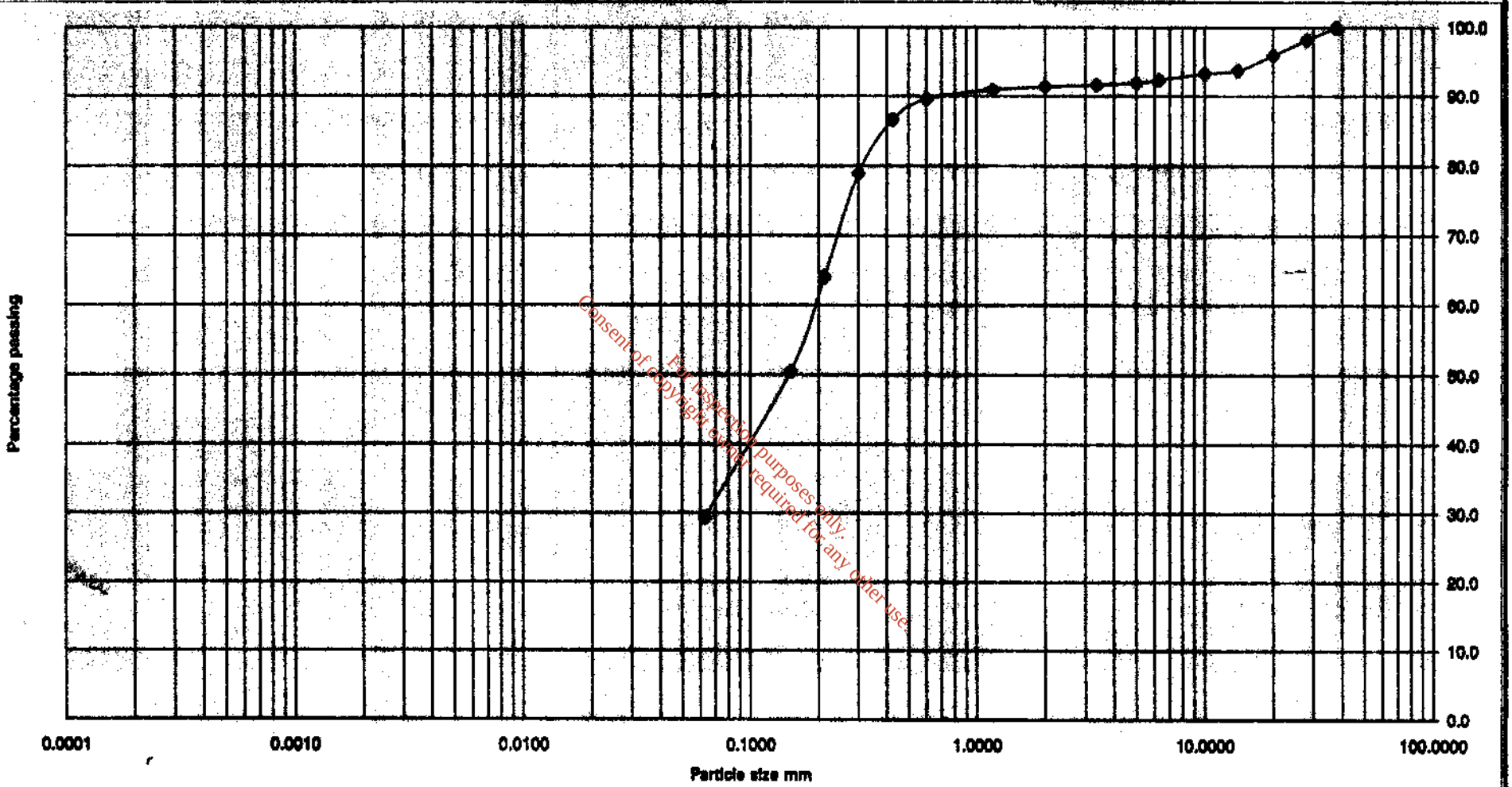
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PROJECT:	Bangor Erris	Project No:	1169	**PARTICLE SIZE DISTRIBUTION**
CLIENT:	Irish Drilling	Reference:	0415	

Borehole No. TP1 Sample No. Depth 3.00 m



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CLAY										COBBLES
	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	
	SILT			SAND			GRAVEL			

Visual Description: Pale grey silty SAND with little gravel

K4 SOILS LABORATORY

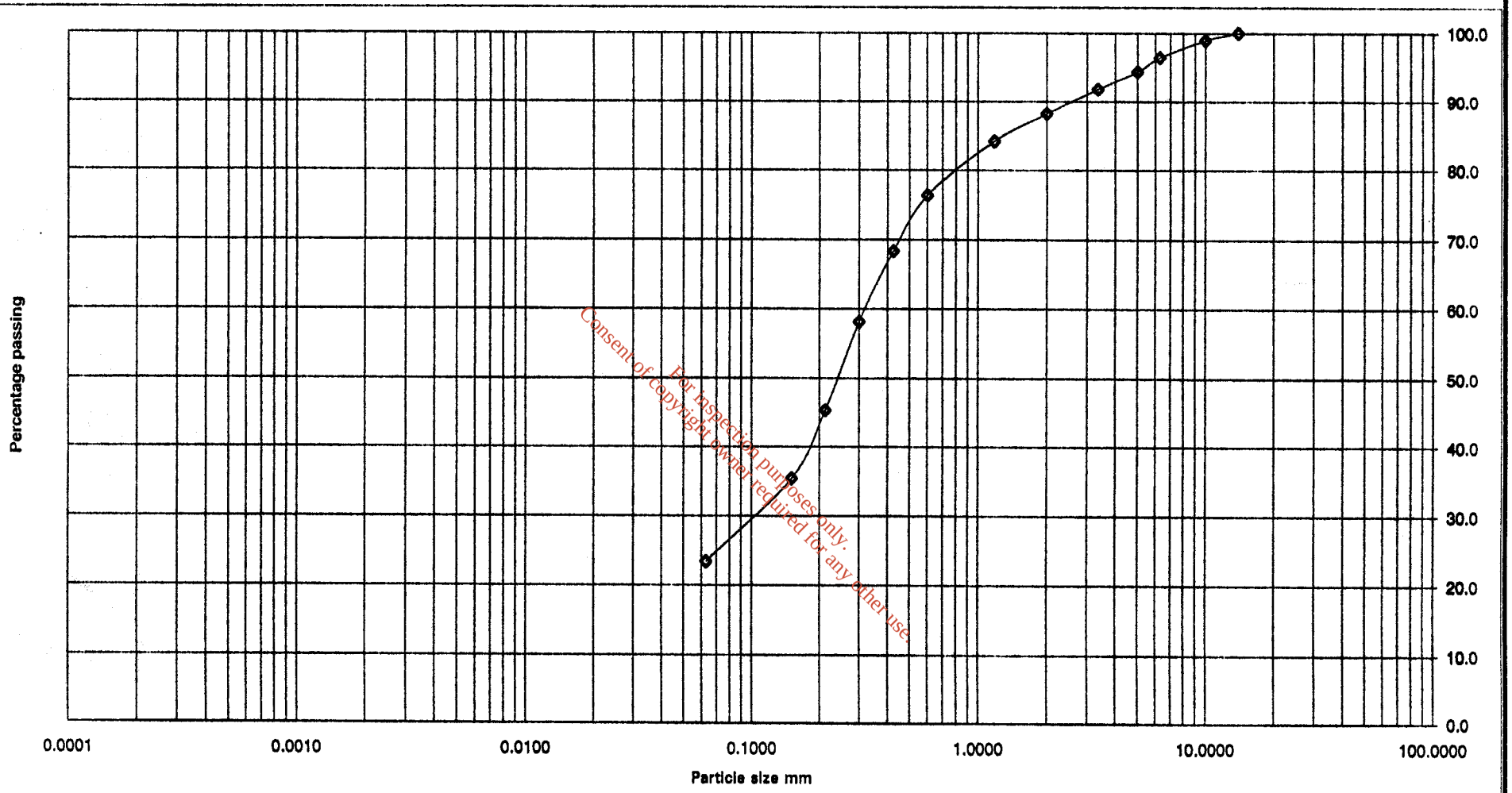
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PROJECT: Bangor Erris
CLIENT: Irish Drilling

Project No: 1169
Reference: 0415

PARTICLE SIZE DISTRIBUTION

Borehole No. TP2 Sample No. Depth 2.50 m



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For inspection purposes only.

CLAY	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	COBBLES
	SILT			SAND			GRAVEL			

Visual Description: Grey silty SAND with a little gravel

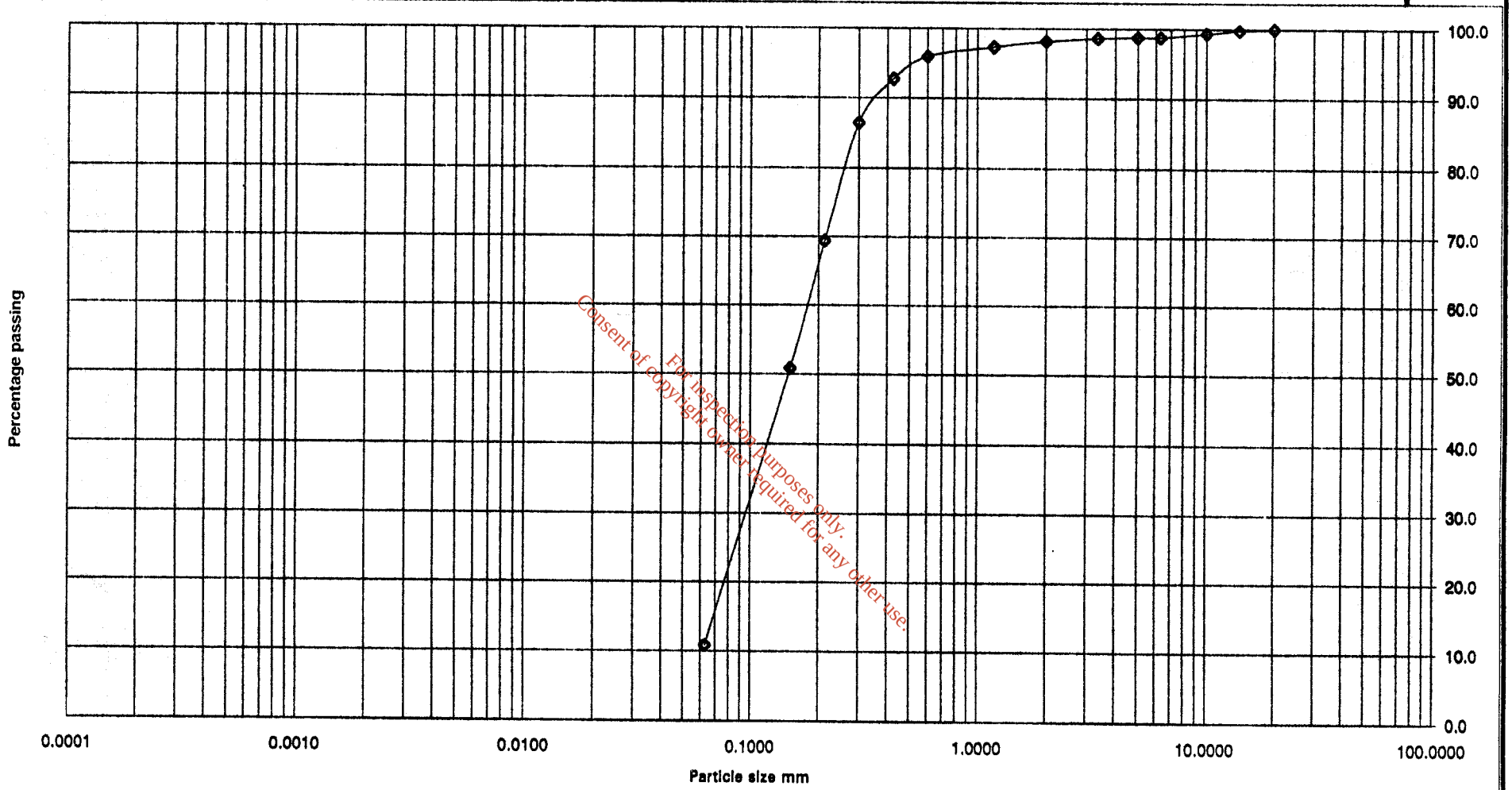
K4 SOILS LABORATORY

EPA Export 26-02-2014:23:31:07

PROJECT:	Bangor Erris	Project No:	1169
CLIENT:	Irish Drilling	Reference:	0415

PARTICLE SIZE DISTRIBUTION

Borehole No. TP3 Sample No. Depth 2.50 m



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CLAY	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	COBBLES
	SILT			SAND			GRAVEL			

Visual Description: Pale grey SAND with a trace of gravel

K4 SOILS LABORATORY

EPA Export 26-02-2014:23:31:07

PROJECT: Bangor Erris

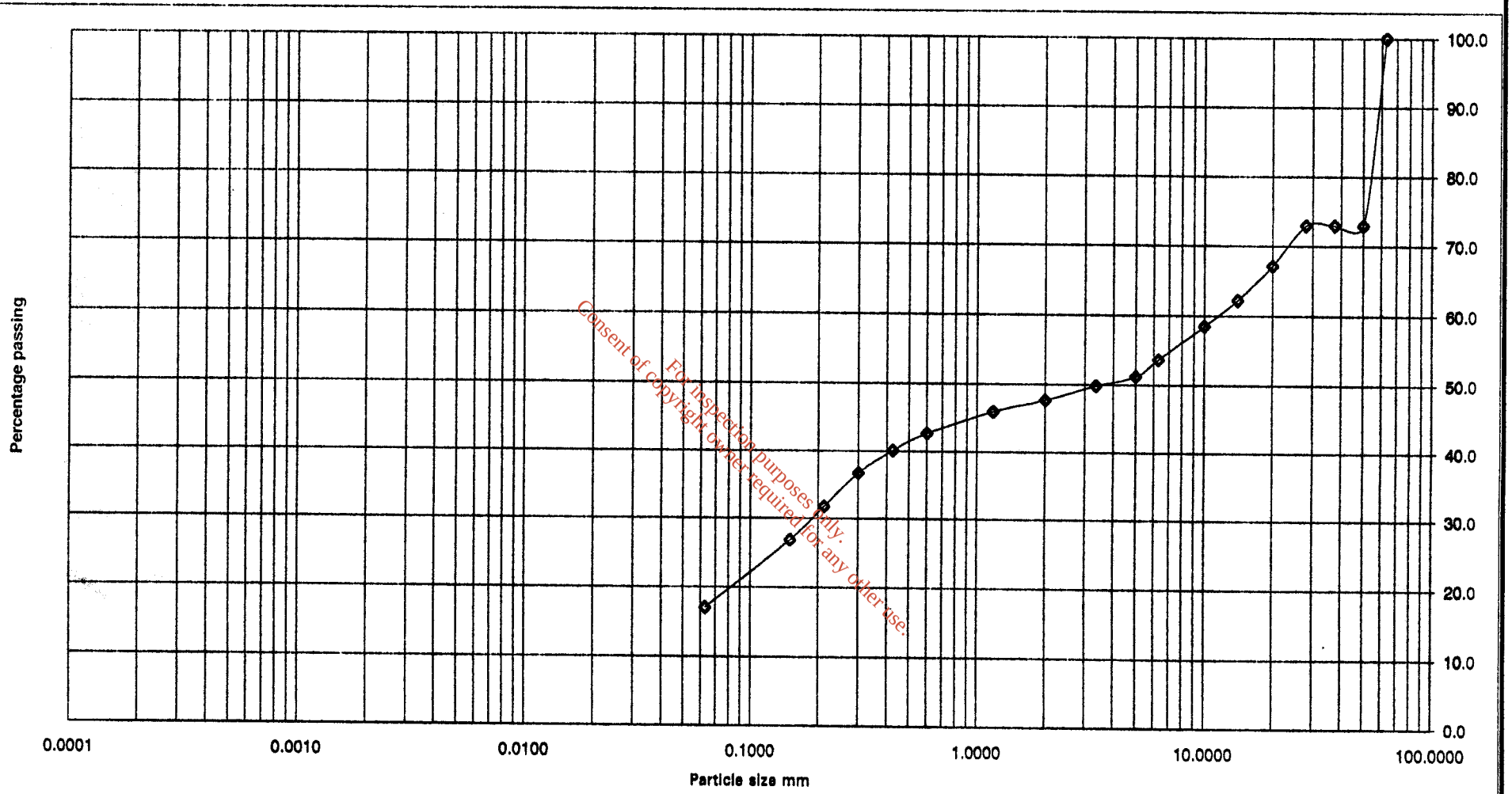
CLIENT: Irish Drilling

Project No: 1169

Reference: 0415

PARTICLE SIZE DISTRIBUTION

Borehole No. TP4 Sample No. Depth 1.00 m



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For inspection purposes only.

CLAY	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	COBBLES
	SILT			SAND			GRAVEL			

Visual Description: Grey silty SAND and GRAVEL

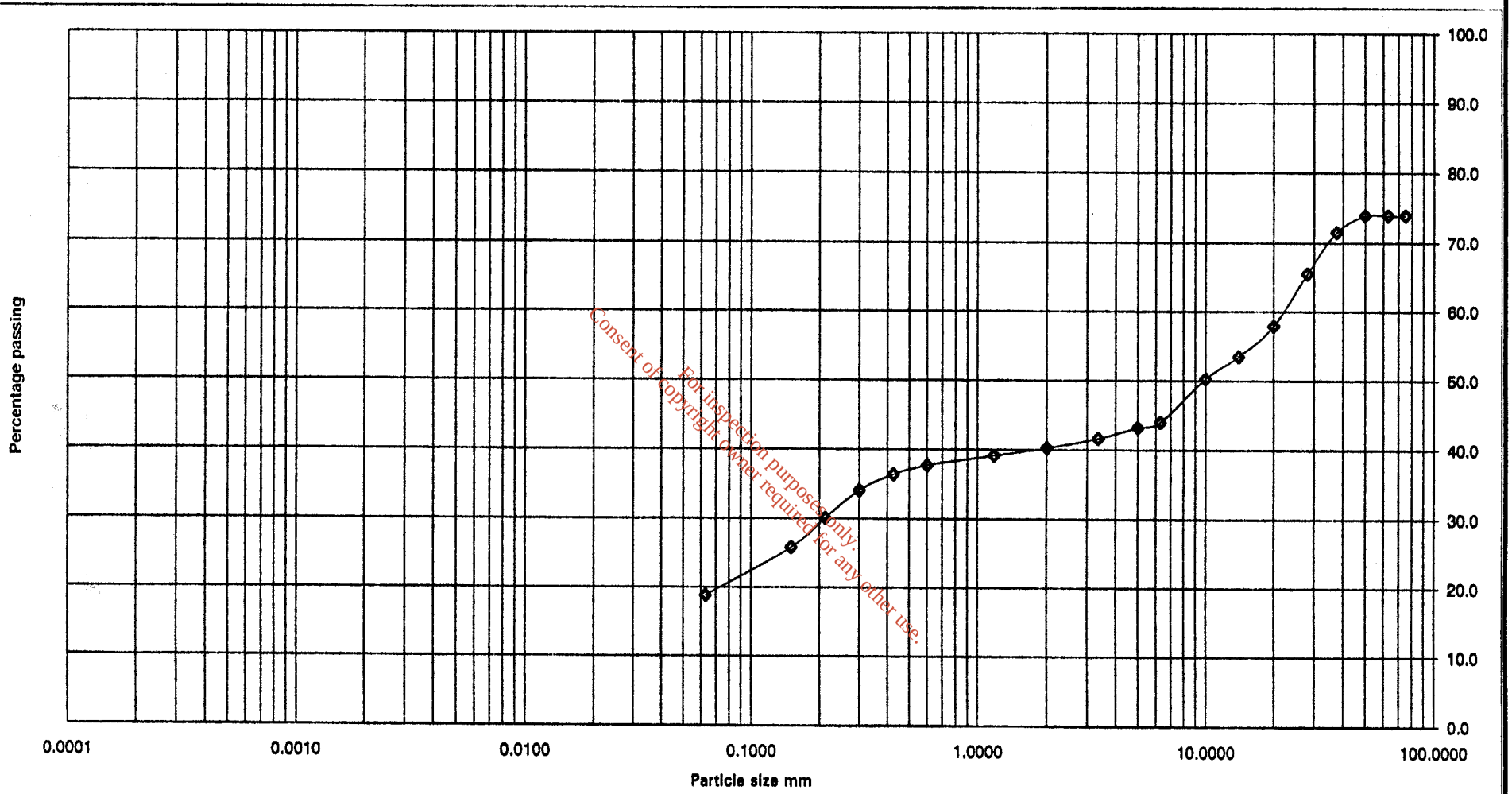
K4 SOILS LABORATORY

EPA Export 26-02-2014:23:31:07

PROJECT:	Bangor Erris	Project No:	1169
CLIENT:	Irish Drilling	Reference:	0415

PARTICLE SIZE DISTRIBUTION

Borehole No. TP5 Sample No. Depth 1.50 m



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CLAY	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	COBBLES
	SILT			SAND			GRAVEL			

Visual Description: Grey silty sandy GRAVEL with occasional cobbles

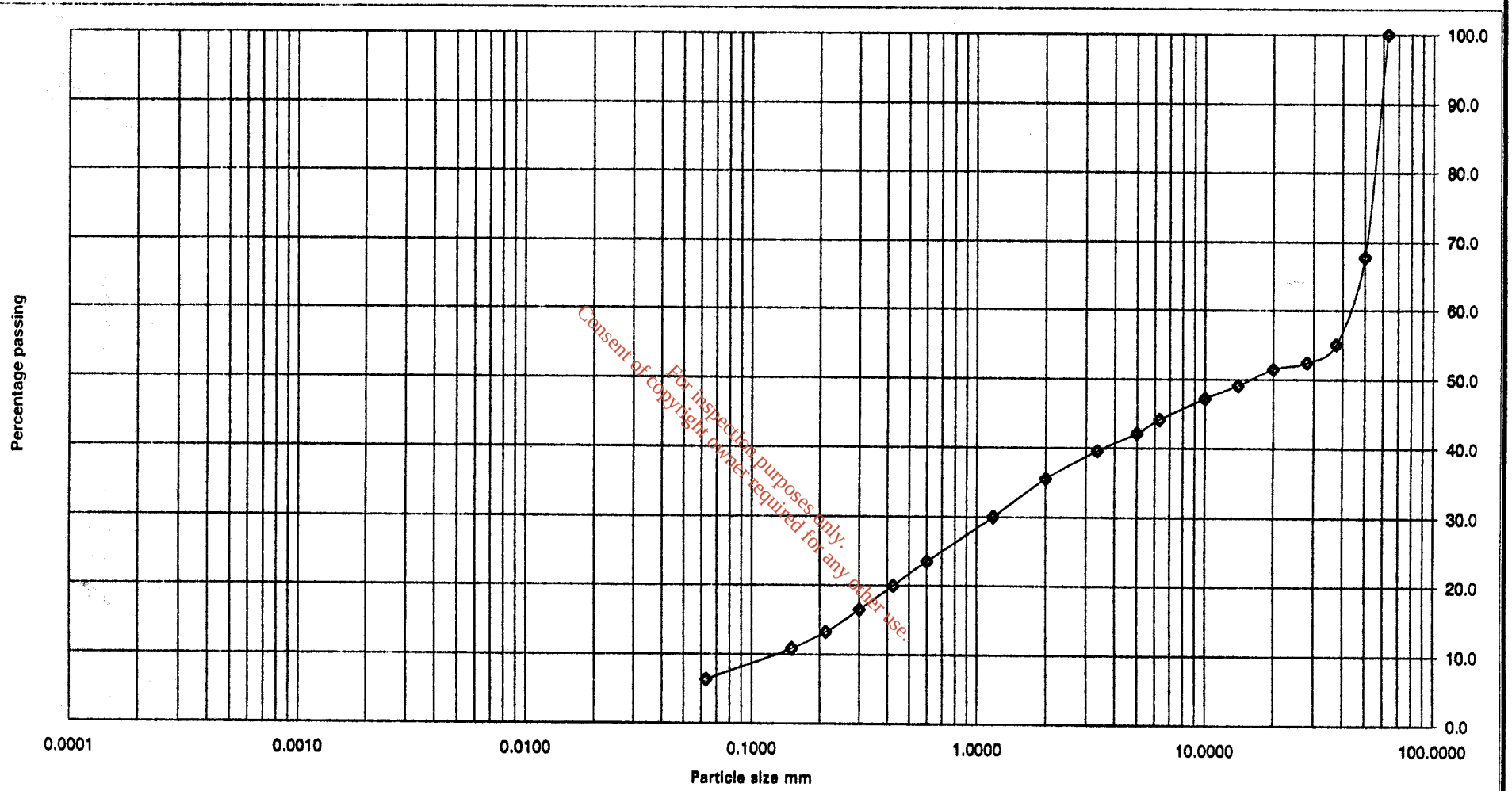
K4 SOILS LABORATORY

EPA Export 26-02-2014:23:31:07

PROJECT:	Bangor Erris	Project No:	1169
CLIENT:	Irish Drilling	Reference:	0415

PARTICLE SIZE DISTRIBUTION

Borehole No. TP6 Sample No. Depth 2.50 m



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CLAY	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	COBBLES
	SILT			SAND			GRAVEL			

