Corrib natural gas

Corrib Gas Field Development

Environmental Impact Statement

Prepared in respect of the proposed Bellanaboy Bridge Gas Terminal and associated Srahmore Peat Deposition Site.

Volume 1:
Proposed Bellanaboy Bridge Gas Terminal
Bellanaboy Bridge
Bellagelly South
Co. Mayo

Prepared on behalf of
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RSK ENSR ENVIRONMENT LTD GENERAL NOTES

Project: No: P40,036

Title: Bellanaboy Bridge Terminal Environmental Impact Statement

Client: Shell E&P Ireland Limited

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Authorised by	David Taylor	Project Manager	Date	December 2003
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TABLE OF CONTENTS

Non-Technical Summary

Preamble

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

Preamble

Preamble

This Environmental Impact Statement (EIS) has been prepared by RSK ENSR Environment Ltd on behalf of Shell E&P Ireland Limited (Shell). It relates to a proposal to develop the Corrib natural gas field, which lies off the north-west coast of County Mayo. The Corrib field is an accumulation of natural gas located about 65km off the coast of County Mayo. Water depth in the area is about 350m. The gas is contained in rocks that lie at a depth of about 3.5km below the seabed.

The Corrib Field is of strategic importance to Ireland in that it will provide natural gas which will enhance continued security of indigenous supply.

The Corrib field is subject to a Petroleum Lease held by Shell (operator) (formerly Enterprise Energy Ireland Limited), Statoil Exploration (Ireland) Ltd and Marathon International Petroleum Hibernia Ltd. The field lies beyond the Irish Territorial Limit but on the continental shelf on which the Irish government, under the 1958 Geneva Convention on the Continental Shelf, has exclusive sovereign rights over hydrocarbon resources. There is no existing infrastructure in this area to support hydrocarbon production.

Shell wishes to develop the Corrib field on behalf of itself, Statoil and Marathon. It has declared Corrib to be commercially viable and applied to the then Minister of Marine and Natural Resources under the exploration licensing terms for a Petroleum Lease. This lease was granted in 2001. It has proposed that Corrib is developed as a subsea tieback to an onshore gas reception terminal (the Bellanaboy Bridge Terminal). The wells, which collect gas from the field, will be connected to equipment placed on the seabed (the manifold). The gas will be transported by a pipeline from the manifold to the terminal, the pipeline coming ashore at Dooncarton in Broadhaven Bay, County Mayo (the landfall). The gas will be treated in the terminal to ensure it meets the necessary sales gas specification.

The gas will be exported from the terminal via a Bord Gáis Éireann owned and operated pipeline to a tie-in located near Craughwell, Co. Galway. It is proposed that the terminal is located near Bellanaboy Bridge in the townland of Bellagelly South.

The proposed terminal site is at a gentle incline and is overlain by a layer of peat. In order to provide a level platform for the construction of the terminal, the peat will be excavated from the footprint of the terminal. The excavated peat will be transported to an area of cutover peatland near Bangor-Erris, where it will be placed, and where the peat is allowed to re-vegetate rapidly.

This EIS is a statement arising from an assessment of the direct and indirect effects of the onshore gas terminal on the environment.

The Scope and content of the EIS have been prepared having regard to the information requirements specified in the following legislation:

- Council Directive 85/337 (amended by Council Directive 97/11/EC);
- Part X of the Planning and Development Act, 2000 and Part X, and Schedules 5, 6, and 7 of the Planning and Development Regulations, (SI I600 of 2001);
- guidelines on the recommended information to be contained in Environmental Impact Statements, published by the Environmental Protection Agency (EPA) in 2002 and the EU Commission; and
- the requirements of Mayo County Council, as elaborated in the new County Development Plan (2003 – 2009), which came into force on 17th November 2003.

The development of the terminal facilities at Bellanaboy Bridge, Bellagelly South, and the associated peat deposition site at Srahmore, Bangor-Erris, are subject of a Planning Application to Mayo County Council.

This application contains all the required information stipulated under the Planning and Development Act 2000, and the Planning and Development Regulations 2001.

The Environmental Impact Statement submitted in support of the Planning Application has the following elements:

- Corrib Field Development Environmental Impact Statement, Bellanaboy Bridge Terminal; and
- Corrib Field Development Environmental Impact Statement, Peat Deposition Site.

Project History

The first Planning Application for the terminal development at Bellanaboy Bridge was lodged with Mayo County Council in November 2000. It was withdrawn in February 2001 due to material changes to the project. A new application was lodged in April 2001 and a request for further information was received from Mayo County Council in July 2001. This was responded to and Mayo County Council granted Planning Permission with Conditions on 3rd August 2001 . This decision was the subject of Appeals by Enterprise Energy Ireland Limited (now Shell) and a number of third parties and an Oral Hearing was held in Ballina County Mayo in

February-March 2002. The Inspector decided that further information was required on the subjects of Alternatives, Visual Impact, Peat Stability and Health and Safety. This information was provided in September 2002 and the Oral Hearing was reconvened in November/December 2002. The Inspector's report recommended rejection on the above grounds. An Bord Pleanála followed the Inspector's recommendation only on the peat stability issue and refused permission on that ground. Shell decided to revisit all alternatives for the Corrib project as well as the site design and development with a view to submitting a new application having taken account of the Board's concerns.