Visual Description: Grey sandy GRAVEL

K4 SOILS LABORATORY

EPA Export 26-02-2014:23:31:07

Compaction/CBR/Moisture content test

2.5kg rammer
BS1377:1990; Part 4, Clause 3.4, 7

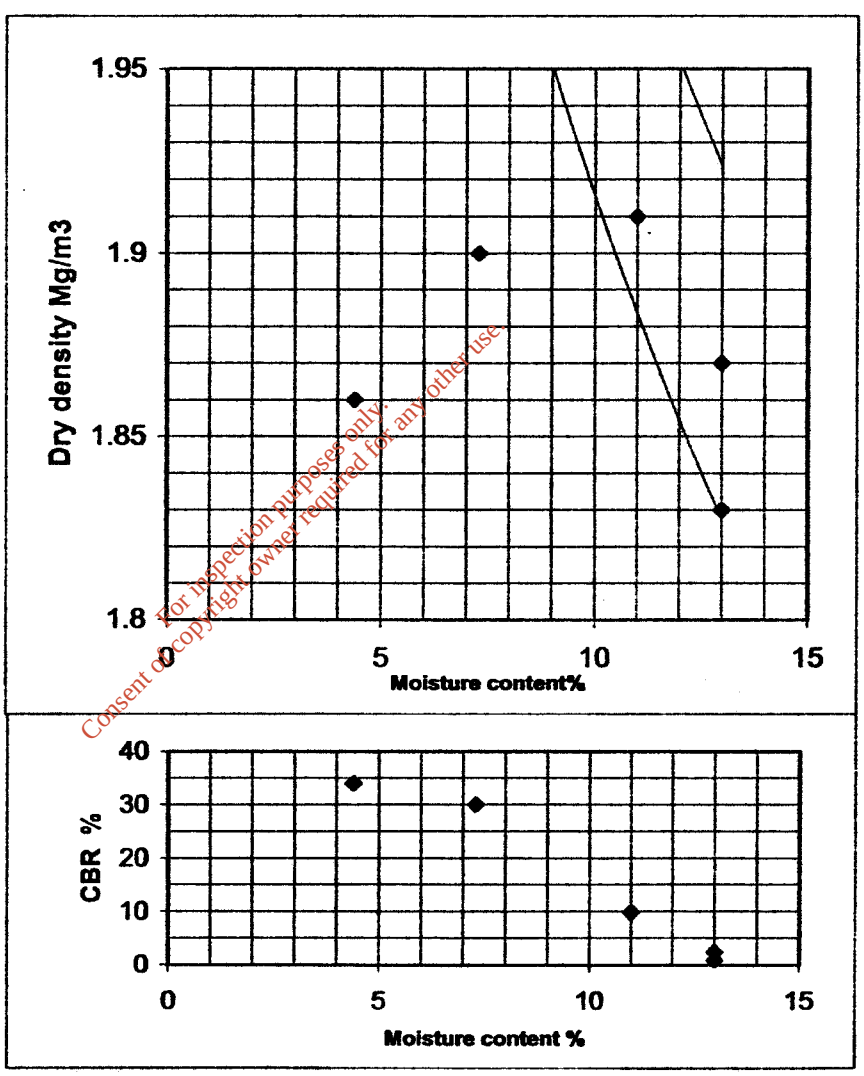
IRISH DRILLING LTD. **Loughrea, Co. Galway**	**Contract:** Peat Deposit Site at Bangor Erris (1169) **Client:** Enterprise oil **Engineer:** TES **Date:** 20/11/2003 **Tested:** DD **Chckd:** DJ	**Location:** TP 2 **Depth:** 1.5 m

Description: Grey slighlty clayey fine to medium SAND.

Moisture Content %	Dry Density Mg/m³
4.4	1.86
7.3	1.9
11	1.91
13	1.83
13	1.87

moisture content %	CBR %
4.4	34
7.3	30
11	9.8
13	2.4
13	0.9

Gs assumed: 2.55



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RESULTS:

Maximum dry density:	1.91	Mg/m³
Optimum moisture content:	11.00	%
Natural moisture content * :	13.00	%
Retained on 20mm Sieve:		%
Natural moisture content **:		%

* refers to bulk sample before removal of coarse particles

** refers to sample after removal of coarse particles

EPA Export 26-02-2014:23:31:07

Compaction/CBR/Moisture content test

2.5kg rammer
BS1377:1990; Part 4, Clause 3.4, 7

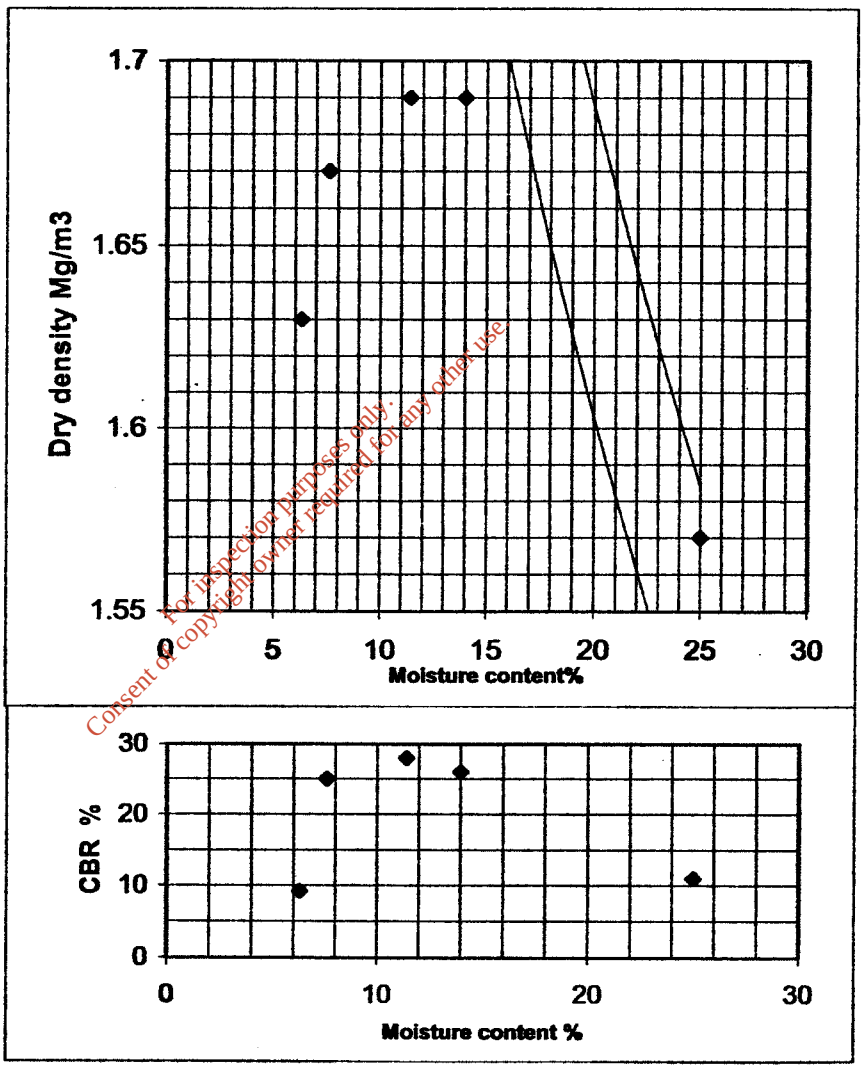
IRISH DRILLING LTD. **Loughrea, Co. Galway**	**Contract:** Peat Deposit Site at Bangor Erris (1169) **Client:** Enterprise oil **Engineer:** TES **Date:** 20/11/2003 **Tested:** DD **Chckd:** DJ	**Location:** TP 3 **Depth:** 2.5 m

Description: Dark grey-green SAND with occasional peat pockets.

Moisture Content %	Dry Density Mg/m³
6.3	1.63
7.6	1.67
11.4	1.69
14	1.69
25	1.57

moisture content %	CBR %
6.3	9.2
7.6	25
11.4	28
14	26
25	11

Gs assumed: 2.55



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RESULTS:

Maximum dry density:	1.69	Mg/m³
Optimum moisture content:	11.50	%
Natural moisture content * :	25.00	%
Retained on 20mm Sieve:		%
Natural moisture content **:		%

* refers to bulk sample before removal of coarse particles

** refers to sample after removal of coarse particles

EPA Export 26-02-2014:23:31:07

Compaction/CBR/Moisture content test

2.5kg rammer
BS1377:1990; Part 4, Clause 3.4, 7

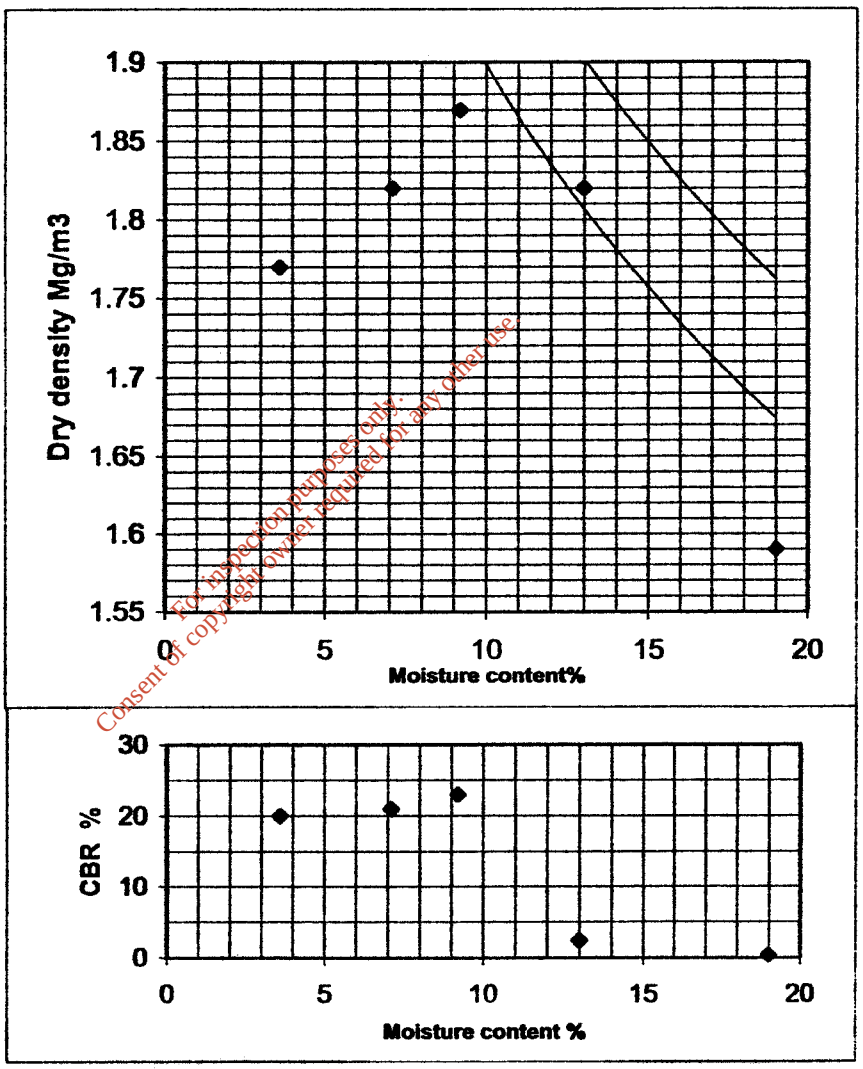
IRISH DRILLING LTD. **Loughrea, Co. Galway**	**Contract:** Peat Deposit Site at Bangor Erris (1169) **Client:** Enterprise oil **Engineer:** TES **Date:** 20/11/2003 **Tested:** DD **Chckd:** DJ	**Location:** TP 5 **Depth:** 1.5 m

Description: Dark grey very sandy CLAY with fine, medium to coarse gravel.

Moisture Content %	Dry Density Mg/m³
3.6	1.77
7.1	1.82
9.2	1.87
13	1.82
19	1.59

moisture content %	CBR %
3.6	20
7.1	21
9.2	23
13	2.4
19	0.36

Gs assumed: 2.55



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RESULTS:

Maximum dry density:	1.87	Mg/m³	
Optimum moisture content:	9.20	%	
Natural moisture content * :	19.00	%	* refers to bulk sample before removal of coarse particles
Retained on 20mm Sieve:		%	
Natural moisture content **:		%	** refers to sample after removal of coarse particles

EPA Export 26-02-2014:23:31:07

Compaction/CBR/Moisture content test

2.5kg rammer
BS1377:1990; Part 4, Clause 3.4, 7

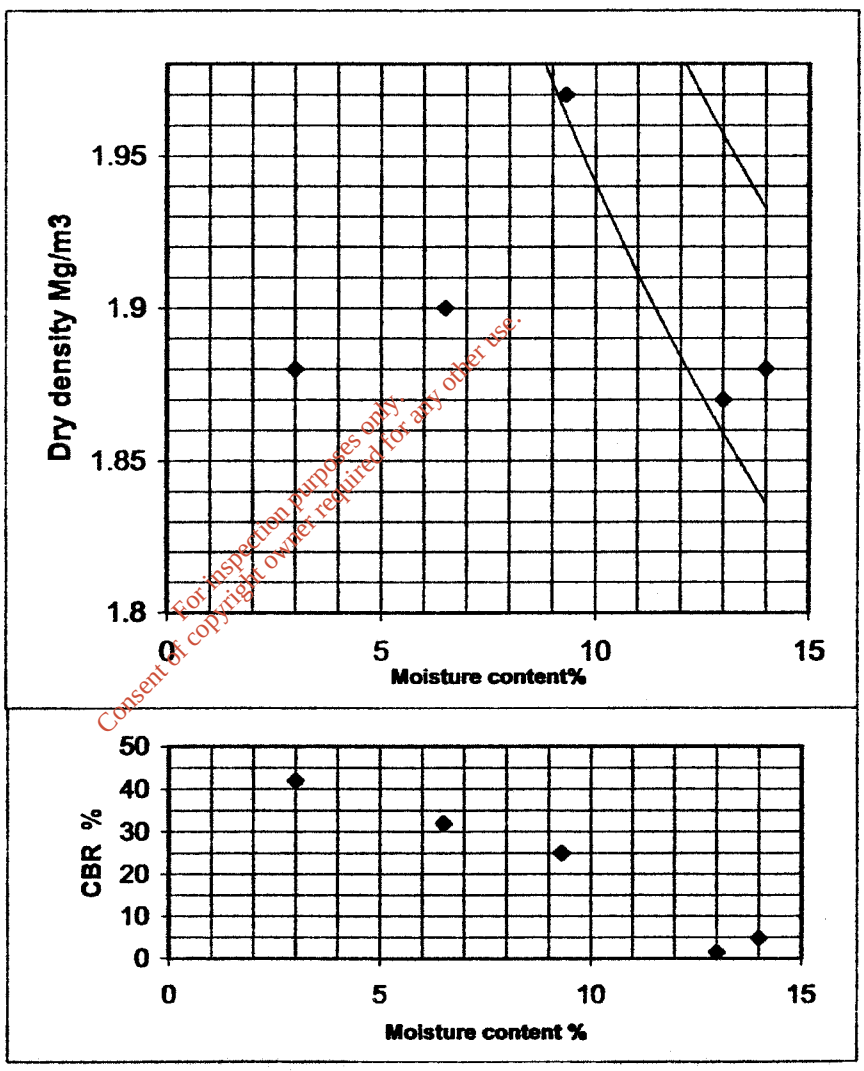
IRISH DRILLING LTD. **Loughrea, Co. Galway**	**Contract:** Peat Deposit Site at Bangor Erris (1169) **Client:** Enterprise oil **Engineer:** TES **Date:** 20/11/2003 **Tested:** DD **Chckd:** DJ	**Location:** TP 6 **Depth:** 1.5 m

Description: Grey SAND with a little gravel.

Moisture Content %	Dry Density Mg/m³
3	1.88
6.5	1.9
9.3	1.97
13	1.87
14	1.88

moisture content %	CBR %
3	42
6.5	32
9.3	25
13	1.4
14	4.79

Gs assumed: 2.60



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RESULTS:

Maximum dry density:	1.97	Mg/m³	
Optimum moisture content:	9.30	%	
Natural moisture content * :	14.00	%	* refers to bulk sample before removal of coarse particles
Retained on 20mm Sieve:		%	
Natural moisture content **:		%	** refers to sample after removal of coarse particles

EPA Export 26-02-2014:23:31:07

Compaction/CBR/Moisture content test

2.5kg rammer
BS1377:1990; Part 4, Clause 3.4, 7

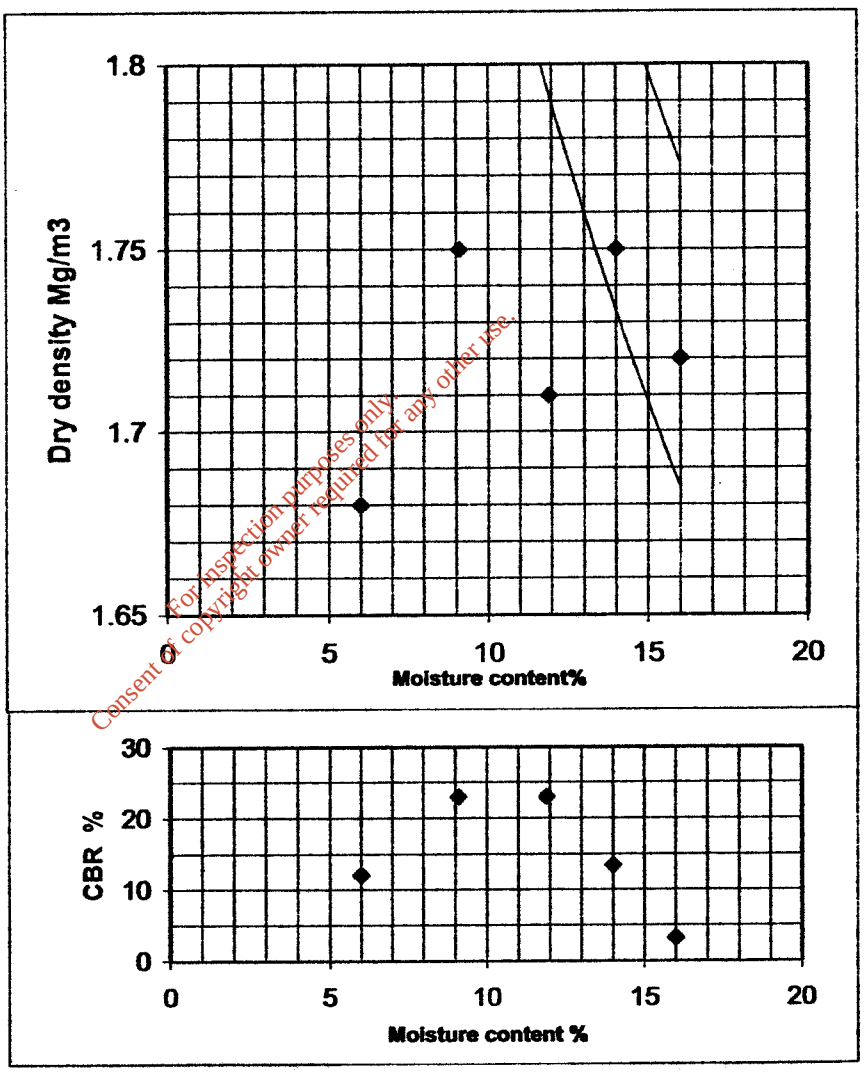
IRISH DRILLING LTD. **Loughrea, Co. Galway**	**Contract:** Peat Deposit Site at Bangor Erris (1169) **Client:** Enterprise oil **Engineer:** TES **Date:** 20/11/2003 **Tested:** DD **Chckd:** DJ	**Location:** TP 7 **Depth:** 2.5 m

Description: Grey SAND with a little gravel.