In order to assist the review of this new EIS, changes to the proposed development are listed in Table P1.

The Developer

Shell E&P Ireland Limited is a wholly owned subsidiary of the Royal Dutch/Shell Group of Companies. The companies in the group are engaged in the business of Exploration and Production, Gas and Power, Oil Products, Chemicals and Renewables as well as other activities**.** The group operates in over 145 countries and employs more than 115,000 people.

Shell set up its first headquarters in Ireland in 1908, and built the country's first bulk terminal at Foynes, Co. Limerick. An office was opened in Belfast in 1922. Shell in Ireland has businesses in Oil Products and Chemicals (Irish Shell Limited) and Exploration and Production (Shell E&P Ireland Limited).

Shell E&P Ireland Limited is part of Shell's E&P Europe organisation, which has extensive experience in operating subsea developments and has safely operated major onshore and offshore gas fields in Europe since the 1960's.

About sixty people are now employed in Ireland working on the Corrib development and related projects. This includes a project office in Bangor-Erris with two full time staff. The number of jobs will rise to about 500 during construction. A further 50 people approximately, will be recruited for the long term operation of the terminal facility at Bellanaboy.

The Corrib Licence Co-venturers

The company's co-venturers in the Corrib development have considerable experience in the development and production of hydrocarbon facilities. Marathon, a subsidiary of Marathon Oil (US based) developed the Kinsale Head gas field offshore Cork in the mid seventies, and has operated in Ireland ever since. Statoil, with its head office in Norway, is the largest oil producer in the North Sea. Statoil operates gas and oil terminals, refineries and pipeline transport systems, and has had a presence in Ireland, both in exploration and in the marketing and distribution of petroleum products, since the early nineties.

The Corrib joint venture thus brings together extensive experience in subsea oil and gas developments, offshore and onshore pipelines and in the construction and operation of oil and gas terminals.

List of Contributors and Experts

The preparation of this volume of the EIS has been co-ordinated by RSK ENSR Environment Ltd, who also prepared the briefing documentation for specialist consultants, as well as a number of the EIS sections. Table P2 details the contribution of each company, whilst Table P3 shows a list of the individual contributors and experts who contributed to this document.

Sources of Information

The assessment of the proposed Bellanaboy Bridge Terminal development has been based on detailed data provided by Shell, Kvaerner the Front End Engineering Design (FEED) contractor, AMEC, the detailed engineering design contractor and various studies carried out on behalf of Shell. Best practice techniques, using latest software programs (where applicable) have been used. All relevant Irish and European legislation has been complied with in this assessment.

Where appropriate, surveys and references are identified, as are the relevant specialist sub-consultants who prepared reports on the proposed terminal.

Consultation

Consultation with government departments and other agencies was a key component of the EIA. The main organisations contacted were:

- Government Departments;
- Mayo County Council;
- National Parks and Wildlife Service, and the National Monuments and Architectural Protection Service of the Department Environment Heritage and Local Government (DoEH&LG), (formerly Dúchas);
- The Environmental Protection Agency (EPA);
- local community/residents groups;
- An Taisce (NGO);
- North Western Regional Fisheries Board;
- tourism industry ;

- National Museum of Ireland;
- Department of Communications, Marine and Natural Resources / Marine Institute; and
- The Geological Survey of Ireland.

In addition, a series of public exhibitions were held and the feedback has been incorporated into this EIS.

Table P4 below summarises the key concerns raised by consultees and references where they have been addressed in the EIS.

An Environmental Monitoring Group, which has representation from Mayo County Council, The Department of Communications, Marine and Natural Resources, Shell, The National Parks and Wildlife Service (formerly Dúchas), The North Western Regional Fisheries Board, local fishing interests and local residents, has been established to monitor all stages of construction and development of the Corrib field and compliance with the Environmental Management Systems as they apply to the various stages of the development.

Technical Difficulties

In the preparation of this EIS there were no technical difficulties or lack of know how encountered which would result in the EIS being incomplete or lacking in the assessment of impacts due to inadequate type or volume of data.