Moisture Content %	Dry Density Mg/m³
6	1.68
9.1	1.75
11.9	1.71
14	1.75
16	1.72

moisture content %	CBR %
6	12
9.1	23
11.9	23
14	13.4
16	3.2

Gs assumed: 2.45



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RESULTS:

Maximum dry density:	1.97	Mg/m³
Optimum moisture content:	9.30	%
Natural moisture content * :	14.00	%
Retained on 20mm Sieve:		%
Natural moisture content **:		%

* refers to bulk sample before removal of coarse particles

** refers to sample after removal of coarse particles

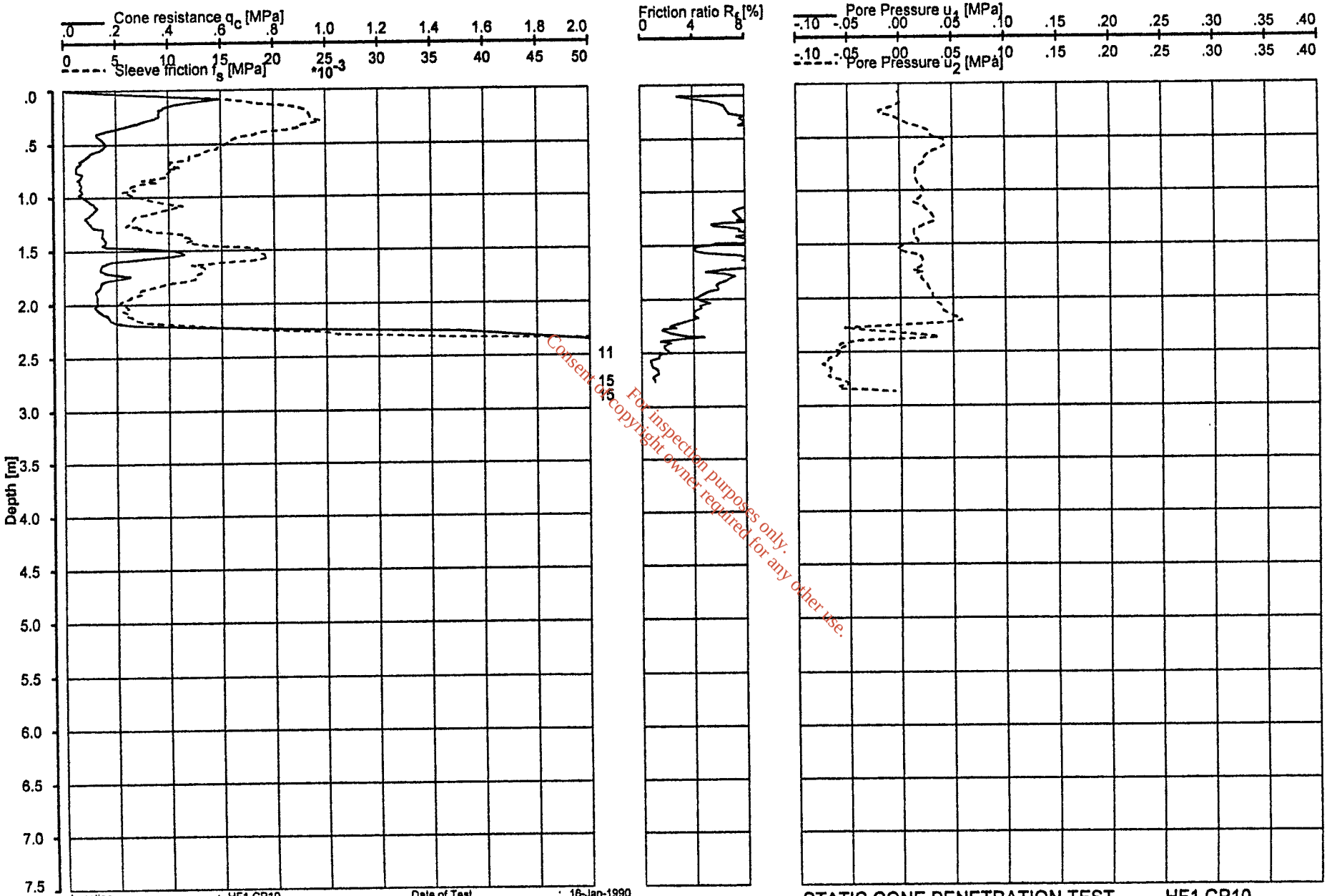
EPA Export 26-02-2014:23:31:08

APPENDIX B PHASE 2 GROUND INVESTIGATION RESULTS

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UNIPLOT 02.15.NL /16:48:38/02QCFSU1.CMD Made by: dd: 4-Dec-2003 Checked by:



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Location	: HF1 CP10	Date of Test	: 16-Jan-1990
Coordinates	:	Date of Plot	: 02-Dec-2003
Ground Level [m]	:	File name	: Hf1cp10.000
Cone used	: F7.5CKEW$_2$/V 1515	Interpretation Checked by	: ...

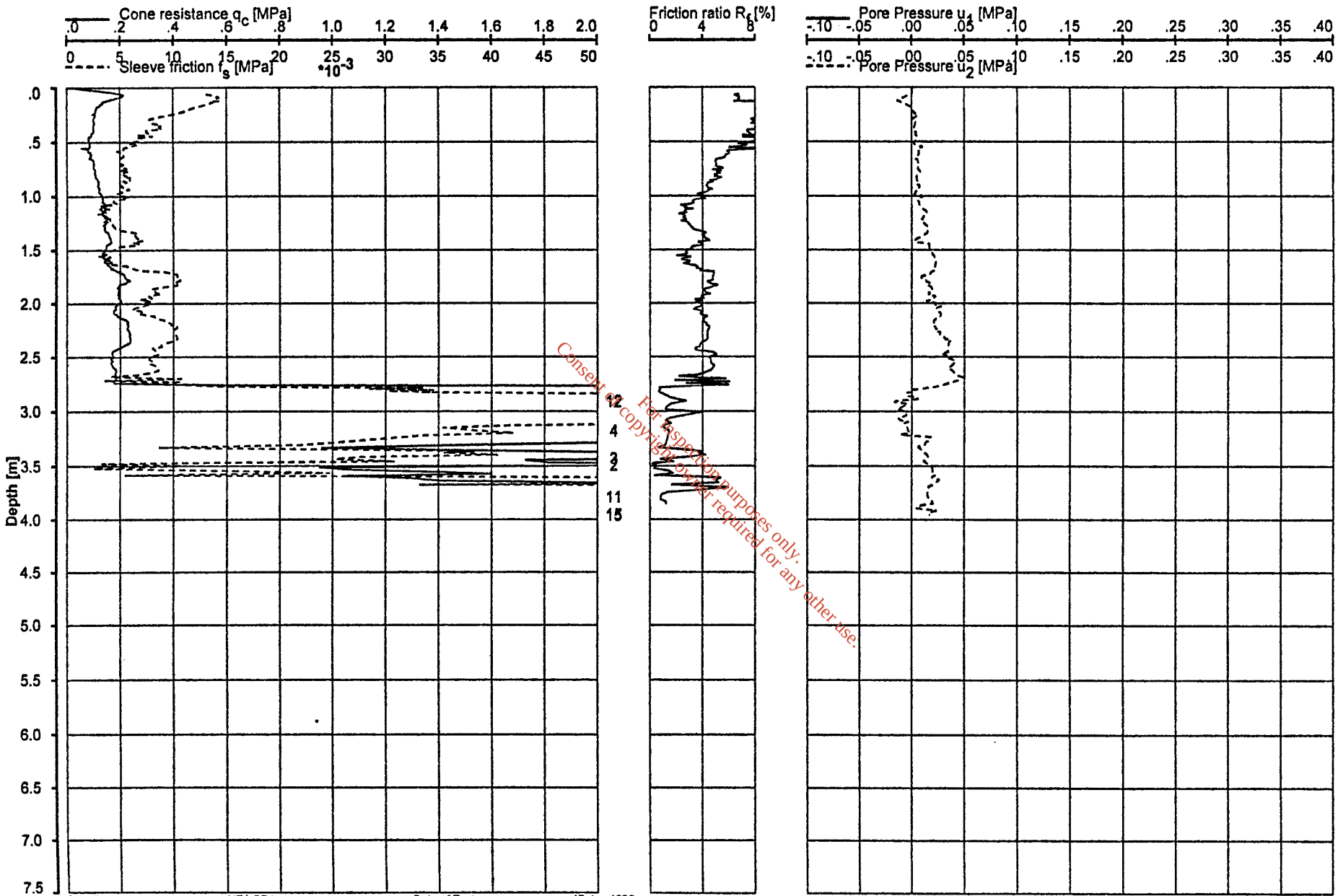
STATIC CONE PENETRATION TEST HF1 CP10
EASINGTON LANFALL PIPELINE
STATOIL

31619-1 (01)

FUGRO ENGINEERING SERVICES LIMITED

EPA Export 26-02-2014:23:31:08

UNIPLOT 02.15.NL /16:48:37/02QCFSU1.CMD Made by: dd: 4-Dec-2003 Checked by:



Location : HF1 CP4
Coordinates :
Ground Level [m] :
Cone used : F7.5CKEW$_2$/V 1515

Date of Test : 17-Jan-1990
Date of Plot : 02-Dec-2003
File name : Hf1cp4.000
Interpretation Checked by : ...

31619-1 (01)

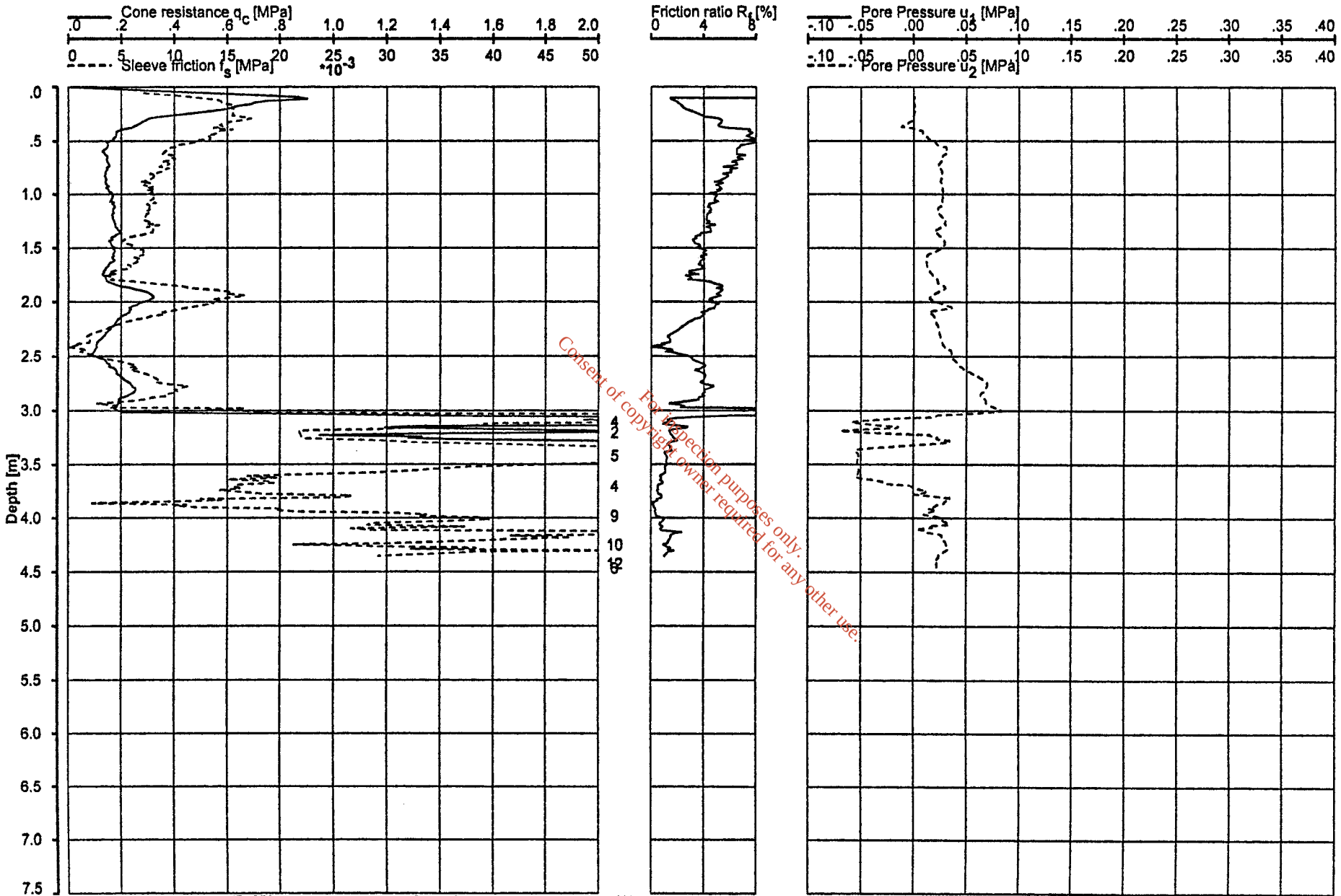
STATIC CONE PENETRATION TEST HF1 CP4
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Consent of copyright owner required for any other use.
For inspection purposes only.

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Coordinates	:	Date of Plot	: 02-Dec-2003
Ground Level [m]	:	File name	: Hf1cp6.000
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31619-1 (01)

STATIC CONE PENETRATION TEST HF1 CP6

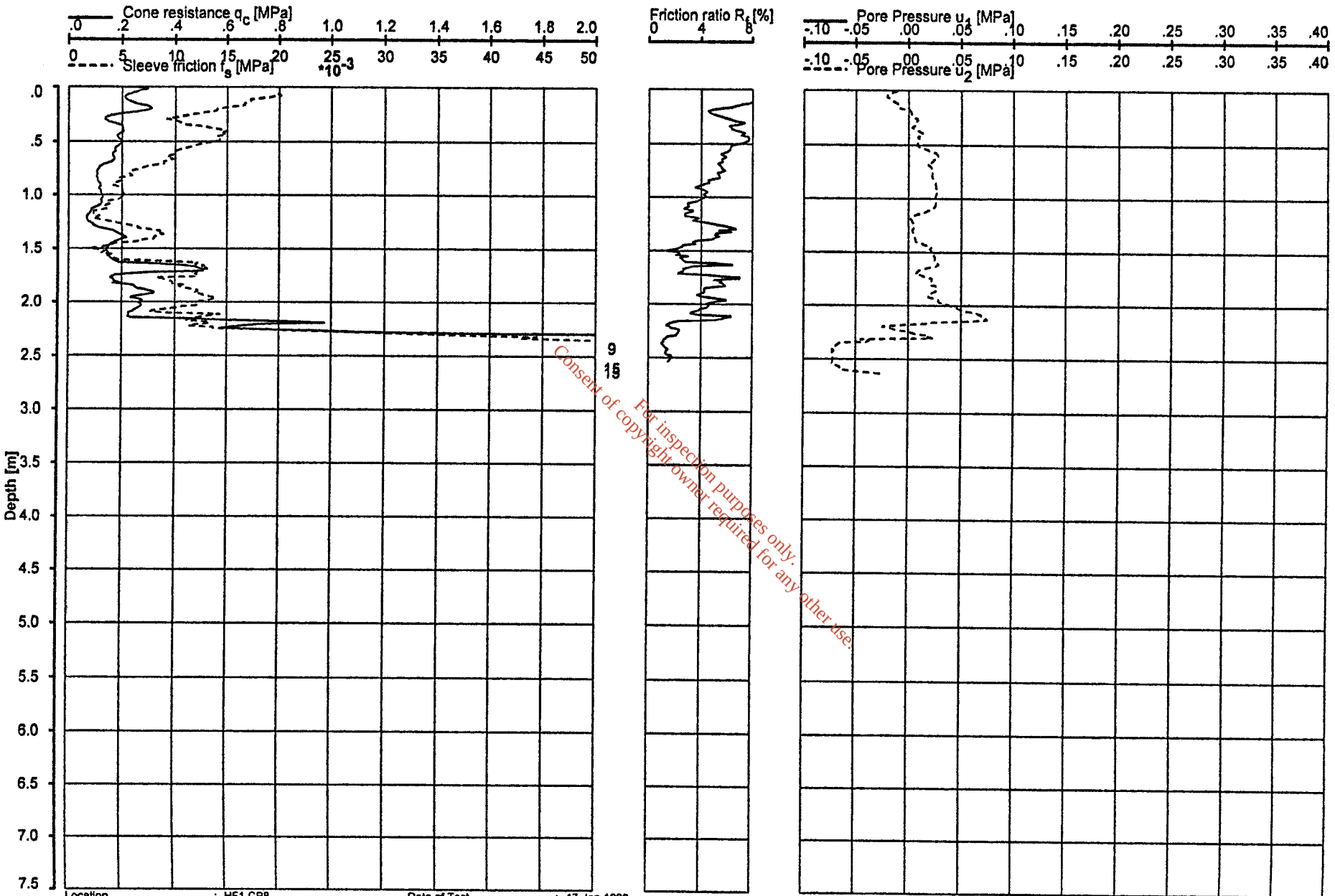
EASINGTON LANFALL PIPELINE

STATOIL

FUGRO ENGINEERING SERVICES LIMITED

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UNIPLOT 02.15.NL /16:48:38/02QCFSU1.CMD Made by: dd: 4-Dec-2003 Checked by:



Consent of copyright owner required for any other use.
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Location	: HF1 CP8	Date of Test	: 17-Jan-1990
Coordinates	:	Date of Plot	: 02-Dec-2003
Ground Level [m]	:	File name	: Hf1cp8.000
Cone used	: F7.5CKEW$_2$/V 1515	Interpretation Checked by	: ...

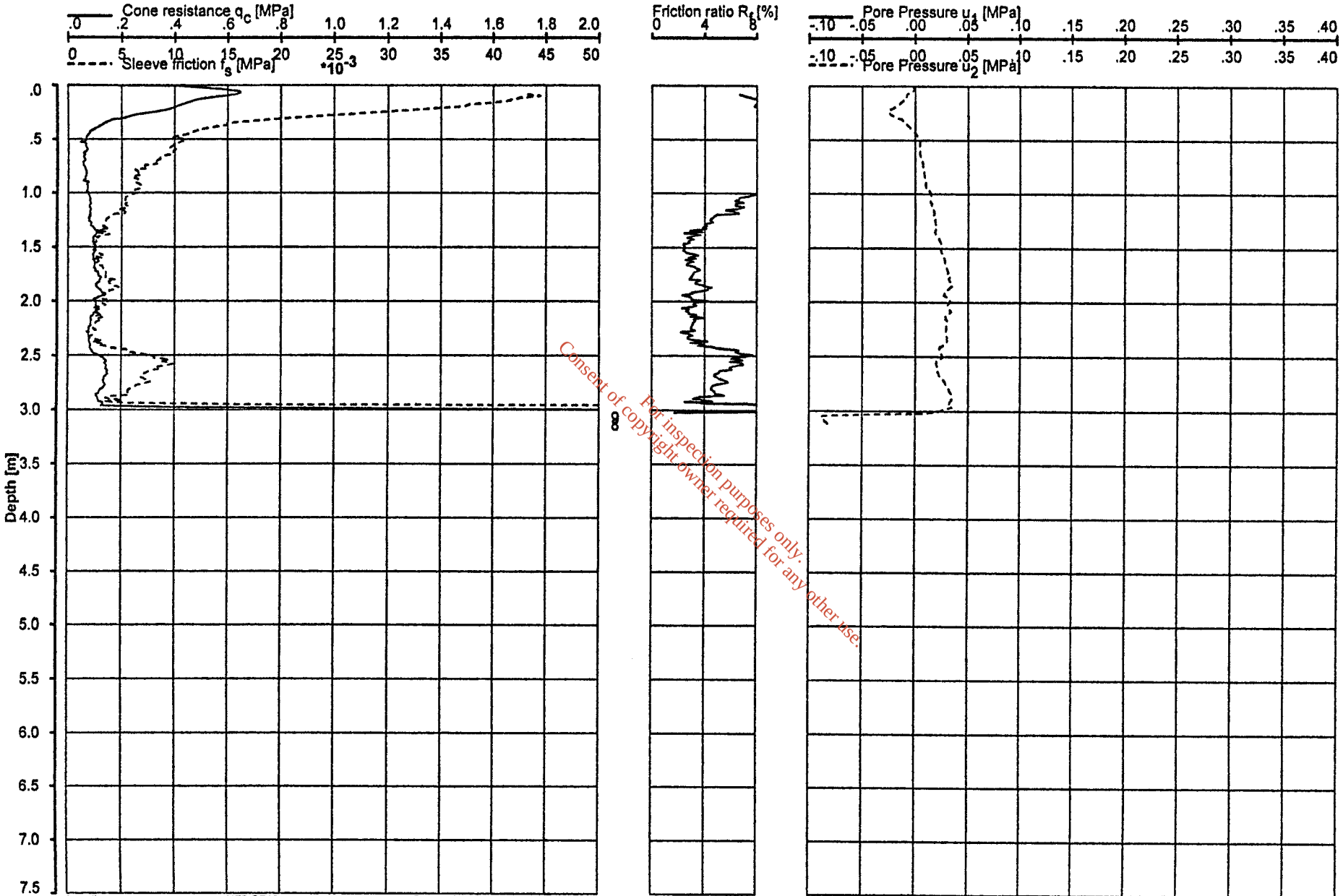
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STATIC CONE PENETRATION TEST HF1 CP8
EASINGTON LANFALL PIPELINE
STATOIL

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EPA Export 26-02-2014:23:31:08

UNIPLOT 02.15.NL /16:48:38/02QCFSU1.CMD Made by: dd: 4-Dec-2003 Checked by:



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For inspection purposes only.

Location	: HF2 CP10	Date of Test	: 16-Jan-1990
Coordinates	:	Date of Plot	: 02-Dec-2003
Ground Level [m]	:	File name	: Hf2cp10.000
Cone used	: F7.5CKEW$_2$/V 1515	Interpretation Checked by	: ...

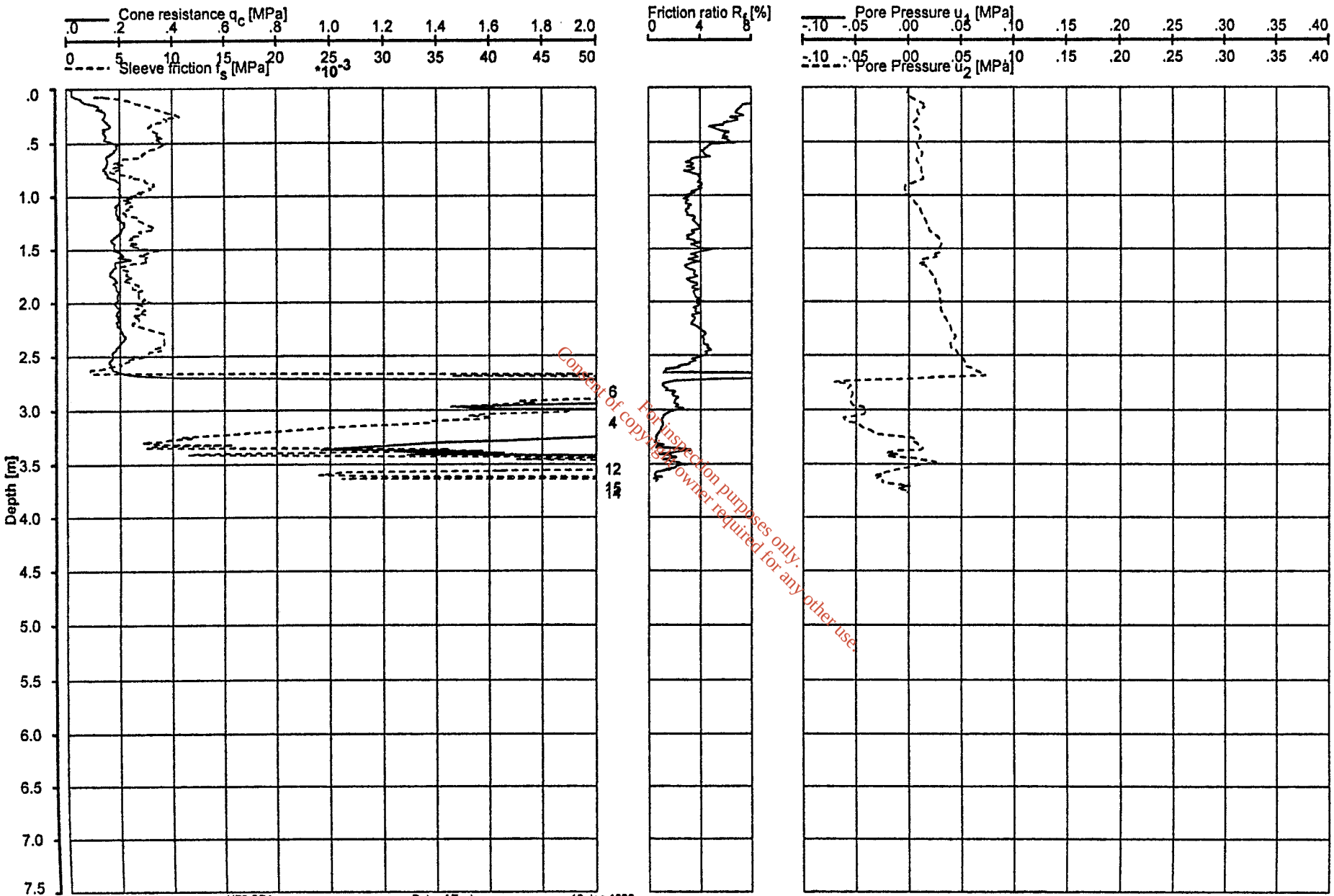
31619-1 (01)

STATIC CONE PENETRATION TEST HF2 CP10
EASINGTON LANFALL PIPELINE
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Location	: HF2 CP4	Date of Test	: 16-Jan-1990
Coordinates	:	Date of Plot	: 02-Dec-2003
Ground Level [m]	:	File name	: Hf2cp4.000
Cone used	: F7.5CKEW$_2$/V 1515	Interpretation Checked by	: ...

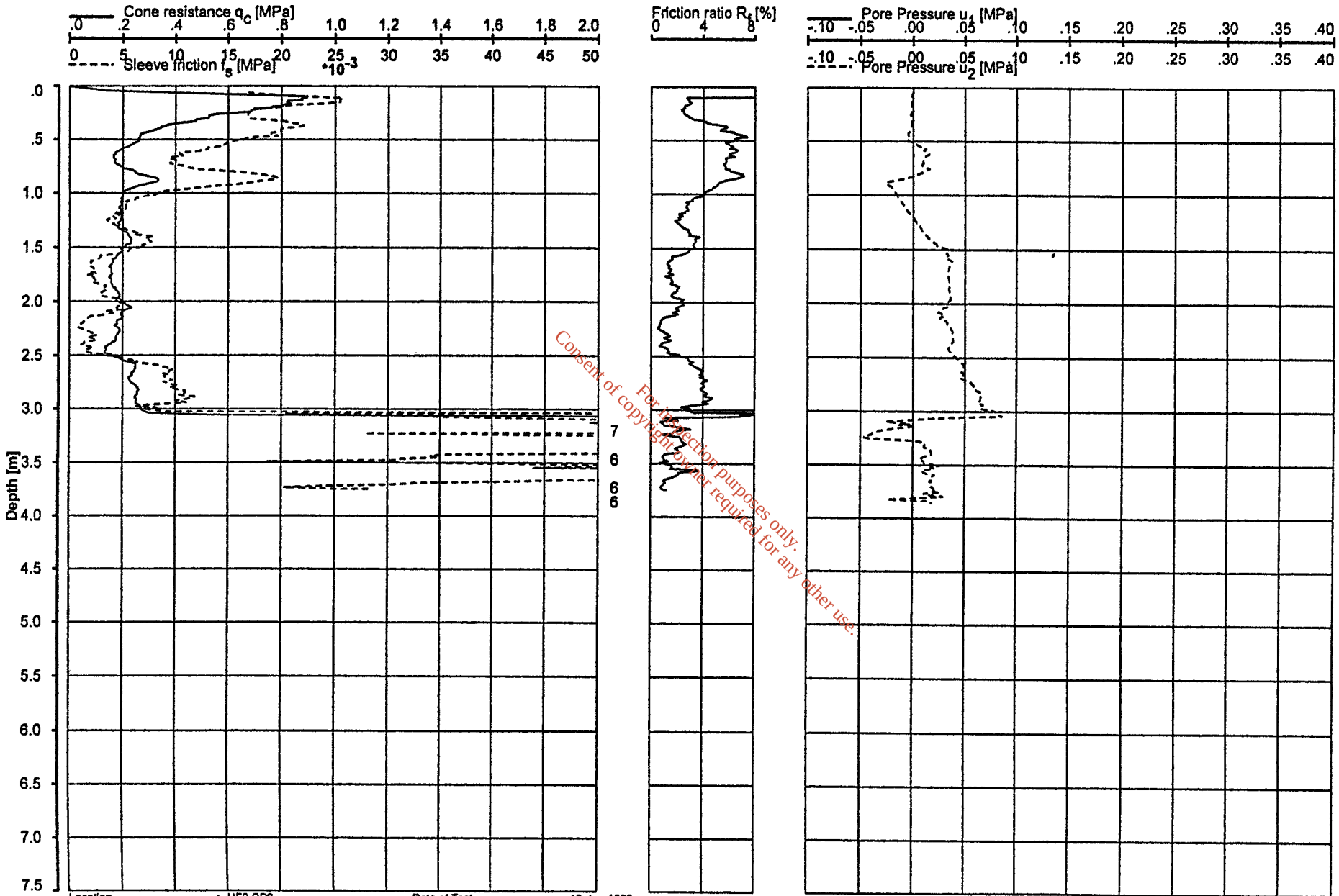
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STATIC CONE PENETRATION TEST HF2 CP4
EASINGTON LANFALL PIPELINE
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UNIPLOT 02.15.NL /16:48:39/02QCFSU1.CMD Made by: dd: 4-Dec-2003 Checked by:



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Location	: HF2 CP6	Date of Test	: 16-Jan-1990
Coordinates	:	Date of Plot	: 02-Dec-2003
Ground Level [m]	:	File name	: Hf2cp6.000
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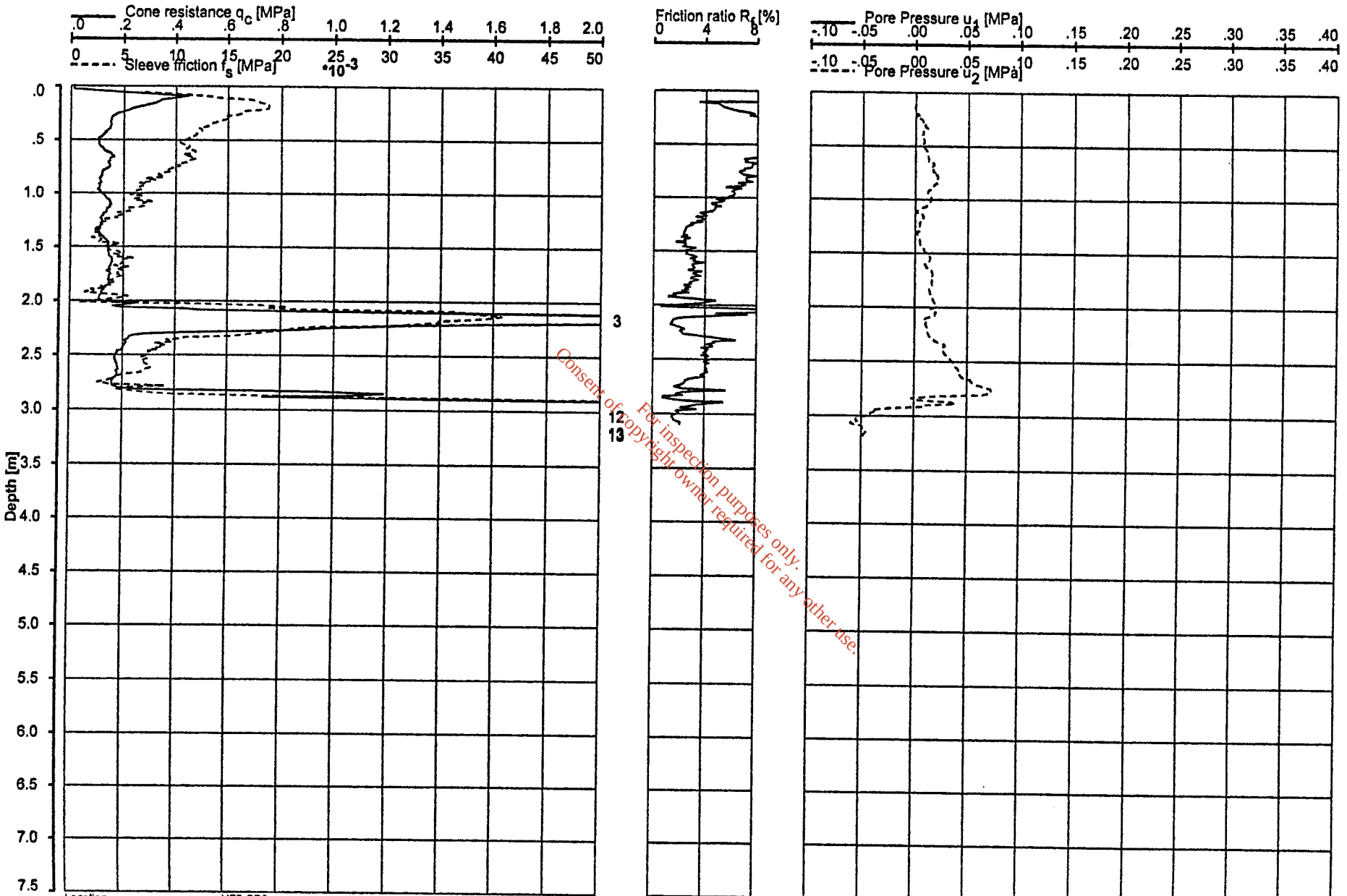
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STATIC CONE PENETRATION TEST HF2 CP6
EASINGTON LANFALL PIPELINE
STATOIL

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Ground Level [m]	:	File name	: Hf2cp8.000
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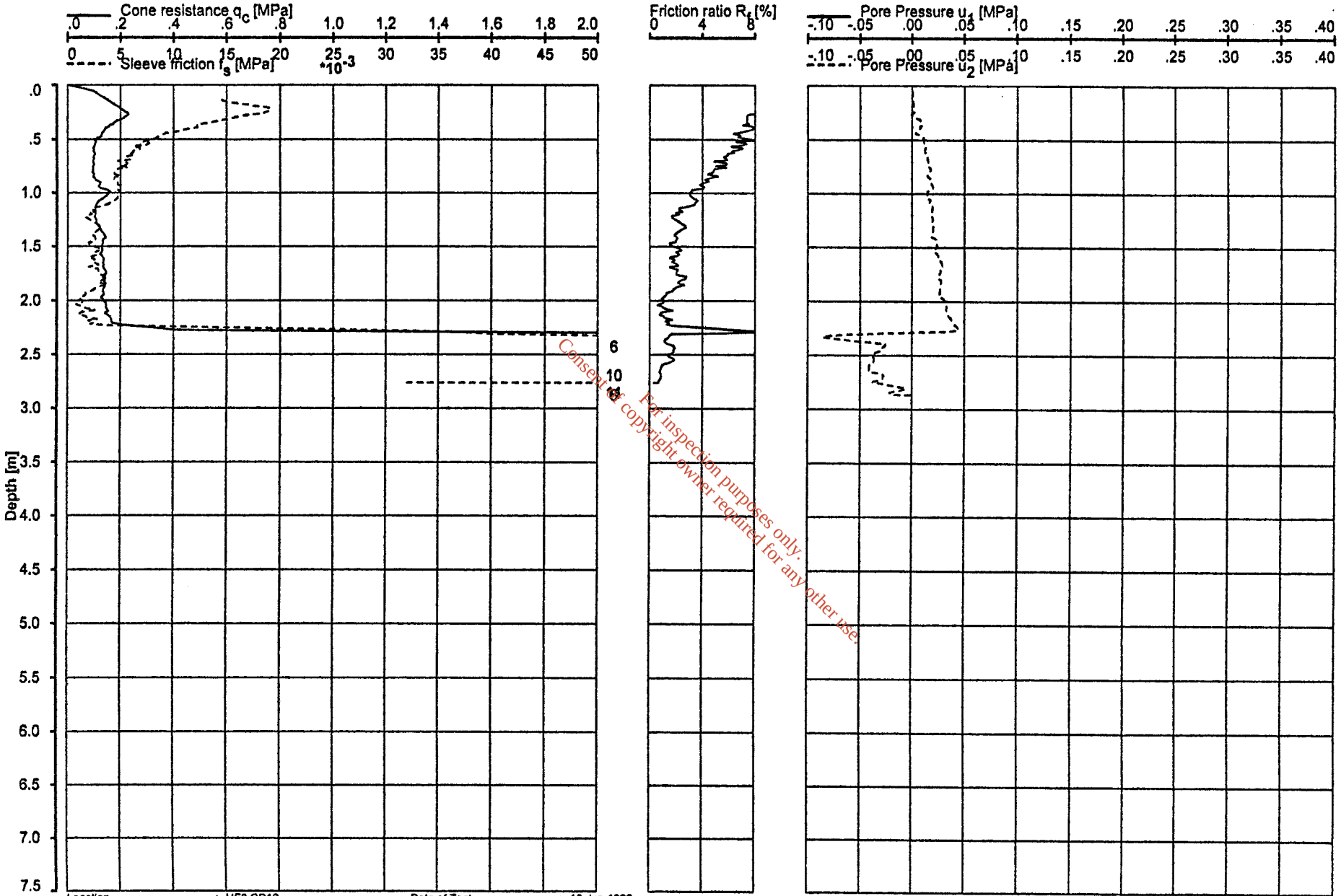
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STATIC CONE PENETRATION TEST HF2 CP8
EASINGTON LANFALL PIPELINE
STATOIL

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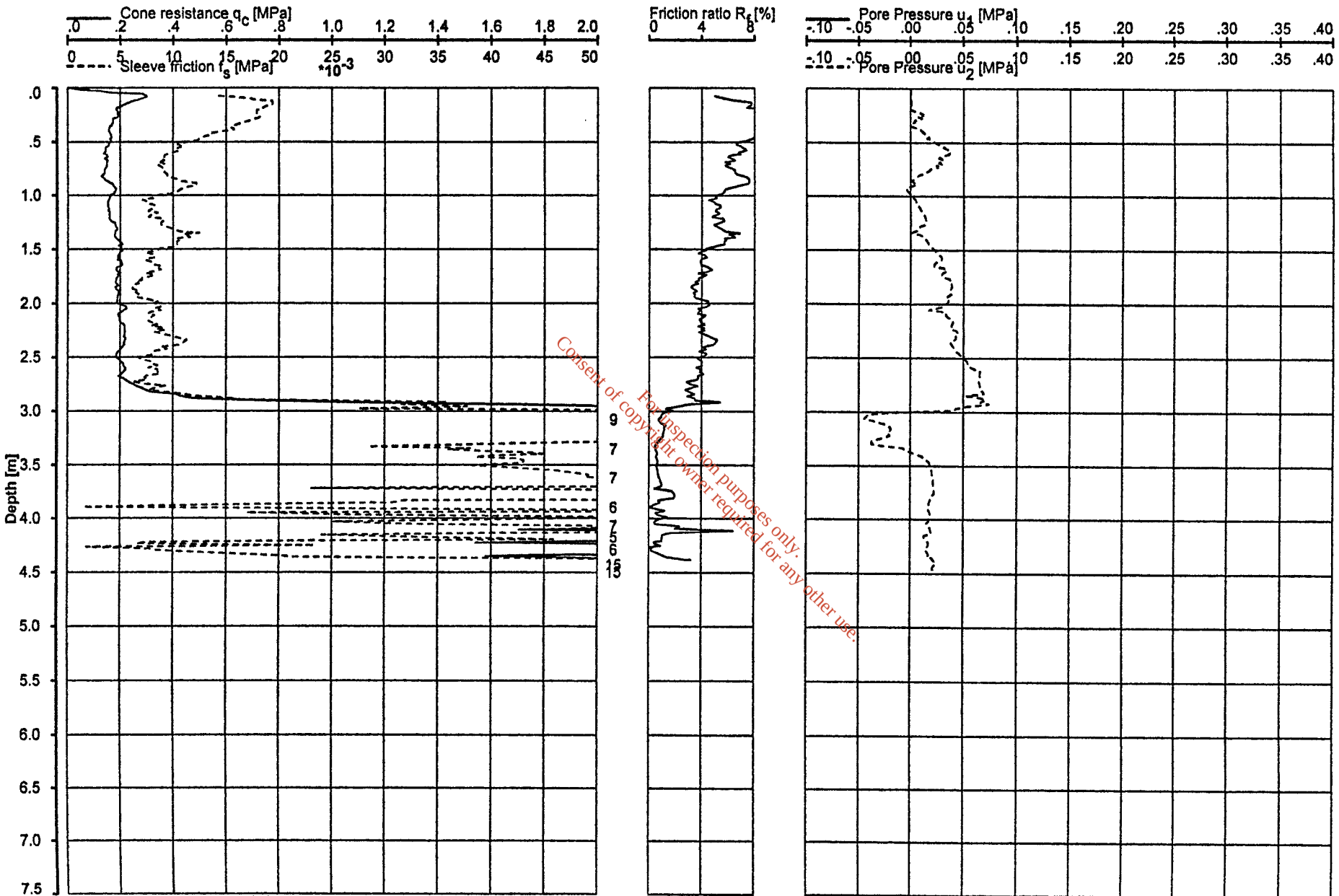
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STATIC CONE PENETRATION TEST HF3 CP10
EASINGTON LANFALL PIPELINE
STATOIL

FUGRO ENGINEERING SERVICES LIMITED

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Location	: HF3 CP2	Date of Test	: 16-Jan-1990
Coordinates	:	Date of Plot	: 02-Dec-2003
Ground Level [m]	:	File name	: Hf3cp2.000
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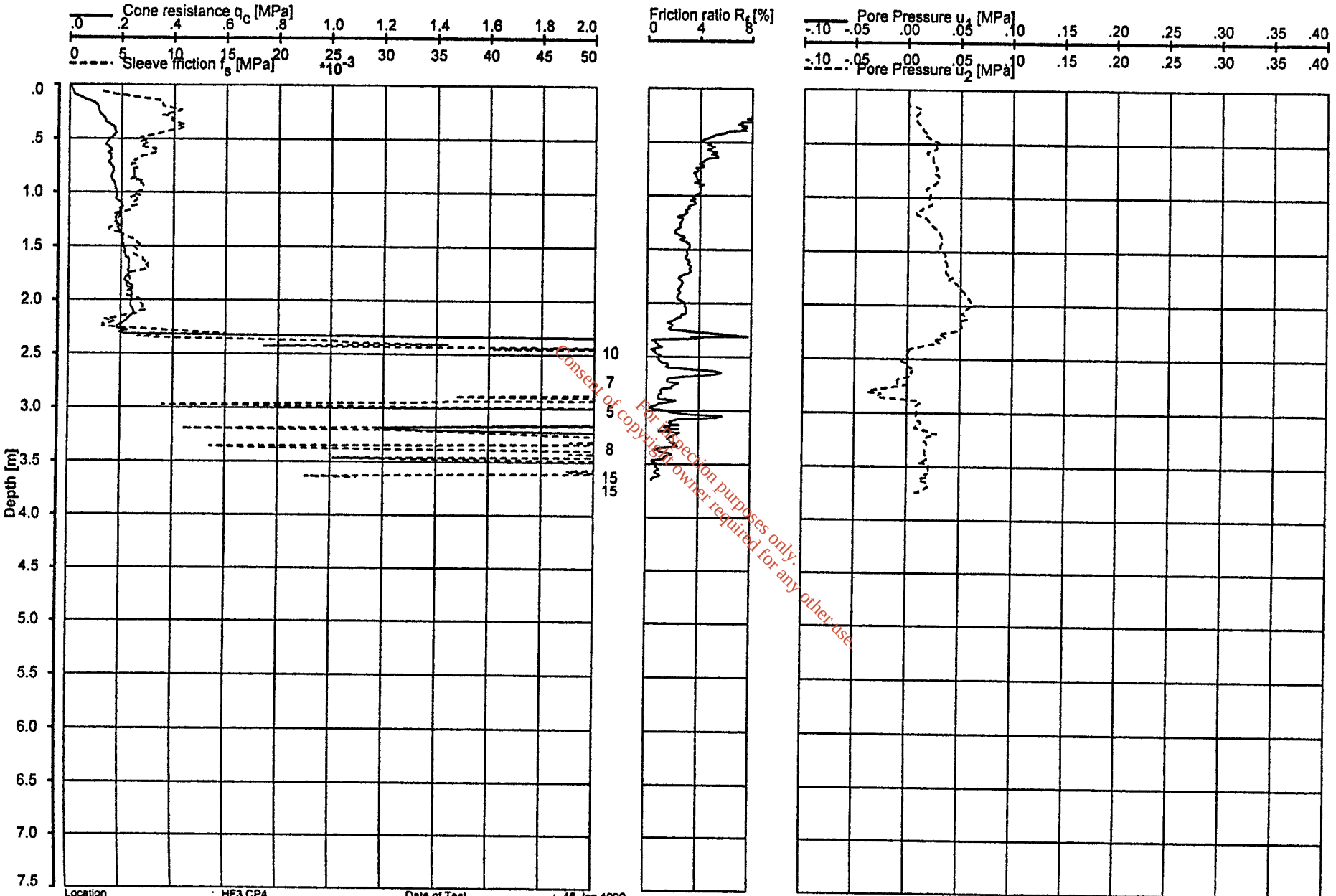
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STATIC CONE PENETRATION TEST HF3 CP2
EASINGTON LANFALL PIPELINE
STATOIL

FUGRO ENGINEERING SERVICES LIMITED

EPA Export 26-02-2014:23:31:08

UNIPLOT 02.15.NL /16:48:42/02QCFSU1.CMD Made by: dd: 4-Dec-2003 Checked by:



Location : HF3 CP4
Coordinates :
Ground Level [m] :
Cone used : F7.5CKEW$_2$/V 1515

Date of Test : 16-Jan-1990
Date of Plot : 02-Dec-2003
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Interpretation Checked by : ...