Table P1 Changes to Scheme

Changes to Scheme		
Main differences between this EIS and the April 2001 Terminal EIS		
No.	**Change**	**Comment**
1	Tanker loading station moved.	As a result of layout changes. It will improve the security of the facility in respect of management of spills.
2	Heating medium heaters to be horizontal.	Reduced visual impact.
3	Water treatment plant details	As a result of detailed design. No change to impacts.
4	Peat Management (removal to Bord na Móna site)	Deals with concerns raised by third parties and ABP in respect of peat stability and impacts on drainage.
5	Reduction in extent of peat removal footprint from 15 Ha to 11 Ha with associated layout changes.	Reduces the volume of peat to be excavated.
6	Changes in buildings / architectural philosophy.	To reflect layout changes.
7	Changes in footprint elevation to 33.4m AOD Malin.	Slightly raises the overall height of all plant buildings to optimise the cut / fill balance.
8	Re-use on site the materials not suitable for engineering fill.	These mineral soils will be used for bulk fill including landscaping.
9	Exit/entry roads.	To reflect current scheme.
10	Height of flare stack.	In order to minimise the amount of peat to be excavated the flare stack will be founded at existing ground level but supported on piles.
11	Fencing changed.	Site security fence will not be electrified.
12	Construction methodology.	Revisions as a result of detailed earthworks design and the decision to remove peat from site.
13	Foundations of control building and administration block now on piles.	Reduces volume of peat to be removed and reduces the potential for differential settlement.
14	Landscaping.	Improved to reflect current scheme.
15	Waste storage area.	Adjacent to firewater pump building to minimise footprint.
16	Firewater retention pond.	This will provide a secure area where used firewater can be contained.
17	Road widening at entrance.	Improves access and visibility for drivers entering and leaving site with consequent improvement in safety.
18	Outfall moved.	The long sea outfall has been moved beyond Broadhaven Bay in accordance with licence requirements set by the Minister for Communication, Marine and Natural Resources.
19	Colour scheme.	Subtle changes with use of two greys on the terminal buildings.

Table P2 EIS Contribution from Specialist Consultants

Specialist Consultants	EIS Contribution
RSK ENSR Environment Ltd	Preamble Introduction· Description of Proposed Development· Construction· Alternatives· Aquatic Ecology Soils, Geology and Hydrogeology· Hydrology and Drainage Effluent Air Emissions Climate Landscape and Visual Impact Material Assets (Solid Waste) Mitigation and Impact Summary and Impact Interactions Cumulative Impacts Sustainable Development· Environmental Management
Alan Saunders Associates	Noise
Tom Phillips Associates	Human Beings Architectural Heritage and Language
Margaret Gowan Associates	Archaeological Heritage
Ecological Advisory and Consultancy Services	Flora and Fauna
FaberMaunsell	Material Assets (Traffic)
Kirk McClure Morton	Marine dispersion modelling
Brady Shipman Martin	Photomontage Study / Landscape and Visual Impact Assessment
Minerex Environment Limited	Hydrological and Hydrogeological Surveys
Amec	Description of Proposed Development Construction Water Peat Air Emissions Material Assets (Solid Waste) Process Description Civil and Architectural Design Detailed Engineering Design
Wood Environmental Management Ltd	Water Quality Surveys Baseline Air Quality Monitoring
Arup Consulting Engineers	Review of EIS (Independent Peer Review) Alternatives
Tobin Consulting Engineers	Haul route Traffic management and road up grade study

Table P3 List of Contributors and Experts

Company	Name	Qualifications
Alan Saunders Associates	Ed Clarke	BEng(Hons) Engineering Acoustics & Vibration Dynamics, MIOA
Arup Consulting Engineers	John Redding	BSc Geology, PhD Marine Geology, FGS, MIG
Arup Consulting Engineers	Ria Lyden	BE, MBA, Ceng, MIEI, MIStructE
Brady Shipman Martin	John Kelly	BArch
Brady Shipman Martin	Thomas Burns	BAgr Sc. (Land Hort) Dip.EIA Management MILI
Ecological Advisory and Consultancy Services (EACS) and Associates	Conor Kelleher	Bat specialist/handler
Ecological Advisory and Consultancy Services (EACS) and Associates	Dr Christopher Smal	B.Sc. Hons. PhD MIEEM
Ecological Advisory and Consultancy Services (EACS) and Associates	Dr John Conaghan	BSc. Hons. (Botany) PhD
Ecological Advisory and Consultancy Services (EACS) and Associates	Jenny Neff	BSc. Hons. (Botany) MSc. (Ecology). Dip. Business Studies MIEEM
Ecological Advisory and Consultancy Services (EACS) and Associates	Lucy Arnold	BSc. Hons. (Biological Sciences) AIEEM
Ecological Advisory and Consultancy Services (EACS) and Associates	Marie-Louise Heffernan	Dip. Applied Biology, MSc (Environmental Science) MIEEM
FaberMaunsell	Cormac O'Brien	BE CEng(Civil) MIEI MICE MIHT
FaberMaunsell	David Thompson	BE CEng(Civil) MIEI
FaberMaunsell	Jonathan Noonan	BE MIEI
Kirk McClure Morton	Malcolm Brian	BSc, PhD, Ceng, MCIWEM, MIEI
Margaret Gowan Associates	Lisa Courtney	MSc (Ag), BA (Hons) MIAI
Margaret Gowen & Co. Ltd	Bill Frazer	MA
Margaret Gowen & Co. Ltd	Joe Fenwick	MA, BA (Hons) MIAI
Minerex Environment Limited	Dan Morton	BSc. Env.Sc Environmental Science
RSK ENSR Environment Limited	David Taylor	BSc (Hons.) Geology, CGeol, EurGeol MSc Marine Geology and Geophysics
RSK ENSR Environment Limited	Dr David Watson	PhD Marine Chemistry BSc Marine and Freshwater Biology
RSK ENSR Environment Limited	Dr Janet Swan	BSc Botany, PhD Plant Biochemistry, DIC (Diploma of Imperial College) MIEEM
RSK ENSR Environment Limited	Dr Lucy Speirs	EngD Environmental Technology, MSc Computational Fluid Dynamics, BA (Hons) Oxon Mathematics
RSK ENSR Environment Limited	Helen Rosenbaum	MSc Environmental Management, BA Hons Geography
RSK ENSR Environment Limited	Ian Milligan	City And Guilds, Computer Aided Design, 1990