31619-1 (01)

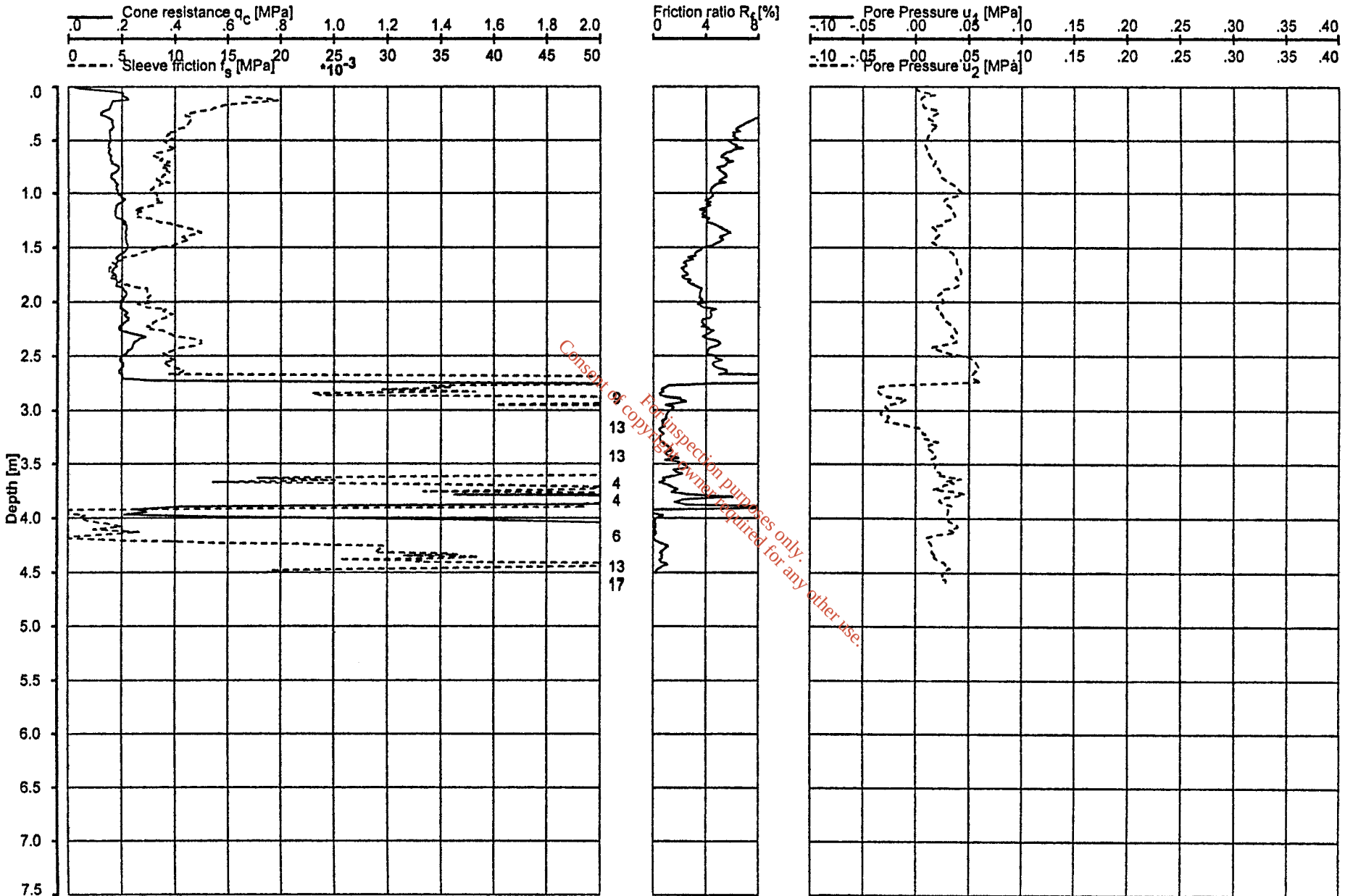
STATIC CONE PENETRATION TEST HF3 CP4
EASINGTON LANFALL PIPELINE
STATOIL

FUGRO ENGINEERING SERVICES LIMITED

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EPA Export 26-02-2014:23:31:08

UNIPLOT 02.15.NL /16:48:42/02QCFSU1.CMD Made by: dd: 4-Dec-2003 Checked by:



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Location	: HF3 CP6	Date of Test	: 15-Jan-1990
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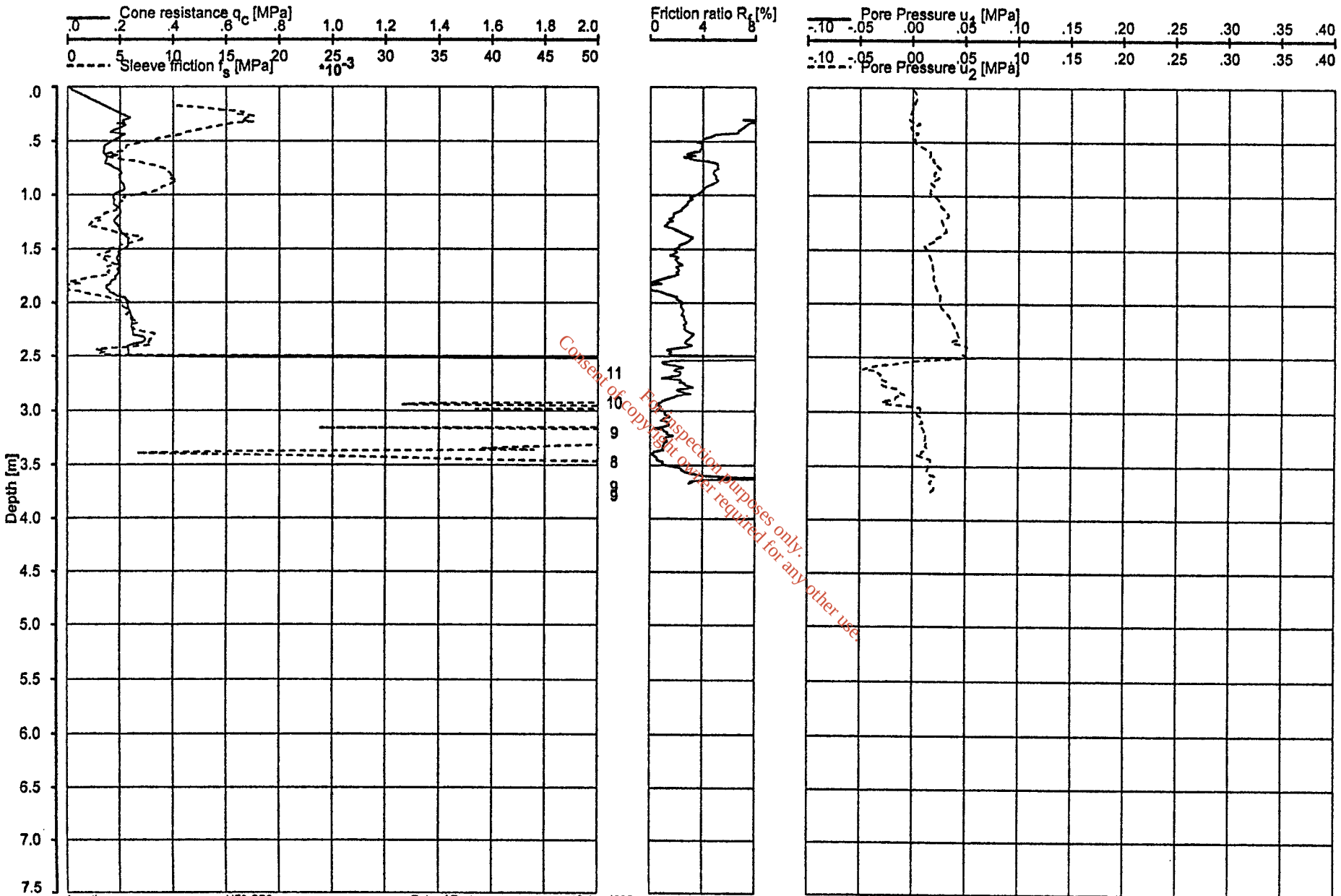
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STATIC CONE PENETRATION TEST HF3 CP6
EASINGTON LANFALL PIPELINE
STATOIL

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Location	: HF3 CP8	Date of Test	: 15-Jan-1990
Coordinates	:	Date of Plot	: 02-Dec-2003
Ground Level [m]	:	File name	: Hf3cp8.000
Cone used	: F7.5CKEW$_2$/V 1515	Interpretation Checked by	: ...

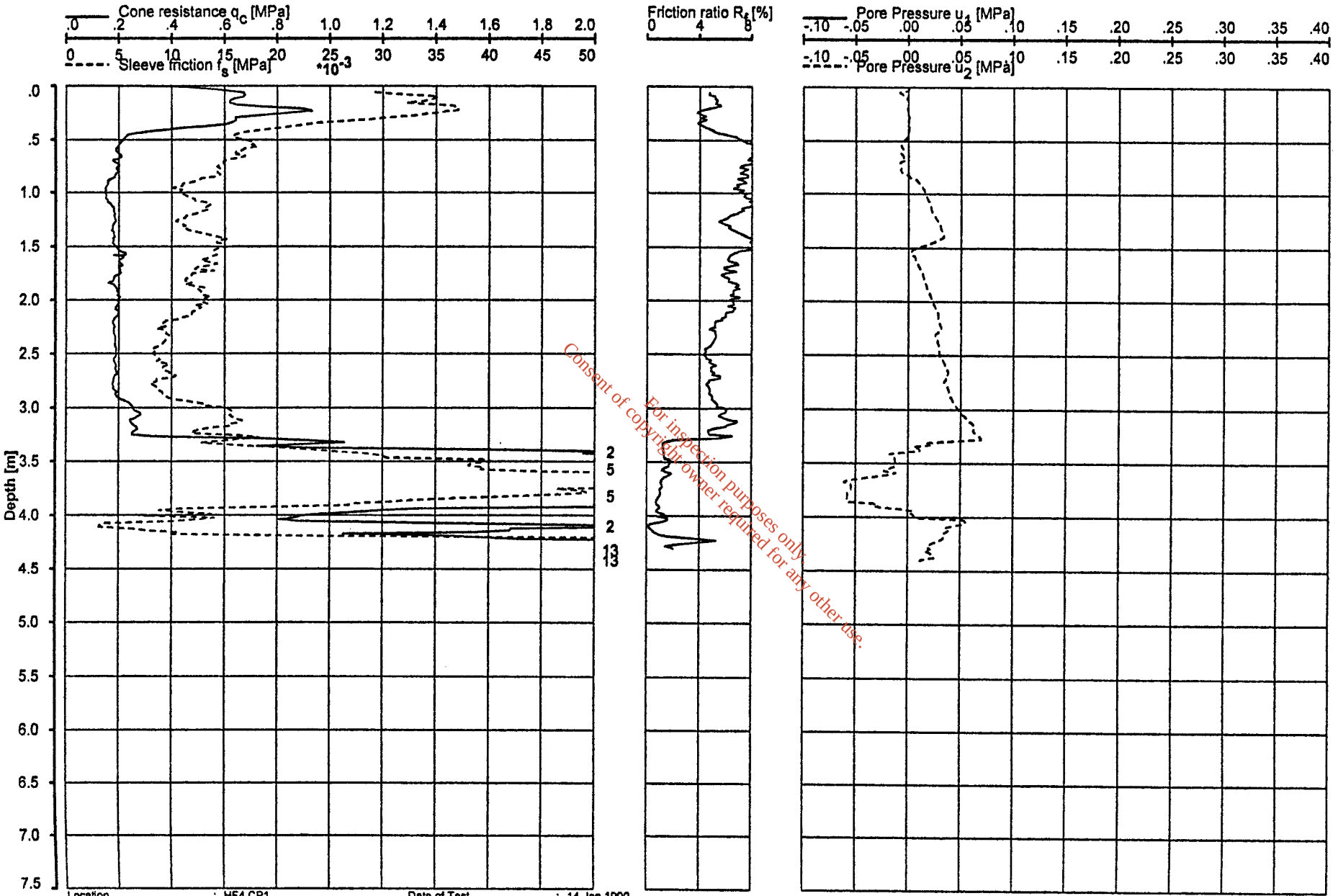
31619-1 (01)

STATIC CONE PENETRATION TEST HF3 CP8
EASINGTON LANFALL PIPELINE
STATOIL

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Location	: HF4 CP1	Date of Test	: 14-Jan-1990
Coordinates	:	Date of Plot	: 02-Dec-2003
Ground Level [m]	:	File name	: Hf4cp1.000
Cone used	: F7.5CKEW$_2$V 1515	Interpretation Checked by	: ...

31619-1 (01)

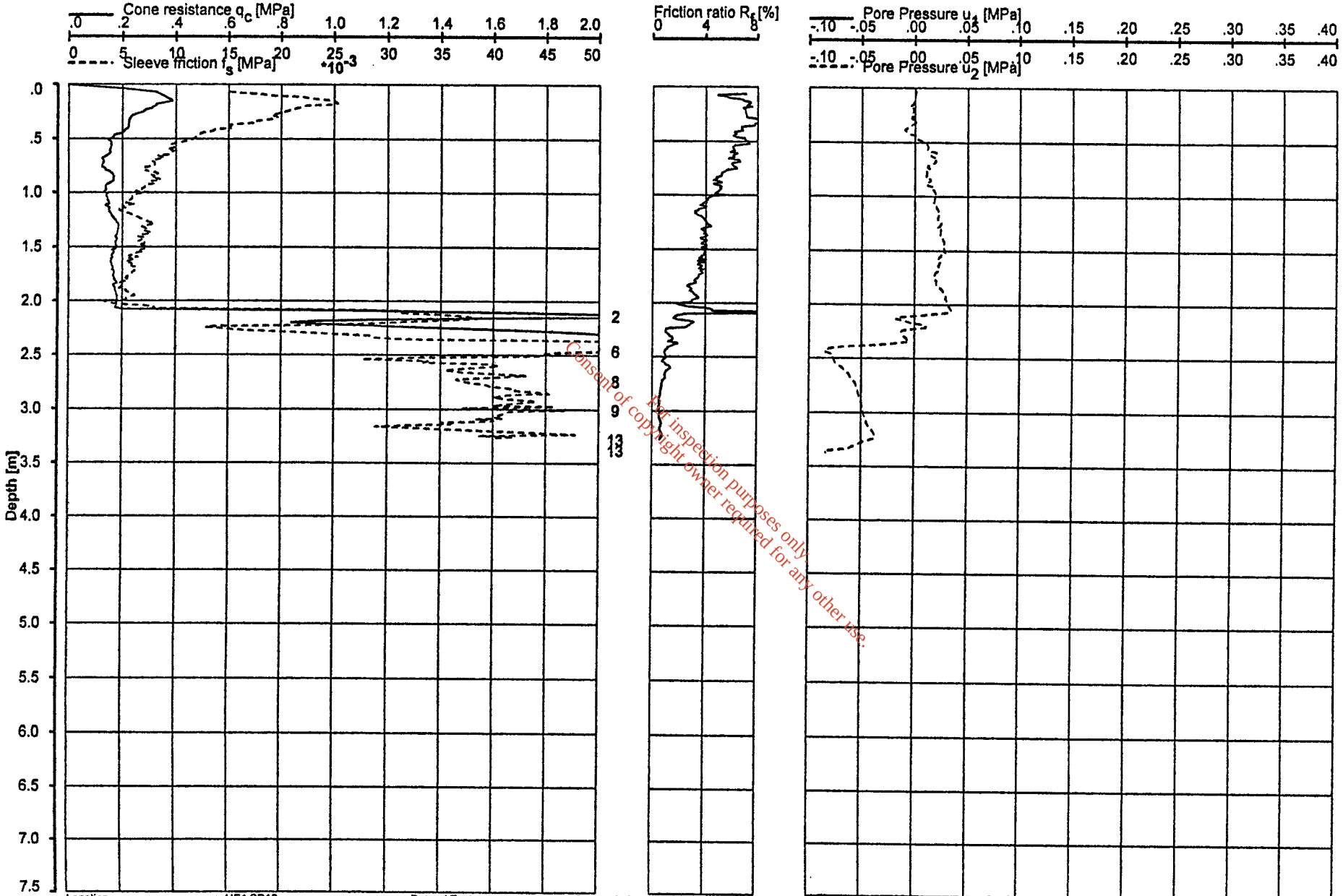
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Location	: HF4 CP10	Date of Test	: 15-Jan-1990
Coordinates	:	Date of Plot	: 02-Dec-2003
Ground Level [m]	:	File name	: Hf4cp10.000
Cone used	: F7.5CKEW$_2$/V 1515	Interpretation Checked by	: ...

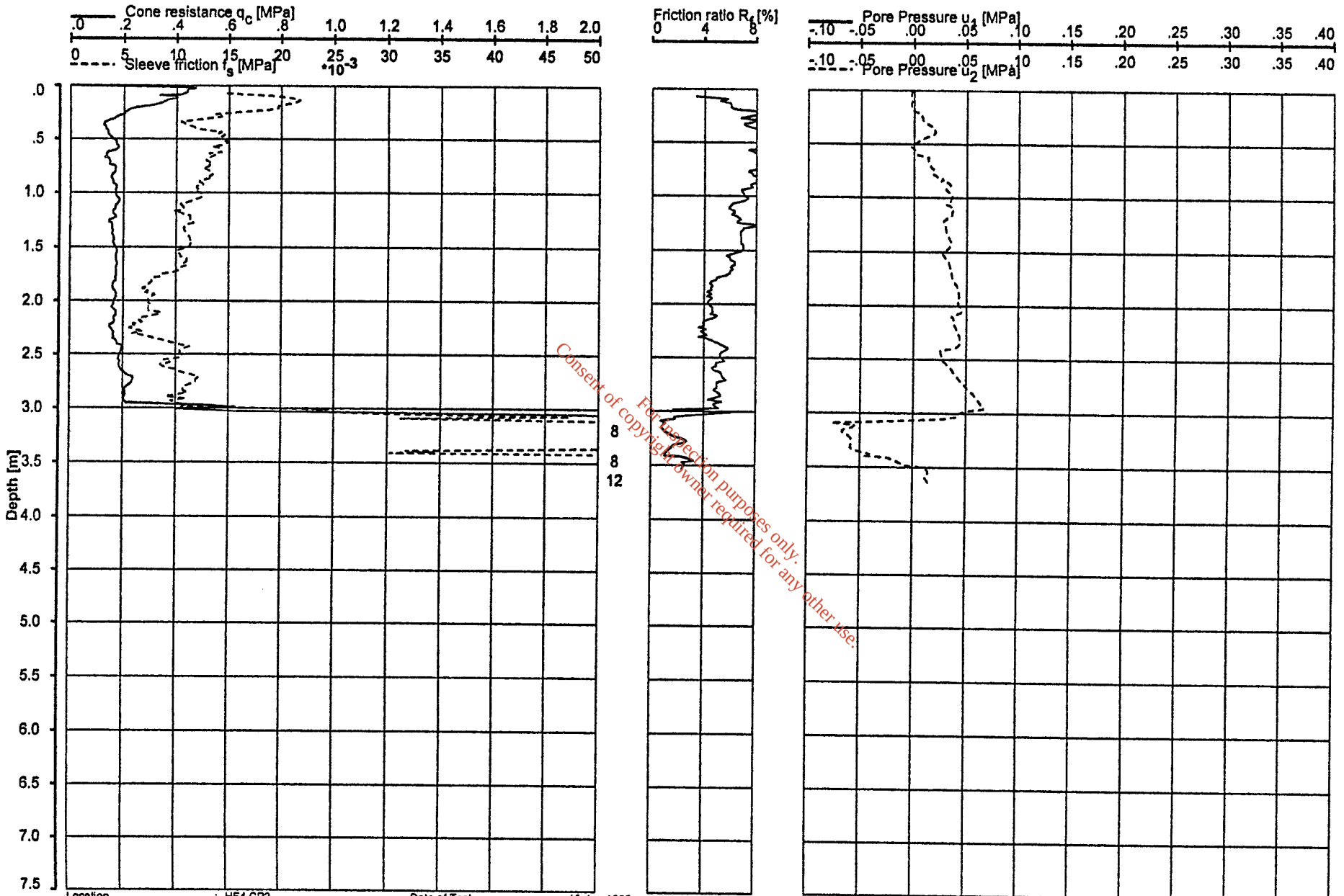
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Location : HF4 CP2
Coordinates :
Ground Level [m] :
Cone used : F7.5CKEW$_2$/V 1515

Date of Test : 15-Jan-1990
Date of Plot : 02-Dec-2003
File name : Hf4cp2.000
Interpretation Checked by : ...

31619-1 (01)

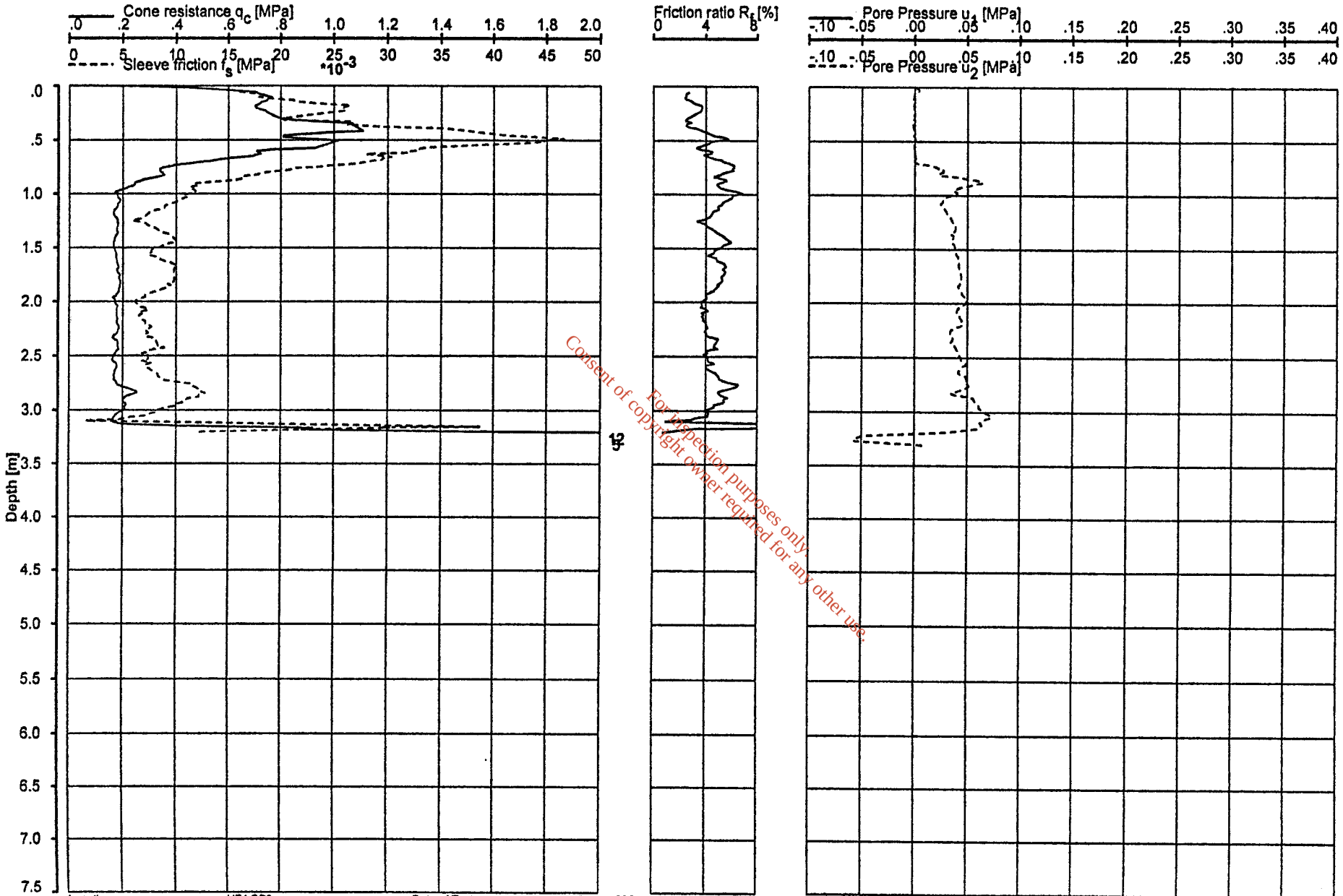
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UNIPLOT 02.15.NL /16:46:45/02QCFSU1.CMD Made by: dd: 4-Dec-2003 Checked by:



Location : HF4 CP3
Coordinates :
Ground Level [m] :
Cone used : F7.5CKEW$_2$/V 1515

Date of Test : 15-Jan-1990
Date of Plot : 02-Dec-2003
File name : Hf4cp3.000
Interpretation Checked by : ...