Company	Name	Qualifications
RSK ENSR Environment Limited	James Garvie	MSc, Environmental Technology with Energy Policy, BSc, Chemistry, Resources and the Environment, MIEMA, CChem, MRSC, AIChemE
RSK ENSR Environment Limited	Jenny Wilson	Dip LA MLI
RSK ENSR Environment Limited	Nick Hogben	PGDip Land and Water Management - Applications of GIS, BA Hons Humanities (Geog)
RSK ENSR Environment Limited	Oliver Brandon	MBA, BSc (Hons) Botany
RSK ENSR Environment Limited	Peter Constantine	MSc (Eng), BSc (Eng)
RSK ENSR Environment Limited	Peter Scott-Wilson	MSc Integrated Environmental Management, PgDip Education, BA Modern Languages, Certified Fluids Engineer
RSK ENSR Environment Limited	Richard Appleyard	BEng (Hons) Environmental Engineering with Resource Management
RSK ENSR Environment Limited	Rob Domeney	MSc Environmental Impact Assessment, BA (Hons) Geography
RSK ENSR Environment Limited	Tom Smith	BSc Applied Ecology
RSK ENSR Environment Limited	Wendy Hogben	M.Sc. Environmental Assessment and Management, BA (Hons) Humanities (Geography)
TES Tobin	Mick Garrick	BE, M Eng Sc, MBA, C Eng, FIEI, MCIWEM, M Cons EI
Tom Philips Associates	Gavin Lawlor	B Soc. Sc. MRUP, MIPI
Wood Environmental Management Ltd	Andy Wood	BSc Marine Biology MSc Environmental Engineering

Table P4 List of Consultees

Consultees	Key Concerns	Addressed in Section
National Parks and Wildlife, Department of the Environment Heritage and Local Government (formerly Dúchas);	Potential for the pollution of Bellanaboy River and Carrowmore Lake.	9
Mayo County Council	Safety Environmental management Water quality Mitigation proposals	2,5,9,17,20
Bellanaboy/Leeinamore Residents	Safety of local children Air Quality Light pollution Radioactive material – control and risk of exposure Emergency procedures – Oil Spillages Decommissioning of the terminal site Control of working hours during construction Impact on future development (planning) in the area	2,3,5,11,13 20

Consultees	Key Concerns	Addressed in Section
Bellanaboy/Leeinamore Residents & Local Community & Mayo County Council, Department of Communication, Marine and Natural Resources Petroleum Affairs Division (PAD)	Traffic Safety Noise Water Quality Major Hazards Environmental Management Visual impact on local properties Alternatives considered Hydrological behaviour of peat Eutrophication of Carrowmore Lake as a result of phosphate leaching from excavated peat, (effect on fishing) Effect on Glenamoy River, seatrout, salmon, flat fish and shellfish Volumes of traffic and routes proposed during emergencies Treatment of silt arising from crossing of the Sruwaddacon Bay Impact on the linguistic and cultural heritage of the Gaeltacht area Information on environmental disaster management and Minimisation of environmental damage Selection of corrosion inhibitors Decommissioning and radiation Health risks to locals from mercury, radiation and corrosion of pipes Pollution to natural amenities: Bellanaboy, Glenamoy, Muingabo River Carrowmore Lake	2,4,5,7,9,10 12,13,15,16 20
Residents affected by haul route operations (Bellanaboy to Srahmore)	Traffic, road condition, road safety and access Noise, vibration Air Quality Accidental spills	3,11,12,16
Issues raised by Planning Authorities during previous Planning Applications	Alternative landfall locations and field development options Socio-economic benefits to the local community Excavated peat disposal options and associated stability issues Visual impact and intrusion into regional landscape Health and safety of local community and compliance with Seveso II Directive Use of potable water and other material assets	4 5 3,4,8,9,16 13 2,17 16
An Taisce (NGO)	Location of terminal Protection of the Sruwaddacon SPA and Glenamoy Bog Release of Phosphate and Co2 Visual impact Decommissioning Sustainable Development Tourism	2,4,5,6,7,8 9,10,11,13 19
North-Western Regional Fisheries Board;	Pollution to natural resources – watercourses and Broadhaven Bay	6,7,10
Tourism Industry	Impact on sustainable tourism	5,19

One

Introduction

1 Introduction

1.1 The Proposed Development

As part of the development of the Corrib Gas Field Shell proposes to construct an onshore terminal near Bellanaboy Bridge, in the townland of Bellagelly South, County Mayo. The location of the proposed terminal is shown in Figure 1.1.