31619-1 (01)

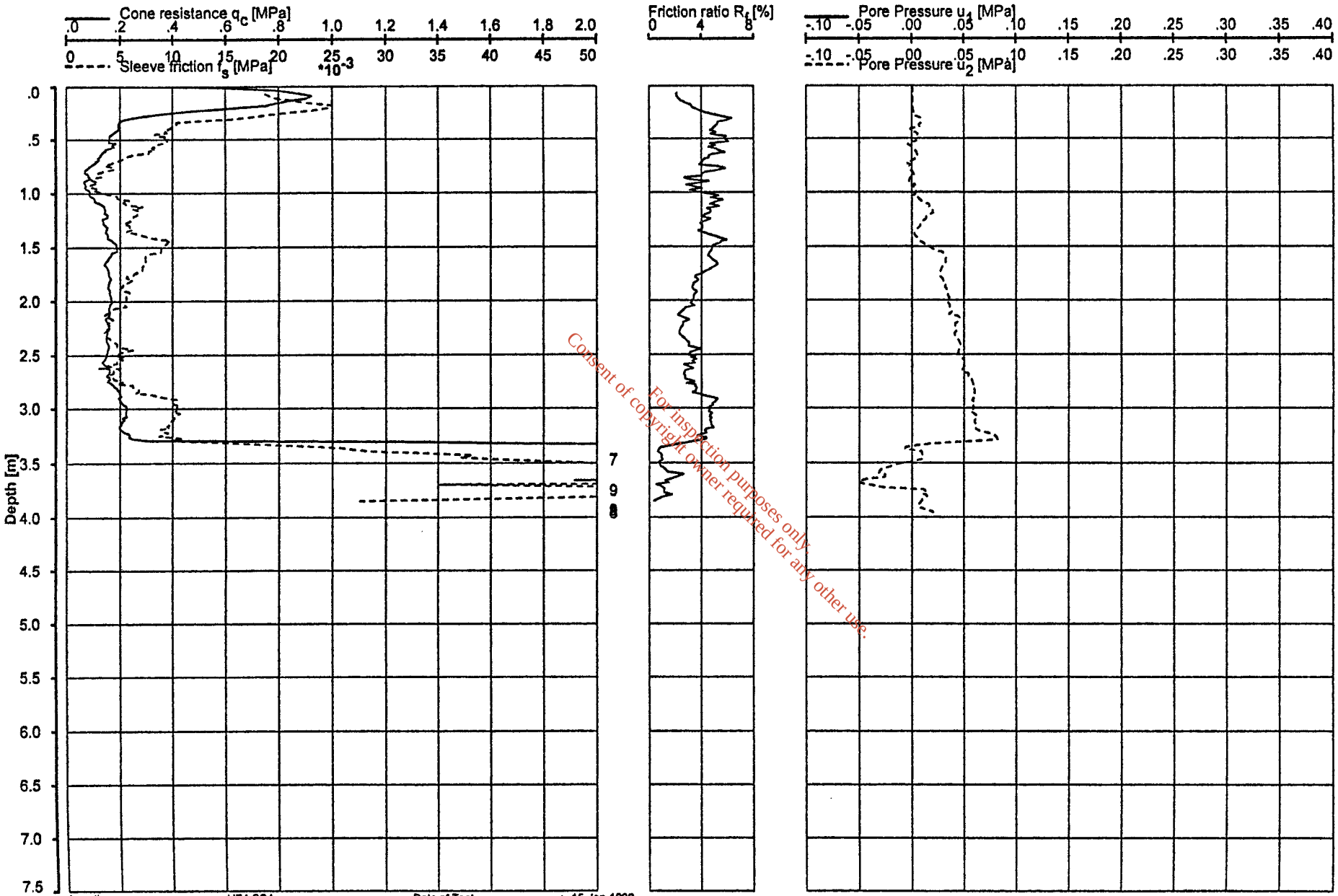
STATIC CONE PENETRATION TEST HF4 CP3
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Location	: HF4 CP4	Date of Test	: 15-Jan-1990
Coordinates	:	Date of Plot	: 02-Dec-2003
Ground Level [m]	:	File name	: Hf4cp4.000
Cone used	: F7.5CKEW$_2$/V 1515	Interpretation Checked by	: ...

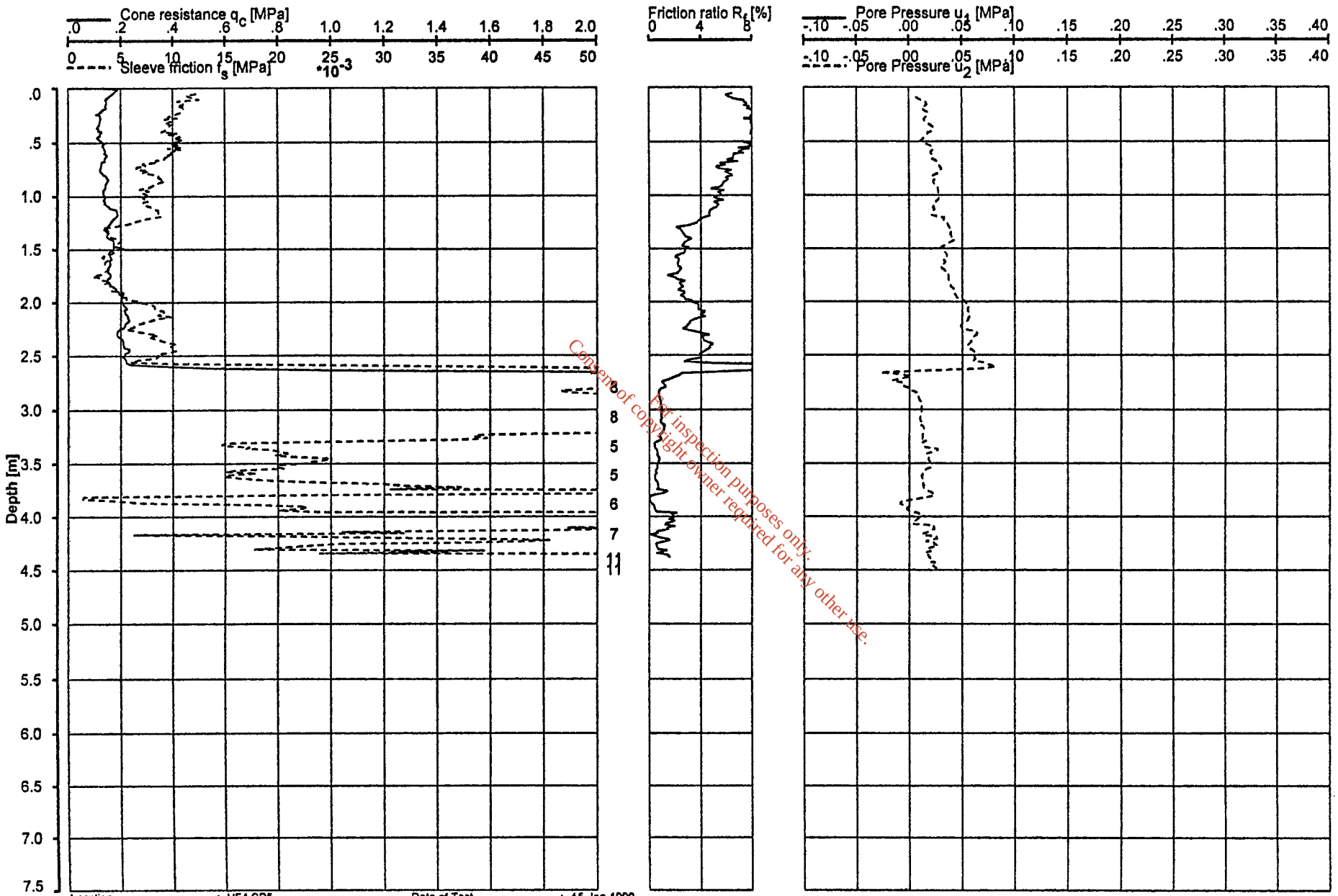
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STATIC CONE PENETRATION TEST HF4 CP4
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Location	: HF4 CP5	Date of Test	: 15-Jan-1990
Coordinates	:	Date of Plot	: 02-Dec-2003
Ground Level [m]	:	File name	: HF4CP5.000
Cone used	: F7.5CKEW$_2$/V 1515	Interpretation Checked by	: ...

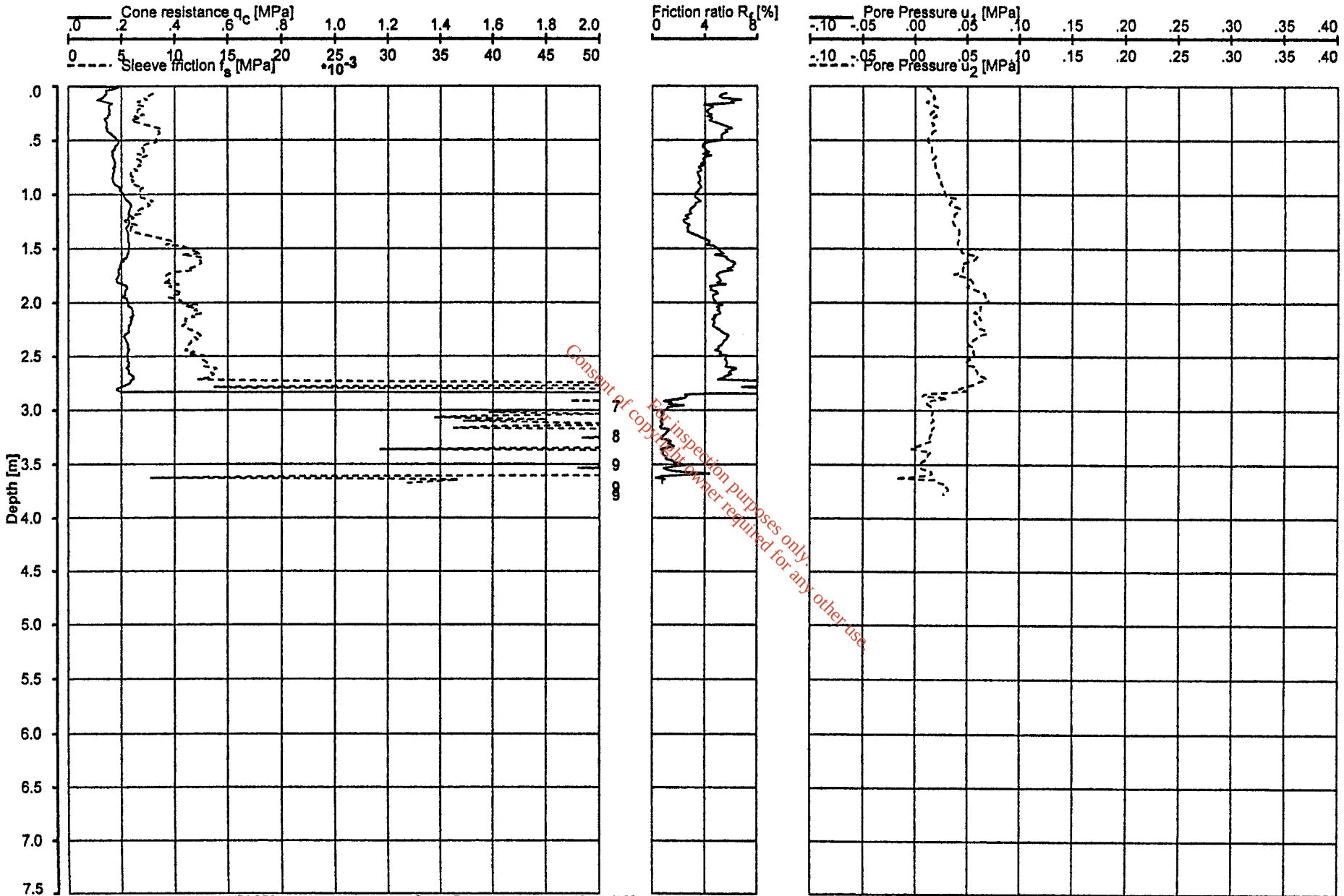
31619-1 (01)

STATIC CONE PENETRATION TEST HF4 CP5
EASINGTON LANFALL PIPELINE
STATOIL

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UNIPLOT 02.15.NL /16:48:46/02QCFSU1.CMD Made by: dd: 4-Dec-2003 Checked by:



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Location	: HF4 CP6	Date of Test	: 15-Jan-1990
Coordinates	:	Date of Plot	: 02-Dec-2003
Ground Level [m]	:	File name	: Hf4cp6.000
Cone used	: F7.5CKEW$_2$/V 1515	Interpretation Checked by	: ...

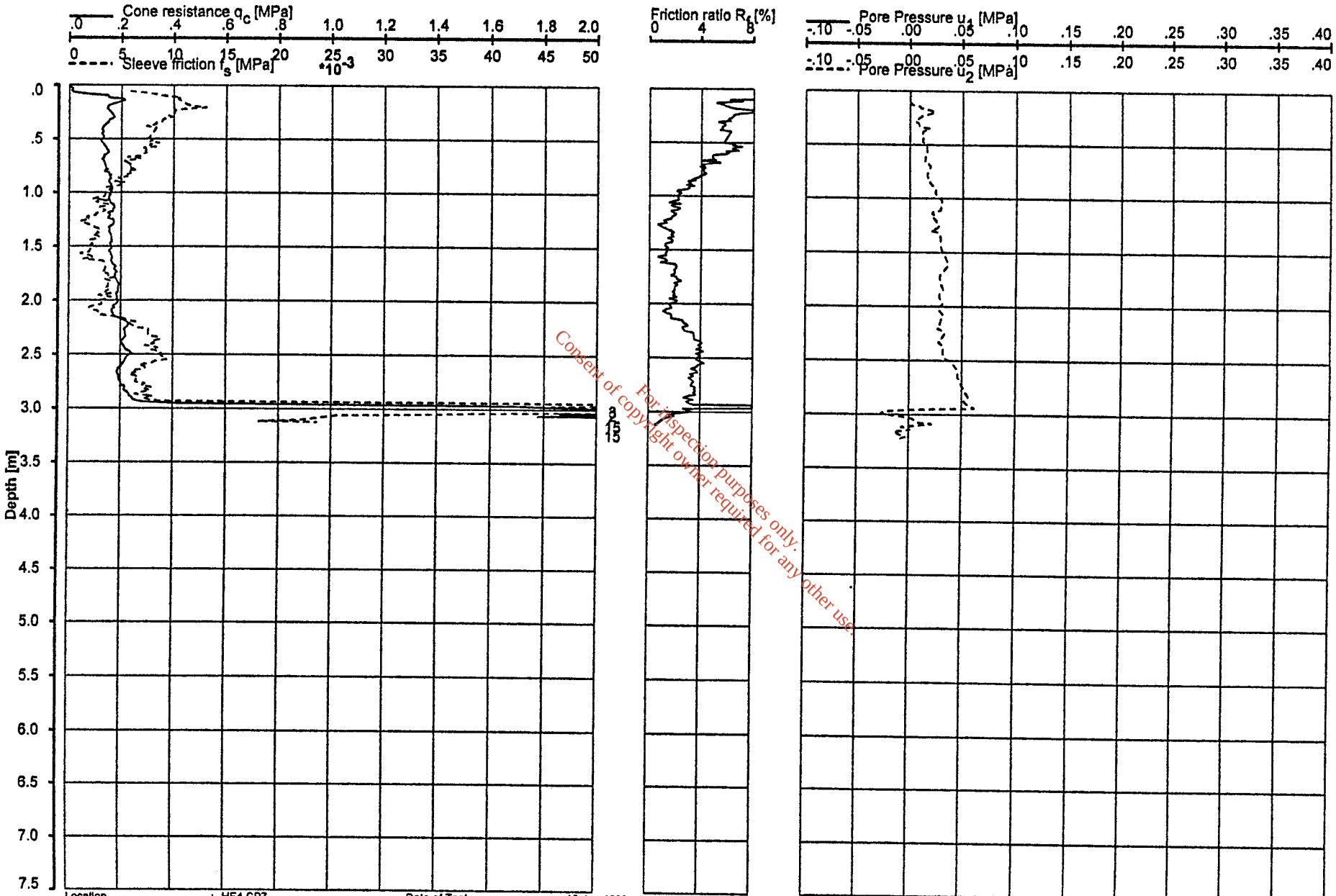
STATIC CONE PENETRATION TEST HF4 CP6
EASINGTON LANFALL PIPELINE
STATOIL

FUGRO ENGINEERING SERVICES LIMITED

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EPA Export 26-02-2014:23:31:09

UNIPLOT 02.15.NL /16:48:47/02QCFSU1.CMD Made by: dd: 4-Dec-2003 Checked by:



Location : HF4 CP7
Coordinates :
Ground Level [m] :
Cone used : F7.5CKEW$_2$/V 1515

Date of Test : 15-Jan-1990
Date of Plot : 02-Dec-2003
File name : Hf4cp7.000
Interpretation Checked by : ...

31619-1 (01)

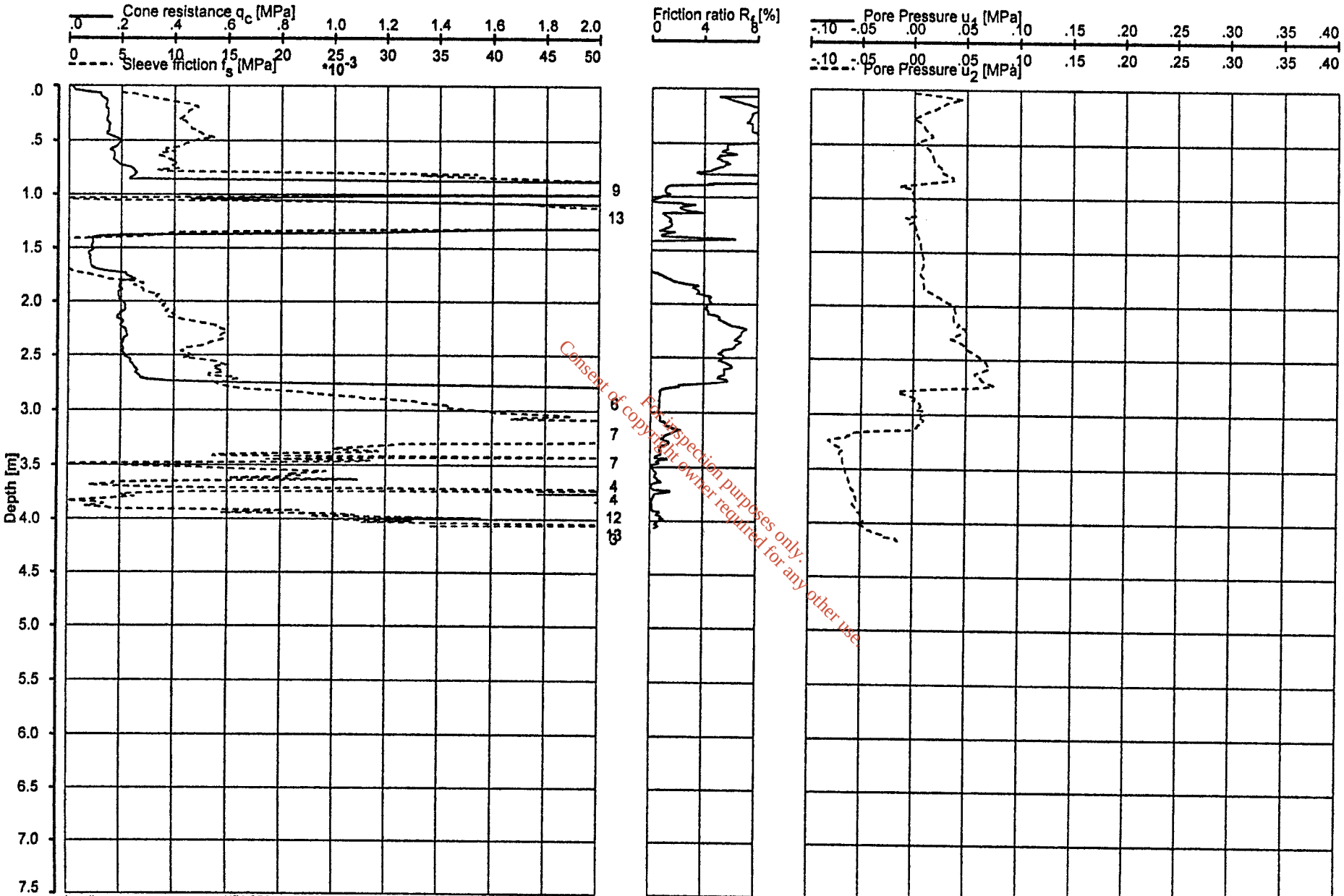
STATIC CONE PENETRATION TEST HF4 CP7
EASINGTON LANFALL PIPELINE
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Location	: HF4 CP8	Date of Test	: 15-Jan-1990
Coordinates	:	Date of Plot	: 02-Dec-2003
Ground Level [m]	:	File name	: Hf4cp8.000
Cone used	: F7.5CKEW$_2$/V 1515	Interpretation Checked by	: ...

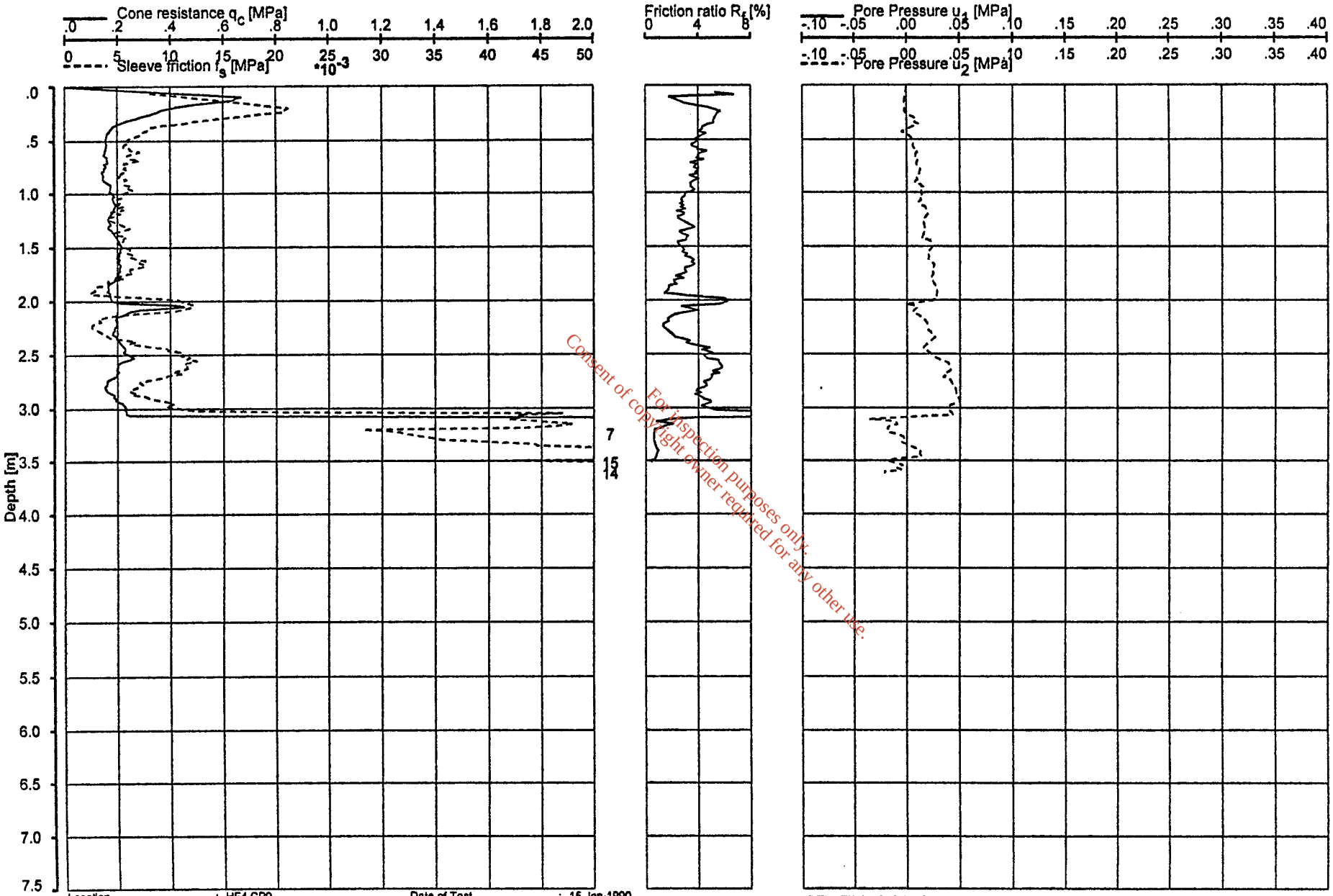
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STATIC CONE PENETRATION TEST HF4 CP8
EASINGTON LANFALL PIPELINE
STATOIL

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UNIPLOT 02.15.NL /16:48:48/02QCFSU1.CMD Made by: dd: 4-Dec-2003 Checked by:



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Location	: HF4 CP9	Date of Test	: 15-Jan-1990
Coordinates	:	Date of Plot	: 02-Dec-2003
Ground Level [m]	:	File name	: Hf4cp9.000
Cone used	: F7.5CKEW$_2$/V 1515	Interpretation Checked by	: ...