In order to construct the terminal, it will be necessary to excavate up to 450,000m^3 of peat from the terminal site. This peat will be transported by public road to a Bord na Móna cutover peatland at Srahmore, Bangor Erris, Co. Mayo.

It is proposed that the Corrib field is developed using a number of subsea gas wells flowing into an underwater pipeline. The wells will be connected to the pipeline via a collecting system known as a manifold placed on the seabed. The pipeline carrying the gas will some ashore at Dooncarton in Broadhaven Bay, County Mayo, from where it will run underground to the terminal. The 508mm (20 inch) diameter pipeline will be made of steel and will be buried to a minimum depth of 1.3m below ground level throughout the route between the landfall and the terminal.

The proposed terminal site is at a gentle incline and is overlain by a layer of peat. In order to provide a level platform for the construction of the terminal, the peat will be excavated from the footprint of the terminal.

The terminal facilities will be developed to include equipment to control the subsea production facilities and to remove liquids from the Corrib gas so that it meets the specification required by Bord Gáis Éireann (BGE). BGE will operate the pipeline that transports the gas from the terminal to the users. The terminal facilities will include compressors to control the flowrate and pressure of the gas in this pipeline. The subsea facilities in the Corrib field will be controlled and monitored from the terminal by means of an electric and hydraulic remote control system. Control signals and power, along with required chemical injection fluids, will be carried between the terminal and the Corrib field in an underwater 'cable' (umbilical), buried in the seabed.

The purpose of the terminal will be to handle fluids arriving at the terminal in the pipeline which will bring the gas ashore from the offshore reservoir. The fluids will comprise gas, a small amount of condensate and water from the reservoir together with methanol and a small quantity of corrosion and scale inhibitor.

Gas received at the terminal will be separated from the condensate, water and methanol. The methanol will be recovered, stored and then pumped back via the umbilical to the seabed installation for re-use. The condensate recovered will be stabilised and used as fuel. Water will be treated and discharged to the sea.

Later in the life of the Corrib Field, as the gas reservoir pressure falls, the treatment at the terminal may need to be slightly modified to ensure that the sales gas requirement can be met. The details of the modifications required will depend on the operating history of the field, and will be subject to the relevant planning permissions and IPPC Licence modifications at that time.

The Bellanaboy Bridge Terminal will perform the following roles:

Incoming gas treatment separation

- a slug catcher, to remove the main bulk of the liquids from the incoming gas; and
- inlet separation, to remove remaining liquids corrosion and scale inhibitor from the gas;

Export gas treatment conditioning

- gas conditioning, to ensure the export sales gas specification quality is attained;
- gas compression, to maintain a constant pressure of export gas leaving the terminal and entering the gas distribution network;
- odorisation, to add a chemical to the export gas to assist leak detection in the Bord Gáis Éireann (BGE) gas distribution network; and
- sales gas metering, to monitor the volume of export gas leaving the terminal and sold into the gas distribution network.

Onsite recycling facilities

- methanol recovery, to distil methanol from the incoming water and recycle it for use as an antifreeze (hydrate inhibitor) in the subsea installation; and
- condensate stabilisation, to cool, degas, and store the condensate (light oil) recovered from the incoming gas. The condensate will be used as fuel in the heating medium heater.

Figure 1.1 Terminal Location Plan

The following utility systems will be provided (in support of the process facilities);

- gas and liquid fuels for power generation;
- hydrate inhibitor injection, to pump recycled methanol back to the subsea installation;
- chemical injection, to inject anti-corrosion and anti-scale chemicals into the subsea well heads to prevent corrosion and scaling of equipment and pipes; and
- water treatment, to purify the water arriving with the incoming gas as well as collected rainwater and runoff water, prior to discharge.

1.2 Environmental Impact Assessment

Environmental Impact Assessment (EIA) may be defined as a systematic integrated evaluation of both the positive and negative impacts of a project on the natural environment; on beneficial uses of the environment, including man-made structures, amenities and facilities; and on the socio-cultural environment.

The aim of the EIA is to:

- identify and predict (for a given proposed development) any impacts of consequence;
- describe the means and extent by which they can be reduced or ameliorated;
- interpret and communicate information about the impacts; and
- provide an input into the decision making and planning process.

It is the intention of Shell to ascertain the potential impact from the project and to incorporate management measures in the design, construction and operation of the project to prevent, control and mitigate the impacts identified.

1.2.1 Need for an Environmental Impact Statement

An Environmental Impact Statement (EIS) is the formal documentation of the impact assessment process.

The requirement for an EIS is set out in a number of EU Directives.