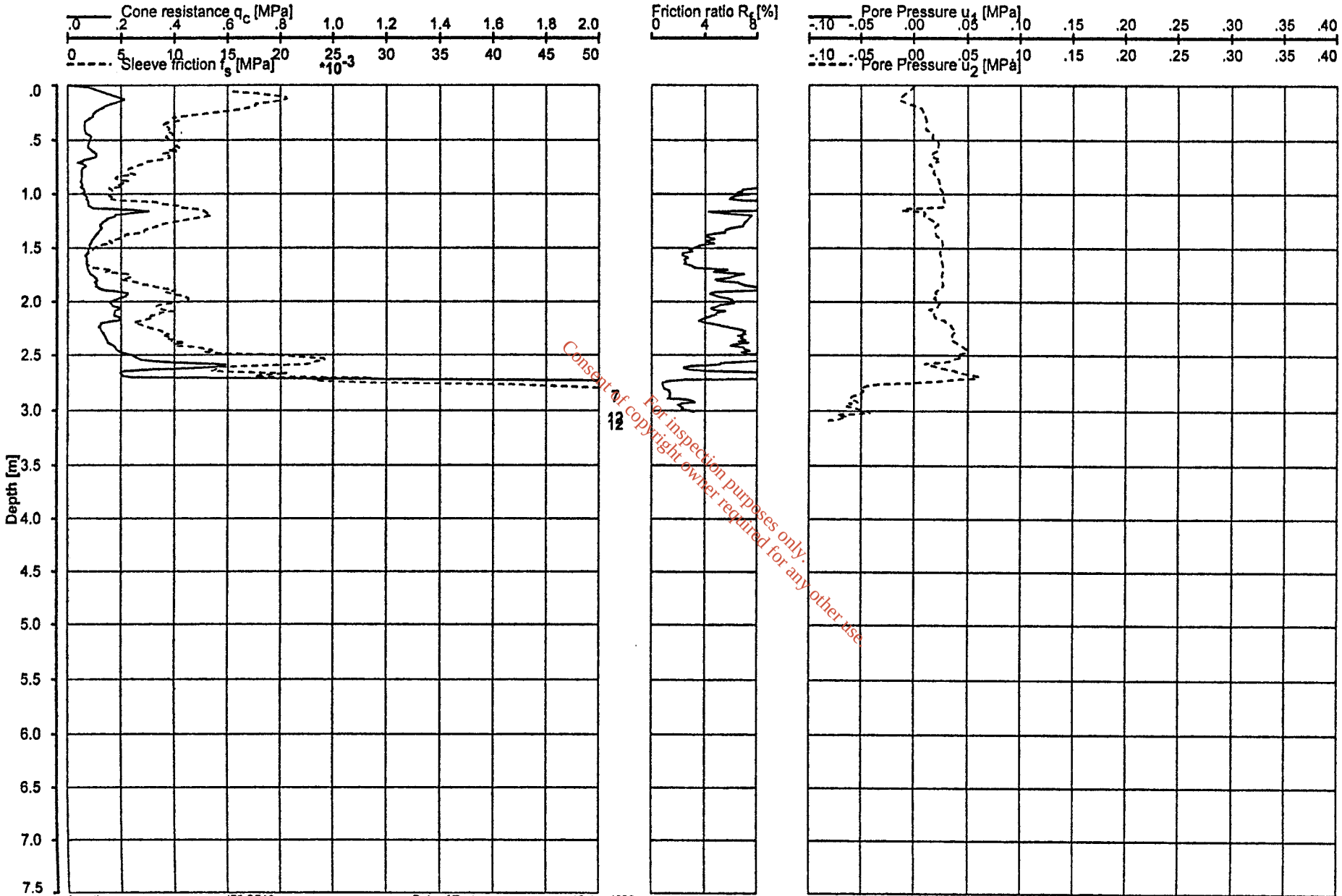
31619-1 (01)

STATIC CONE PENETRATION TEST HF4 CP9
EASINGTON LANFALL PIPELINE
STATOIL

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EPA Export 26-02-2014:23:31:09

UNIPLOT 02.15.NL /16:48:49/02QCFSU1.CMD Made by: dd: 4-Dec-2003 Checked by:



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Location	: IF2 CP10	Date of Test	: 16-Jan-1990
Coordinates	:	Date of Plot	: 02-Dec-2003
Ground Level [m]	:	File name	: Lf2cp10.000
Cone used	: F7.5CKEW$_2$/V 1515	Interpretation Checked by	: ...

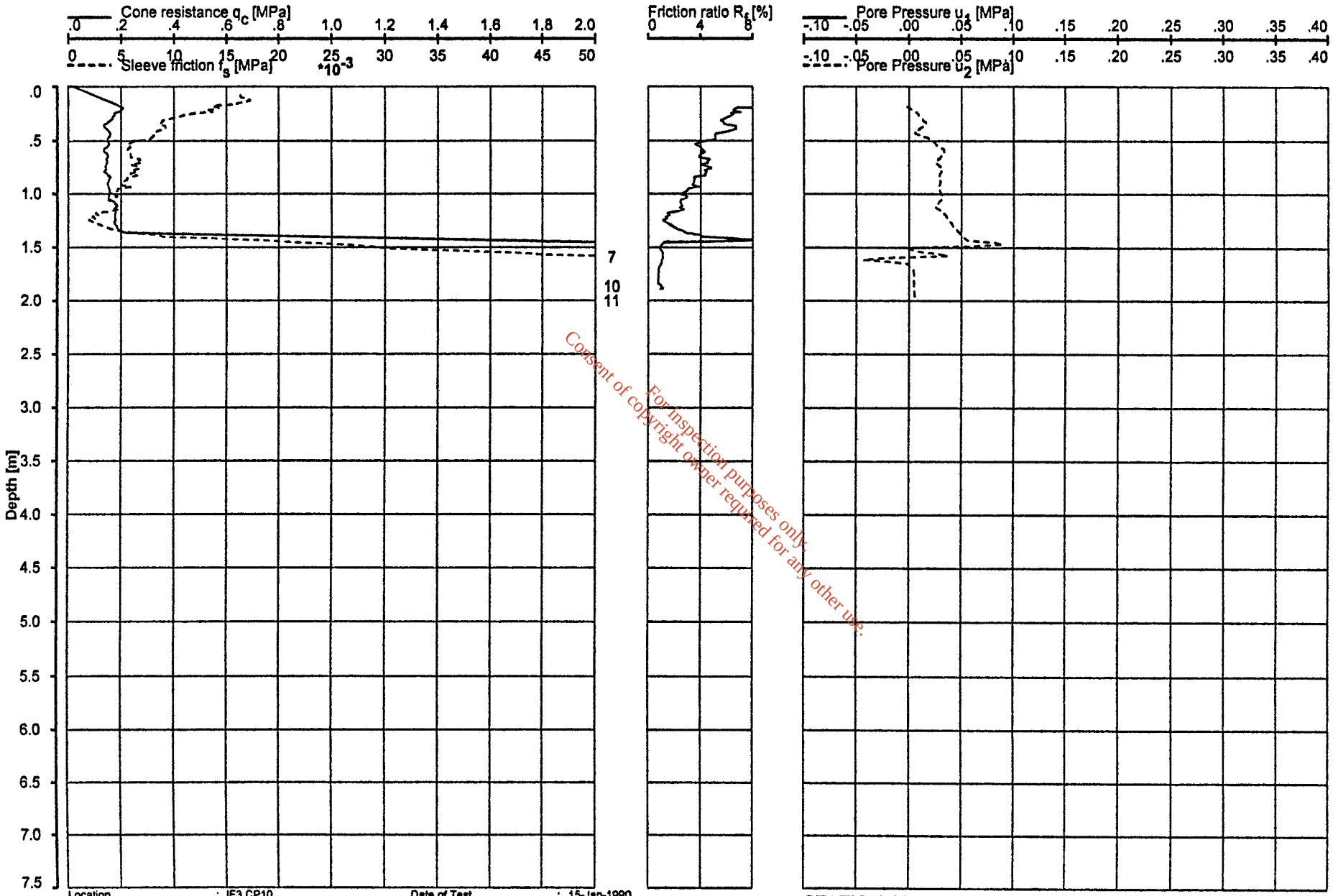
31619-1 (01)

STATIC CONE PENETRATION TEST IF2 CP10
EASINGTON LANFALL PIPELINE
STATOIL

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UNIPLOT 02.15.NL /16:48:49/02QCFSU1.CMD Made by: dd: 4-Dec-2003 Checked by:



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Location	: IF3 CP10	Date of Test	: 15-Jan-1990
Coordinates	:	Date of Plot	: 02-Dec-2003
Ground Level [m]	:	File name	: Lf3cp10.000
Cone used	: F7.5CKEW$_2$/V 1515	Interpretation Checked by	: ...

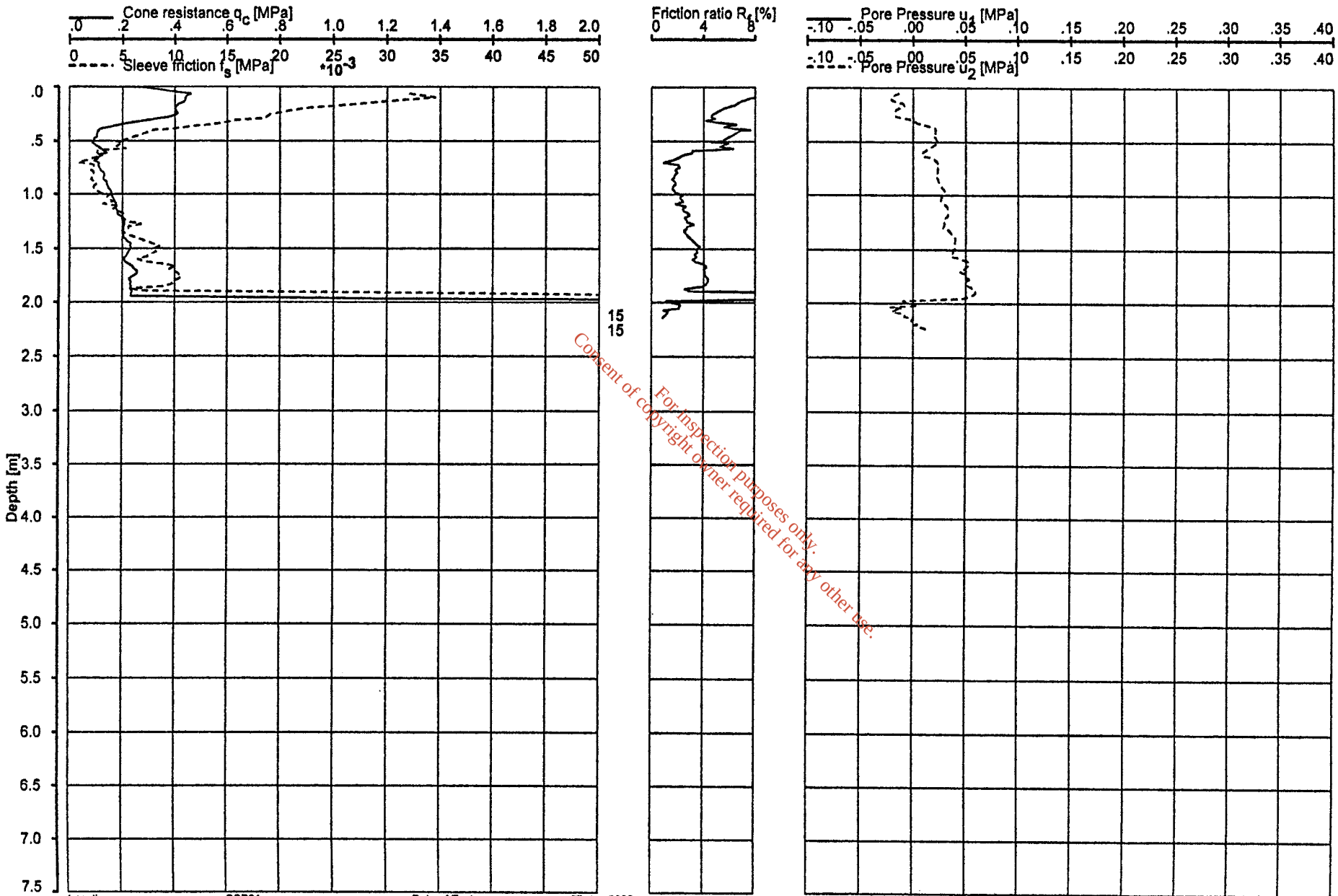
31619-1 (01)

STATIC CONE PENETRATION TEST IF3 CP10
EASINGTON LANFALL PIPELINE
STATOIL

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UNIPLOT 02.15.NL /16:48:50/02QCFSU1.CMD Made by: dd: 4-Dec-2003 Checked by:



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Location	: SCP01	Date of Test	: 27-dec-2003
Coordinates	:	Date of Plot	: 02-Dec-2003
Ground Level [m]	:	File name	: Scp01.000
Cone used	: F7.5CKEW$_2$/V 1515	Interpretation Checked by	: ...

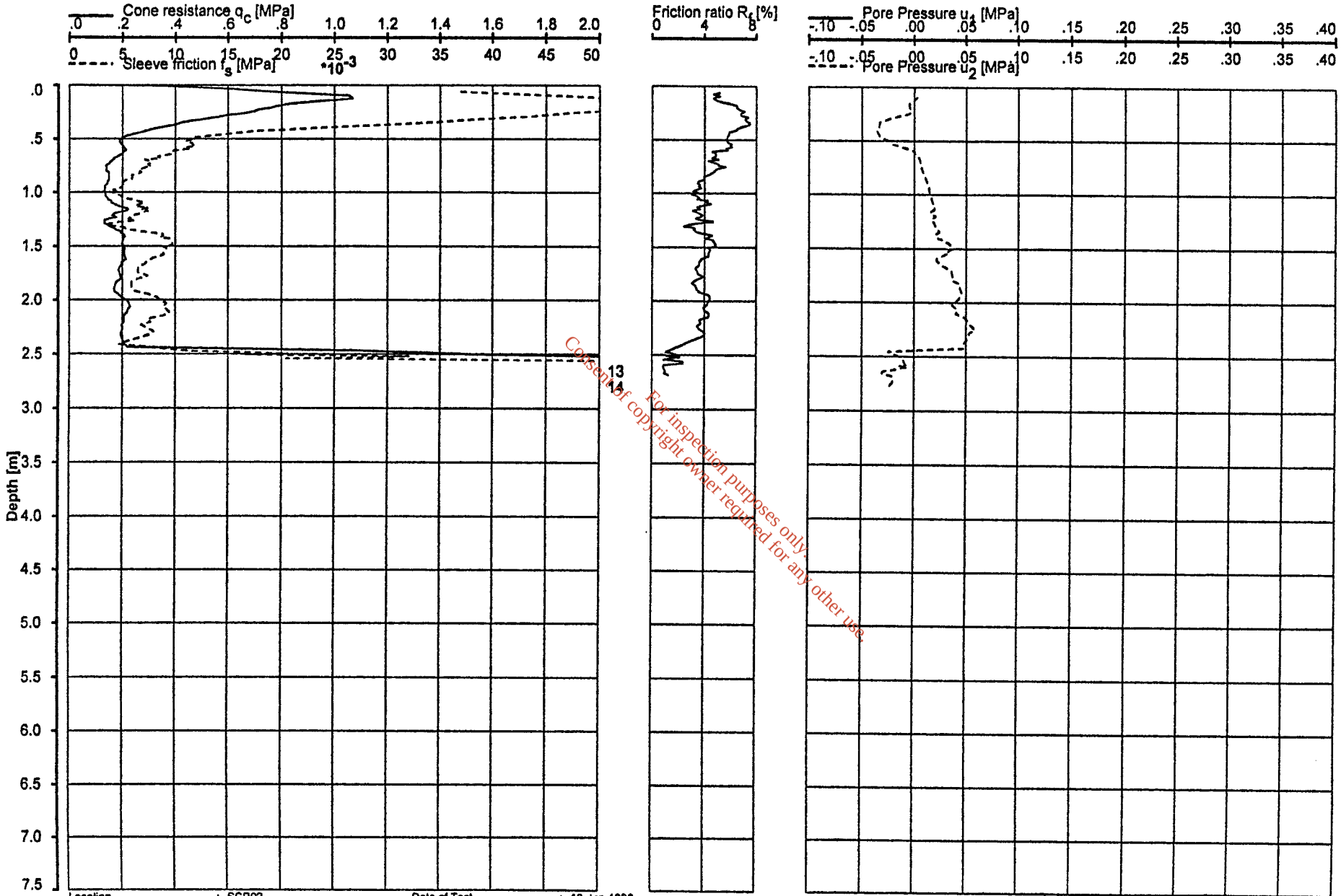
31619-1 (01)

STATIC CONE PENETRATION TEST SCP01
EASINGTON LANFALL PIPELINE
STATOIL

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EPA Export 26-02-2014:23:31:09

UNIPLOT 02.15.NL /16:48:50/02QCFSU1.CMD Made by: dd: 4-Dec-2003 Checked by:



Location : SCP02
Coordinates :
Ground Level [m] :
Cone used : F7.5CKEW$_2$/V 1515

Date of Test : 12-Jan-1990
Date of Plot : 02-Dec-2003
File name : Scp02.000
Interpretation Checked by : ...

31619-1 (01)

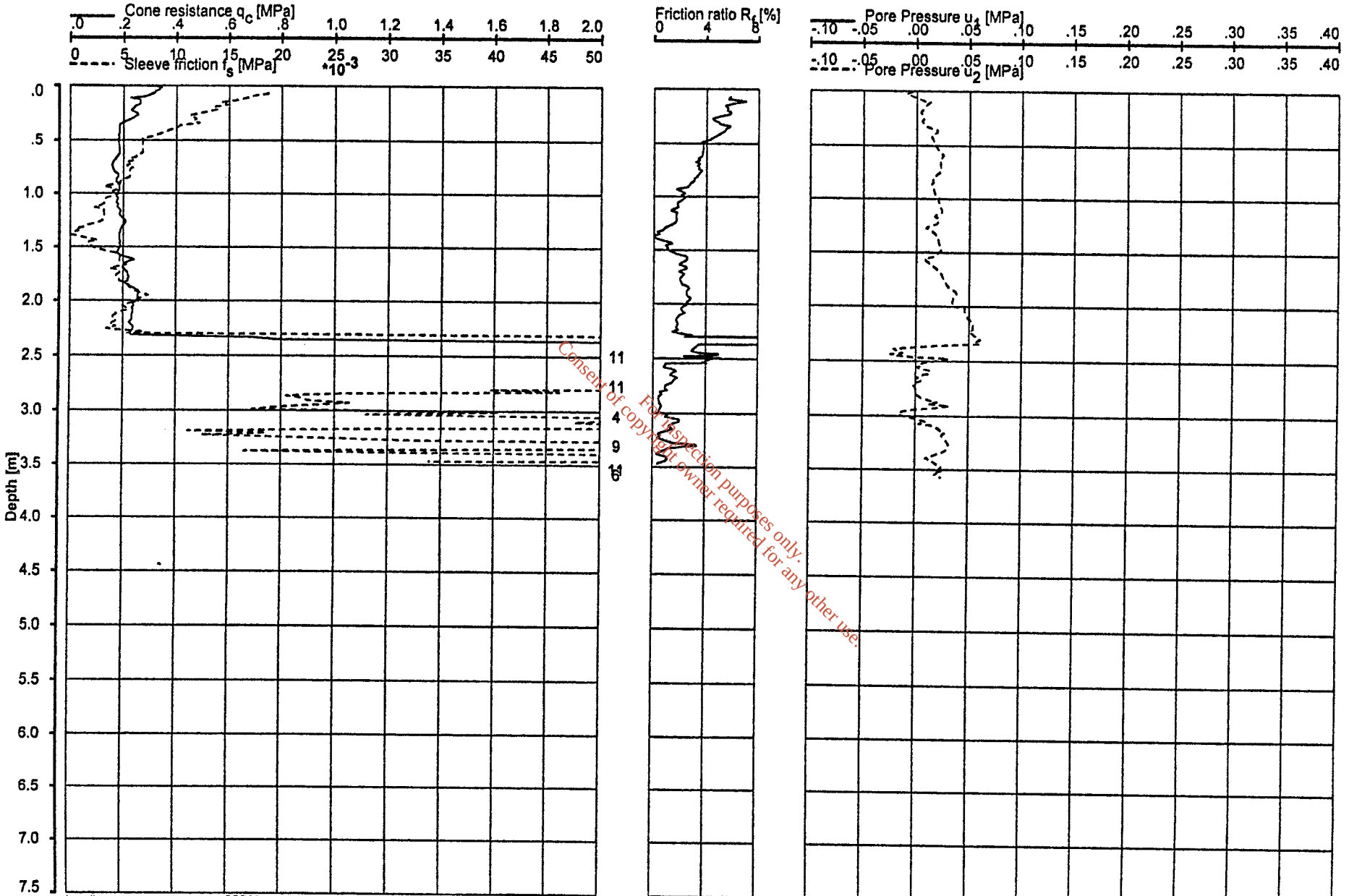
STATIC CONE PENETRATION TEST SCP02
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Location : SCP03
Coordinates :
Ground Level [m] :
Cone used : F7.5CKEW$_2$/V 1515

Date of Test : 13-Jan-1990
Date of Plot : 02-Dec-2003
File name : Scp03.000
Interpretation Checked by : ...