The EU Directives were incorporated into Irish Legislation by Part X of the Planning and Development Act 2000 as well as Part 10, and Schedules 5, 6 and 7 of the Planning and Development Regulations, 2001. Part X of the Planning and Development Act 2000 requires that an EIS be submitted with a Planning Application for certain developments. Those developments that must be accompanied by an EIS are referred to in Part 10 and set out in Schedule 5 of the Planning and Development Regulations, 2001.

The information that needs to be contained in the EIS is listed in Annex III of Council Directive 85/337/EEC (as amended) and in Article 94 and Schedule 6 of the Planning and Development Regulations, 2001.

This EIS has been prepared in accordance with both EU and Irish legislative requirements.

The development of the terminal facilities at Bellanaboy Bridge, Bellagelly South, and the associated peat deposition site at Srahmore and Attavally, Bangor-Erris, are subject of a Planning Application to Mayo County Council. The Environmental Impact Statement submitted in support of the Planning Application has the following two volumes:

Corrib Field Development Environmental Impact Statement, Bellanaboy Bridge Terminal, volume I, and
Corrib Field Development Environmental Impact Statement, Peat Deposition Site, volume II.

1.3 Non Technical Summary

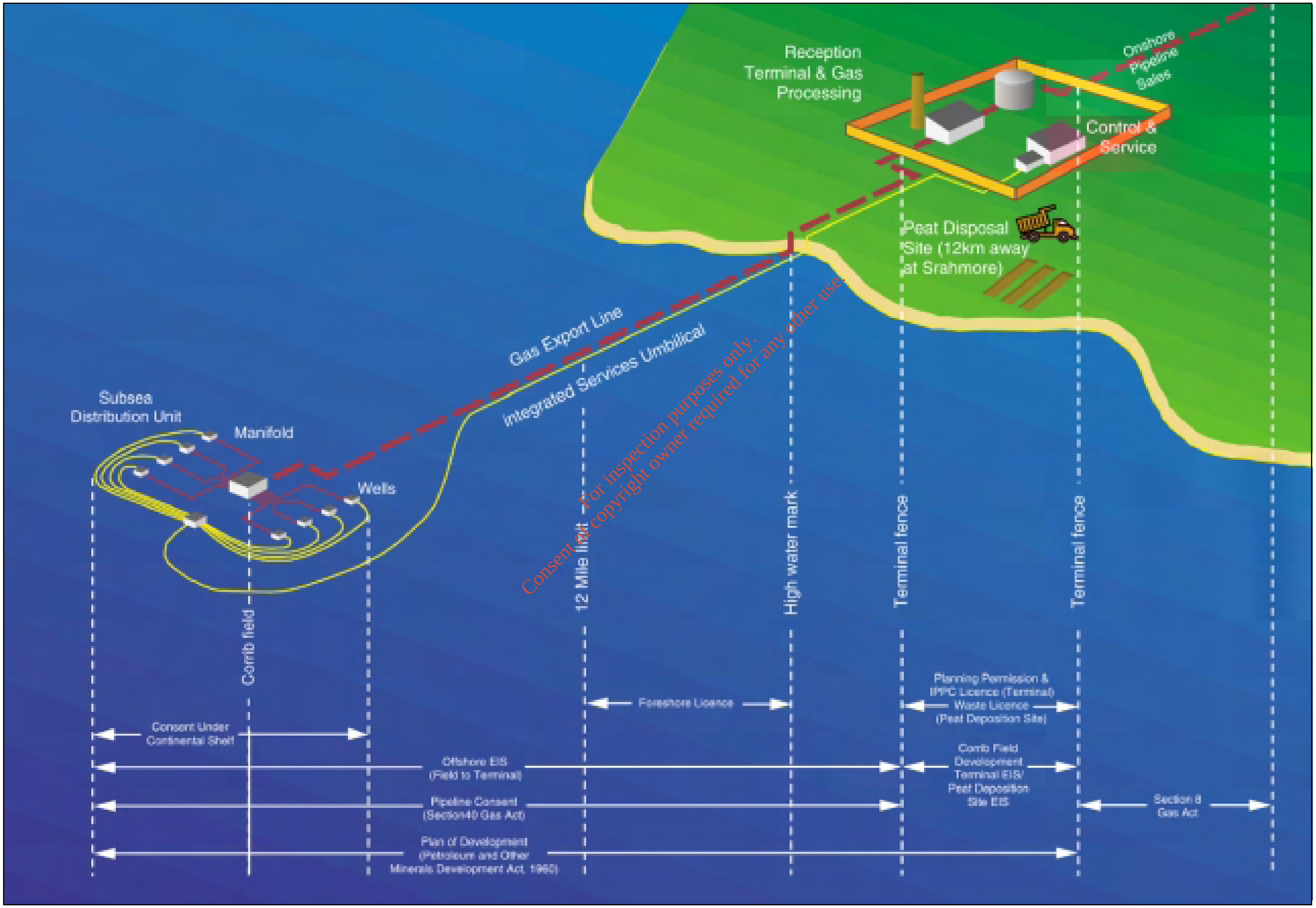
The Non-Technical Summaries are bound into this document and are also provided as separate and self-contained document available from the offices of Shell in Dublin. The Non-Technical Summaries will be posted on the Corrib Website: www.ShellIreland.com.