31619-1 (01)

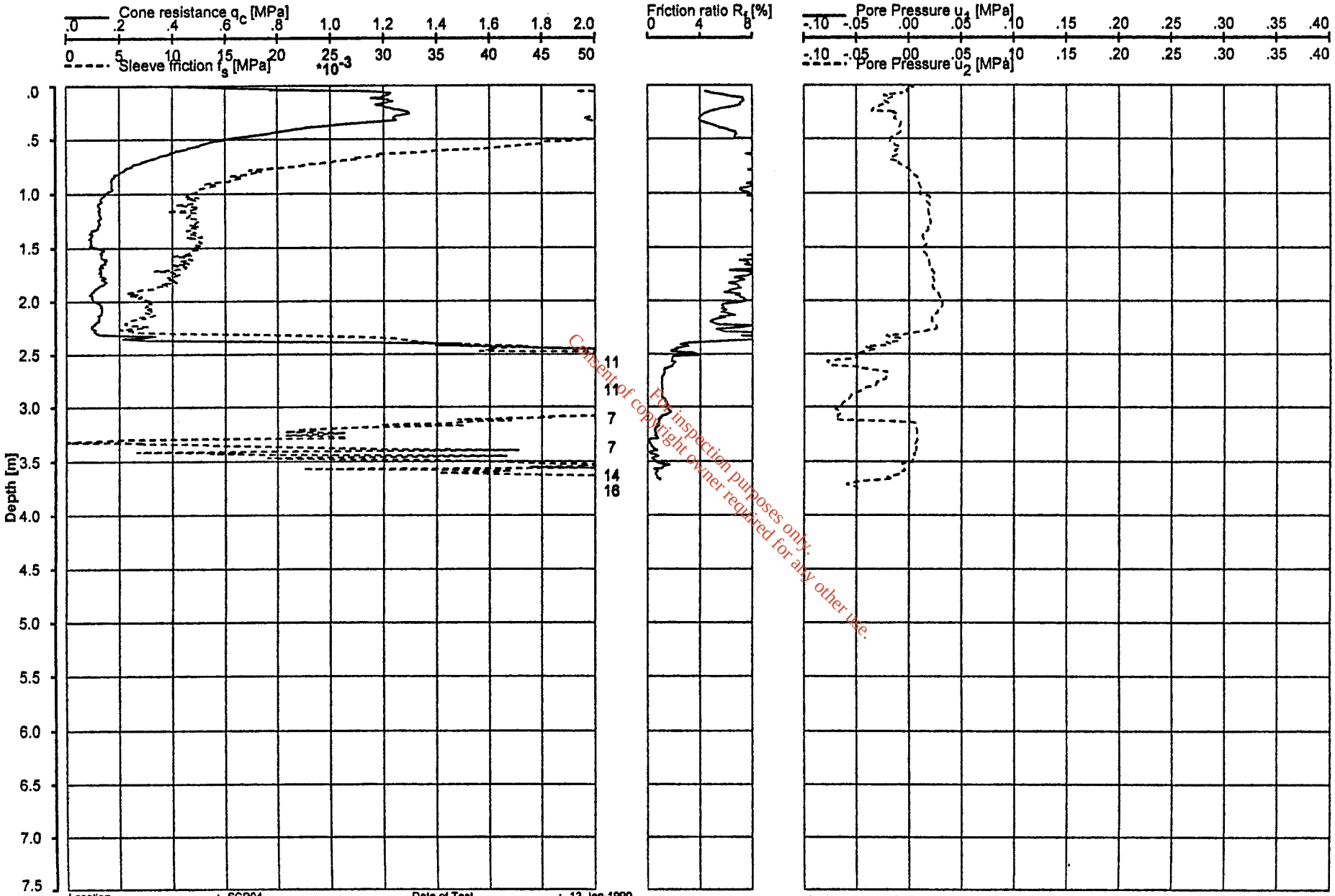
STATIC CONE PENETRATION TEST SCP03
EASINGTON LANFALL PIPELINE
STATOIL

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UNIPLOT 02.15.NL /16:48:51/02QCFSU1.CMD Made by: dd: 4-Dec-2003 Checked by:



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Location	: SCP04	Date of Test	: 13-Jan-1990
Coordinates	:	Date of Plot	: 02-Dec-2003
Ground Level [m]	:	File name	: Scp04.000
Cone used	: F7.5CKEW$_2$/V 1515	Interpretation Checked by	: ...

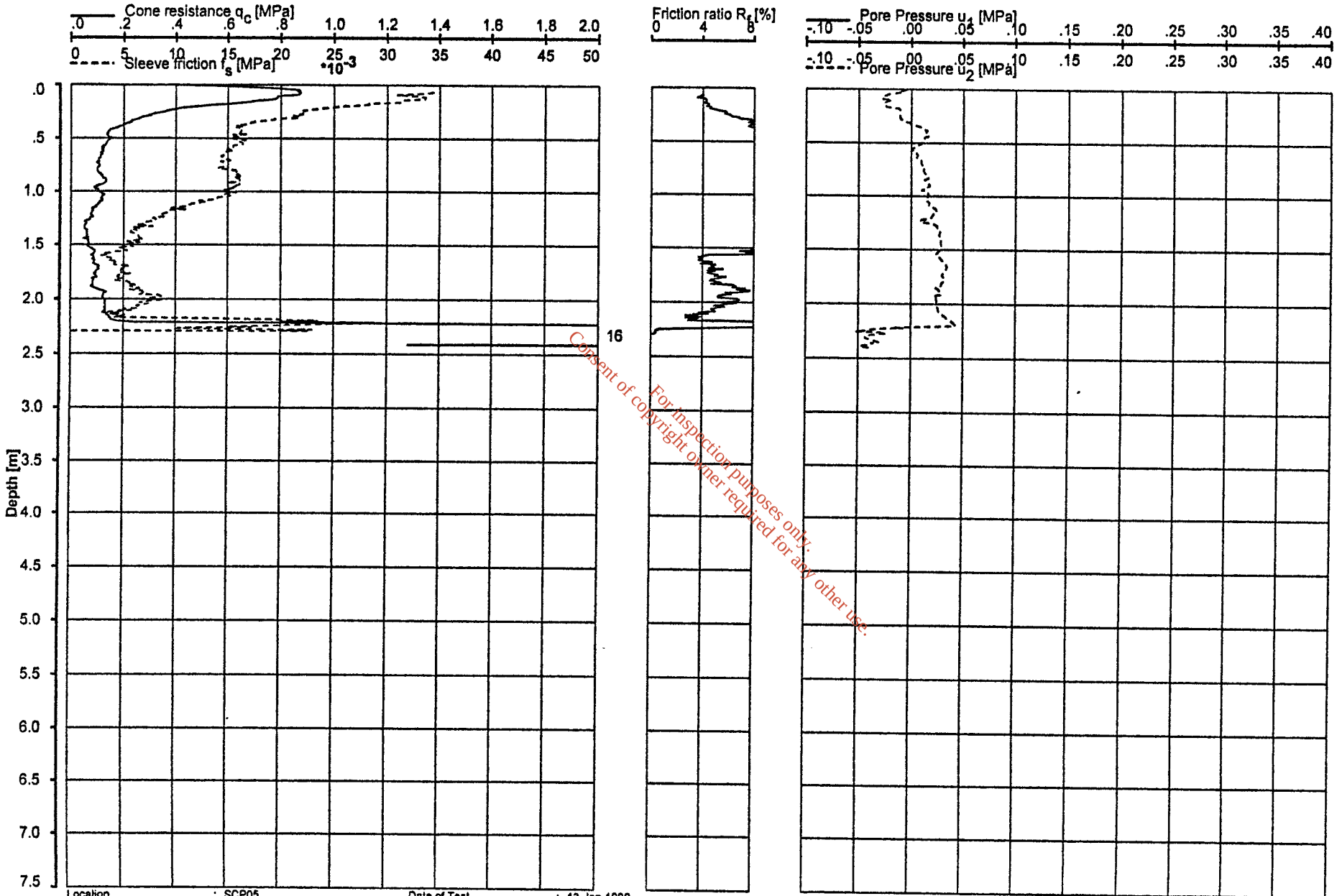
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STATIC CONE PENETRATION TEST SCP04
EASINGTON LANFALL PIPELINE
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Location	: SCP05	Date of Test	: 13-Jan-1990
Coordinates	:	Date of Plot	: 02-Dec-2003
Ground Level [m]	:	File name	: Scp05.000
Cone used	: F7.5CKEW$_2$/V 1515	Interpretation Checked by	: ...

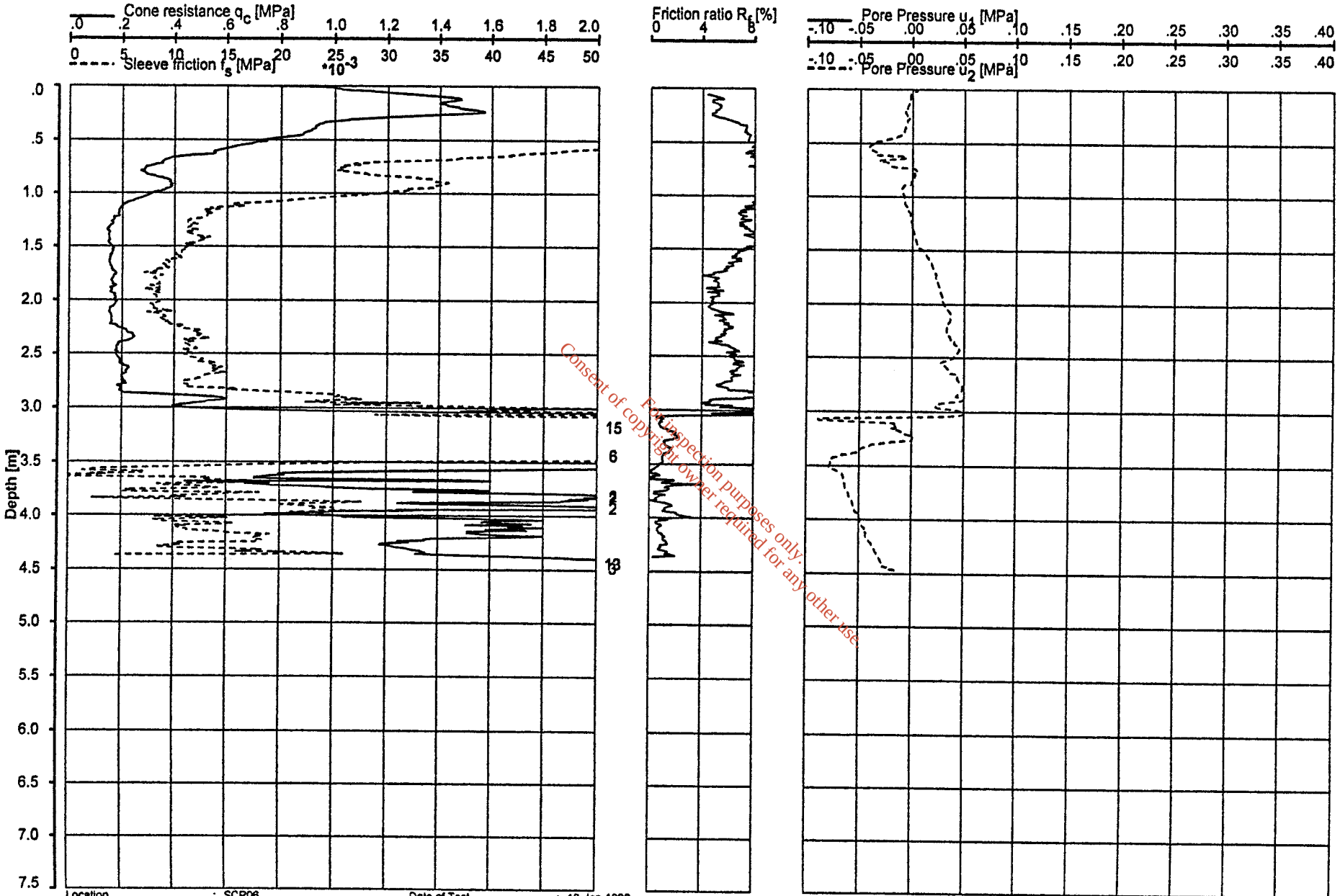
31619-1 (01)

STATIC CONE PENETRATION TEST SCP05
EASINGTON LANFALL PIPELINE
STATOIL

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Location	: SCP06	Date of Test	: 13-Jan-1990
Coordinates	:	Date of Plot	: 02-Dec-2003
Ground Level [m]	:	File name	: Scp06.000
Cone used	: F7.5CKEW$_2$/V 1515	Interpretation Checked by	: ...

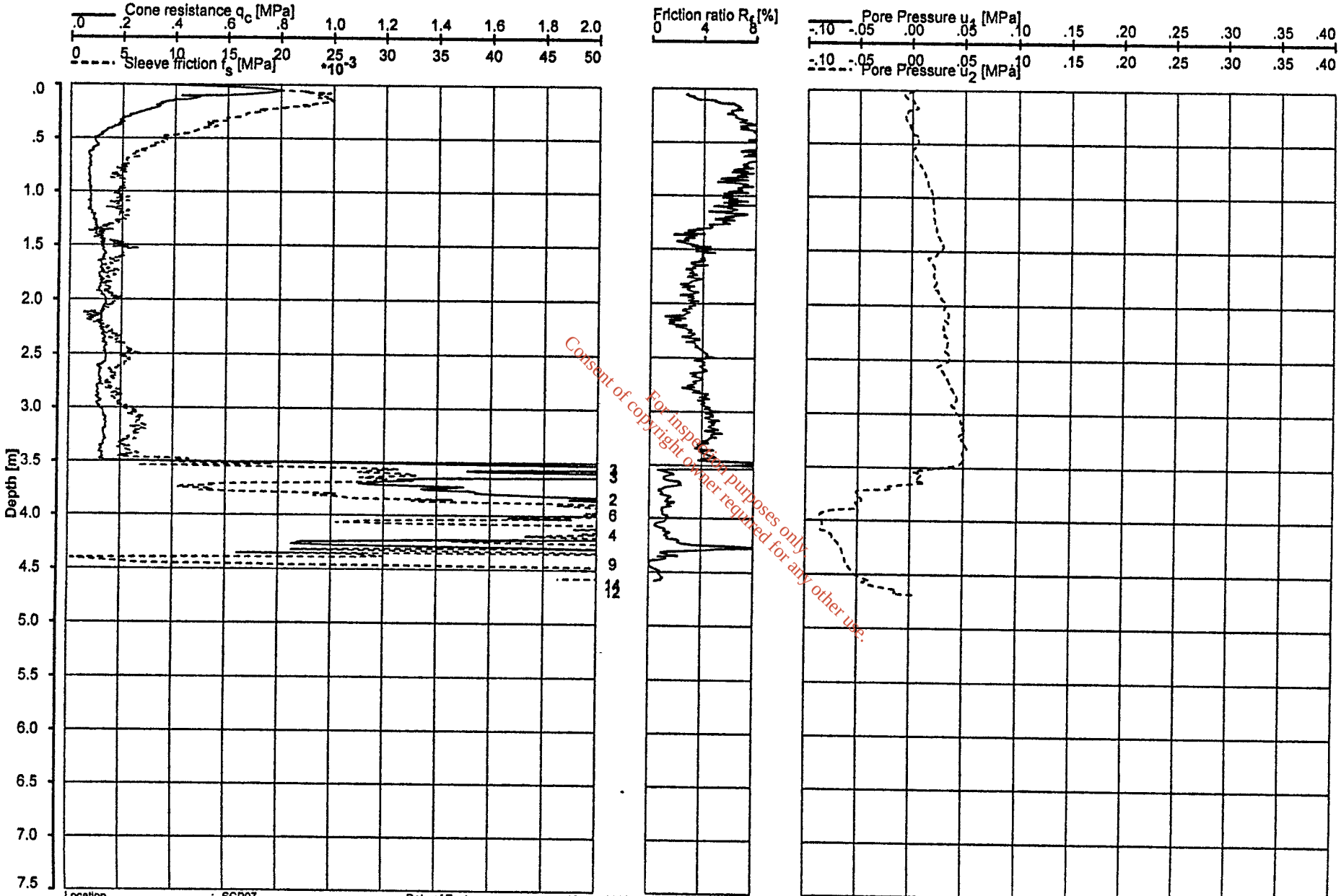
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STATIC CONE PENETRATION TEST SCP06
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Location	: SCP07	Date of Test	: 13-Jan-1990
Coordinates	:	Date of Plot	: 02-Dec-2003
Ground Level [m]	:	File name	: SCP07.000
Cone used	: F7.5CKEW$_2$/V 1515	Interpretation Checked by	: ...

31619-1 (01)

STATIC CONE PENETRATION TEST SCP07
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APPENDIX C REVIEW OF EFFECTIVE STRESS PARAMETERS FOR PEAT

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Reference	Cohesion, c' (kPa)	Friction angle, ϕ' (degs.)	Testing Apparatus/ Comments
Hanrahan et al (1967)	5 to 7	36 to 43	From triaxial apparatus
Rowe and Mylleville (1996)	2.5	28	From simple shear apparatus
Landva (1980)	2.4	27.1 to 32.5	Mainly ring shear apparatus for normal stress greater than 13kPa
	5 to 6	-	At zero normal stress
Farrell and Hebib (1998)	0	38	From ring shear and shear box apparatus
	0.61	31	From DSS apparatus. Result considered too low therefore DSS not considered appropriate
Rowe, Maclean and Soderman (1984)	1.1	26	From simple shear apparatus
	3	27	From DSS apparatus
Sandorini et al (1984)	4.5	28	From triaxial apparatus
McGreever and Farrell (1988)	6	38	From triaxial apparatus using soil with 20% organic content
	6	31	From shear box apparatus using soil with 20% organic content
Hungr and Evans (1985)	3.3	-	Back-analysed from failure
Madison et al (1996)	10	23	-

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Table: Review of Effective Stress Parameters for Peat

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APPENDIX D RISK REGISTER

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D.1 Geotechnical Risk Register

A Geotechnical Risk Register has been compiled to show the degree of risk attached to various elements of the design. The purpose of the register is to provide an outline description of the hazard, identify the potential likely cause, describe the consequence or impact of the hazard and identify the design and construction controls to be implemented in order to reduce the probability to a tolerable level. The overall application of the risk register will allow the management of geotechnical risk.

Whilst probability of a hazard occurring can be reduced to a minimum by geotechnical design, the probability cannot be reduced below Negligible. The likelihood of a hazard occurring has been judged on a qualitative scale. The scale has been derived from Clayton (2001) as follows:

Scale	Probability	Chance, per section of Works
>1	Negligible	< 10 %
2	Unlikely	10 – 30 %
3	Likely	30 – 50 %
4	Probable	50 – 70 %
5	Very Likely	> 70 %

Table of Qualitative Probability Scales

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The severity of the risk is also assessed qualitatively and depends on the risk tolerance. The risk results from the combination of the hazard and the impact/consequence. A similar qualitative scale has been derived for the impact of the hazard as follows:

Scale	Impact
5	Very High
4	High
3	Medium
2	Low
1	Very Low

Table of Qualitative Impact Scales

The impact of a hazard manifesting itself can be either financial, health & safety or environmental or combinations of all three.

The degree of risk is determined by combining the probability and impact assessments and has been judged against a third qualitative scale, the Risk Rating which includes a descriptive response as follows:

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Risk	Risk Rating	Response
1 to 4	Trivial	Monitor
5 to 8	Tolerable	Regular Attention
9 to 12	Substantial	Early Attention
13 to 25	Intolerable	Unacceptable

Table of Qualitative Risk Scales

The probability of a hazard manifesting itself can be reduced by geotechnical design but the impact cannot be influenced. Whilst a high impact event with low probability may have a similar risk rating as a low impact event with a high probability, the net effect of these separate hypothetical events may be viewed differently by the different parties involved with the project.

During construction, the ground conditions will be observed, monitored and recorded as appropriate. This will allow methods of construction and revision in design to be appropriately amended whilst the risks highlighted in the Geotechnical Risk Register are continuously monitored.

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HAZARD	CAUSE	IMPACT	Design Controls	Construction Controls	AFTER CONTROL			CONTINGENCY MEASURES
					P	I	R	
1. Rutting of haul road from transfer area to deposition area.	Over trafficking of previously unknown weaker surface areas.	Impede operations and/or loss of ground.	Incorporate geotextile with drainage layer material where required. Design appropriate geotechnical instrumentation for monitoring.	Place geotextile and drainage layer material where necessary.	0.5	1.5	0.75	Install additional geotextile, increase thickness of haul road, import selected granular material, switch to lighter construction plant, reduce trafficking.
2. Movement of placed peat over the top of highfield	Overestimating the geotechnical properties of the ex-situ peat and/or allowing the peat to be reworked to low shear strenghts. Drainage not provided or impeded.	Overtopping could allow movement of peat within depostion area blocking construction traffic. Loss of strength of placed material.	Review the site investigation of ex-situ peat and use conservative values for geotechnical parameters. Ensure no overfilling of placed peat.	Adopt construction measures to minimise disturbance of ex-situ peat. Provide adequate drainage and also maintain existing drainage. Adopt observational approach	0.75	2	1.5	Peat must be allowed to regain sufficient strength either by ceasing operations or some artificial means. Increased windrowing time for ex-situ peat prior to transport from gas terminal site.
3. Failure of internal highfield	Inadequate shear strength. Overloading of wagons. Too close spacing of wagons. Piling fill materials too high. Severe dynamic effects, e.g., imposing speed limits and requiring fills to be spread as trucks are emptied.	Loss of plant, closure of access, danger to operatives	Undertake conservative ground investigation & adopt conservative design strength.	Limit plant weight & spacing of plant. Limit loading on roadway. Adopt observational approach	1	2	2	Import selected granular material for improved strength & drainage, relocate access road.
4. Bog slide	Insufficient understanding of the mechanisms of failure and inadequate design. Presnce of weak peat.	Movement of placed and in-situ peat form depostion area. Cessation of works. Loss of ground. Existing and proposed drainage inundated.	Understand mechanisms of a 'bog slide' and assess the site for sliding potential, based on published information and site investigation data. Undertake stabilty analysis of the site.	Adopt observational approach	0.25	5	1.25	Cease operations, remove displaced material, provide check barriers to impede/contain slide.
5. Failure of perimeter highfield	Ground too weak.	Movement of placed and in-situ peat form depostion area. Cessation of works. Loss of ground. Existing and proposed drainage inundated.	Undertake comprehensive ground investigation, adopt conservative design parameters. Undertake stability analysis for design proposal.	Adopt observational approach	1	1	1	Import selected granular fill, flatten slope, use granular haunch.
6. Bearing failure of access road from R313	Inadeqaute strength in ground. Excess water in retained peat and access track. Inadequate drainage provisions.	Movement of ground below access road with loss of ground strength.	Undertake comprehensive ground investigation, interpret and adopt conservative design parameters. Provide design that avoids weak founding material.	Install geotechnical instrumentation prior to construction where road is o peat. Establish threshold/trigger values and engage appropriate personnel to monitor and interpret geotechnical instrumentation during and post construction. Where road is not founded on peat/weak material then no requirement for instrumentation and monitoring	1	4	4	Cease traffic operations. Excavate failed area and replace with selected granular fill.

Table: Preliminary Geotechnical Design for Srahmore Peat Deposition Site - Geotechnical Risk Register

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