1.4 Other EISs Relating to this Development

This EIS is a statement arising from an assessment which identifies and describes the direct and indirect effects of the proposed terminal development on the existing environment. In addition an EIS was submitted in support of the Plan of Development, Foreshore Licence Application and Pipeline Consent Application by Shell (then Enterprise Energy Ireland Ltd) in October 2001. The environmental aspects of the pipeline from the landfall at Glengad to the terminal and the landfall itself are discussed in the Offshore Field to Terminal EIS (Section 19).

The export pipeline from the Bellanaboy Bridge Terminal to the Bord Gáis Éireann network (at Craughwell) is the subject of a separate EIS published by Bord Gáis Éireann.

Figure 1.2 Legislation Requirements for Corrib



1.5 Other Statutory Approvals

In addition to the Planning Permission for the terminal and its associated peat deposition site, the terminal will require an Integrated Pollution Prevention and Control (IPPC) Licence to operate.

Other statutory approvals/licences/consents that are associated with the development are listed in Table 1.1 below and shown graphically on Figure 1.2.

The Continental Shelf Act (1968) makes provision in relation to the exploration and exploitation of the continental shelf whereby an operator of a hydrocarbon prospect has to apply for Consent to exploit and extract the reserve.

Table 1.1 Legislation Requirements and Status

Licence/Consent	Status
The grant of a Petroleum Lease by the Minister of the Marine and Natural Resources	Granted 2001
Approval of a Plan of Development for the Corrib Field by the Minister of the Marine and Natural Resources.	Granted 15/04/02
A Foreshore Licence for the pipeline, umbilical and outfall	Granted 17/05/02
Consent under the Continental Shelf Act 1968	Granted 2001
Pipeline Consent (Section 40 Gas Act)	Granted 15/04/02
Export Pipeline (terminal to Craughwell) BGE Section 8 Gas Act	Granted 28/02/02
Planning Permission Bellanaboy Bridge terminal and associated peat deposition site.	
Waste Licence for the Peat Deposition Site at Srahmore BnM	
IPPC Licence for Bellanaboy Bridge	

Petroleum Licence

The Minister for Communication, Marine and Natural Resources regulates all exploration activities in Irish waters. Shell and its co-venturers have carried out exploration in the Corrib field in accordance with the terms set out in an exploration licence. As the joint venture proposed to develop the field, they applied for a Petroleum Lease, which, when granted, set out the conditions for production operations.

Plan of Development Approval

When a Petroleum Lease has been granted, the Licence Operator must apply for formal approval of their Plan of Development. In the autumn of 2001 Shell submitted a Plan of Development for the Corrib field development to the Minister for the (then) Marine and Natural Resources.

Offshore Pipeline Consents

Shell also submitted an application for Pipeline Consent under the Gas Act 1976 (as amended) to construct the pipeline from the subsea installation to the terminal. The application was accompanied by an EIS.
In addition, a separate application was submitted to the Minister for a Foreshore Licence to lay pipelines across the foreshore.

Export Pipeline Approval

A consent to construct the export pipeline from the proposed Bellanaboy Bridge Terminal to the Bord Gáis Éireann network (at Craughwell) is required under Section 8 of the Gas Act. An application, accompanied by an EIS, was made to the (then) Minister of the Department of Public Enterprise in 2001.

Consent Approvals

The Minister for the Marine and Natural Resources requested the Marine Licence Vetting Committee (MLVC) to examine all environmental aspects of the Corrib gas field development in the light of the applications for statutory permissions to the (then) Department of the Marine and Natural Resources. The terms of reference given to the MLVC were as follows:

"The MLVC will assess all environmental issues relating to the Plan of Development, Petroleum Lease Application and Foreshore Licence Application. This will include the pipeline and umbilical from the wellhead to the landfall and on to the terminal and the terminal itself and will include all outfalls."

On the basis of its consideration the MLVC recommended that the project be given the relevant statutory permissions subject to a number of conditions which should be rigorously enforced. The principal proposed conditions were:

1. The outfall point of the discharge pipeline shall be located outside the cSAC, not closer than 12 kilometres from the landfall site.
2. The effluent shall be treated to at least EQS as specified in the EIS using best available technology (BAT) subject to IPC licensing by the EPA.
3. The methodology of pipelaying within Broadhaven Bay and at the landfall and between

the landfall and the terminal shall be agreed with the Department of the Marine and Natural Resources before commencement of construction. The methodology shall be developed in full consultation with Dúchas to ensure that it meets their requirements for the protection of habitats and species as well as conservation and preservation of archaeological artefacts.

4. An Environmental Management Plan shall be drawn up for the approval of the Minister (subject to such modifications, if any, as he may deem appropriate).
5. The Environmental Management Plan shall, in respect of each discrete element of construction, be in place prior to work commencing.
6. The Minister shall, in consultation with Mayo County Council, cause an Environmental Monitoring Group to be set up which will be charged with monitoring the development during all stages of construction and subsequent operation.

The Minister approved the Corrib Plan of Development and authorised the construction of the pipeline between the Corrib field and the proposed terminal on 15th April 2002. He granted a Foreshore Licence on 17th May 2002.

The export pipeline from the Bellanaboy Bridge Terminal to the Bord Gáis Éireann network (at Craughwell) was granted Pipeline Consent by the (then) Minister of the Department of Public Enterprise in 2002.

Approvals Required for the Bellanaboy Terminal

The building of the terminal requires planning permission from the local authority. Because of the energy requirements at the terminal, arising from the need to pressurise the export gas, it will also need an Integrated Pollution Prevention and Control Licence (IPPC) from the Environmental Protection Agency before operations can commence. This licence will set out the detailed limits for all emissions from the terminal, and will specify the monitoring and reporting regime to be put in place to ensure and demonstrate that these limits are adhered to.

Peat Deposition Site

Planning Permission and a Waste Disposal Licence will also be required for the proposed peat deposition site.

Consultation

Each of these permissions and licences involves a high degree of consultation, particularly through the environmental impact assessment process. This process provides opportunities for authorities and agencies with specific environmental responsibilities, as well as the public and other interested parties, to have input into the development process.

1.6 Scoping of the EIS

A scoping exercise was conducted to establish the range and aspects of the environment to be considered. This exercise commenced with:

- initial consultations between Shell and the EIS Project Team;
- review of existing activities on the site; and
- review of other similar developments and EISs prepared for similar uses.

The scope of the EIA conducted in respect of the proposed Bellanaboy Bridge Terminal development included the following:

- the requirements of relevant legislation;
- the direct and indirect effects of the proposed terminal on the environment;
- the likely concerns of local residents, adjoining land users, and other interested third parties;
- the nature, location and scale of the proposal;
- the existing environment, including any vulnerable or sensitive features and current users;
- the significant effects of the proposed terminal on the environment of Bellanaboy Bridge and its environs;
- available methods of reducing or eliminating undesirable impacts;
- comments received from NGO's and other interested parties.

The Planning and Development Regulations, 2001 require that a description of the aspects of the environment likely to be significantly affected by the proposed development, in particular:

- human beings, flora and fauna;
- soil, water, air, climatic factors and the landscape;
- material assets, including the architectural and archaeological heritage, and the cultural heritage; and
- the inter-relationship between the above factors,

be included in the EIS. The above criteria were studied and prioritised with respect to the proposed terminal, ensuring that particular attention was paid to the issues which were directly relevant to the impact of the proposed terminal.

The scope of these areas of the environment was set out in the Corrib Field Development Onshore Briefing document issued in early 2000. This document identified the main issues potentially associated with the proposal (see Table 1.2).

In respect of the current EIS, certain changes have been made as described in Table P1. Additional scoping related to these changes, including a public exhibition have been carried out during Autumn 2003.

Table 1.2 Main Issues and Studies/Surveys Undertaken

Main Issues	Study / Survey Undertaken
Human Impact Issues	The socio-economic study reviewed population and employment trends. The impact of the development on existing and potential future commercial and recreational activities was assessed and the potential of the development to contribute to regional development was considered.
Flora and Fauna	The ecological assessment, which included field surveys, established baseline conditions, evaluated terrestrial and aquatic habitats and identified measures to protect against adverse impacts on those habitats.
Soils and Geology	A geological assessment which assessed the soils and geology to identify and mitigate against any potential impacts was undertaken. Its scope included engineering geological assessments for design purposes.
Hydrology and Hydrogeology	A hydrological and hydrogeological assessment was undertaken to assess the potential impacts on surface and groundwater. Measures to avoid or mitigate potential impacts were identified.
Air Quality and Noise	The potential impact of the development on air quality and potential noise emissions was reviewed. Dispersion modelling using the latest generation of computer model was carried out to predict how releases from the gas terminal disperse in the atmosphere and to determine the potential levels of exposure.
Landscape and Visual	The landscape and visual study included an assessment and description of the existing landscape context, features and vulnerable areas. An evaluation of the impacts on the landscape proposals and residual effects was also described.
Material Assets	The study considered the implications of the development, and of its construction, on existing and possible future development.
Roads and Traffic	The traffic study for the project reviewed the current traffic network and evaluated traffic impacts of the terminal on the network. Particular scrutiny was applied to construction impacts.
Effluent and Solid Wastes	The characteristics, fate and potential impacts of the effluent and solid wastes from the terminal operations and from construction activities was reviewed.
Cultural Heritage (Archaeological and Architectural Heritage)	The study, which included a field inspection, identified the archaeological, architectural and cultural heritage significance of any known sites, in order to reduce any predicted adverse impacts.
Sustainable Development	A review of how the proposed development meets the needs of the present without compromising the ability of future generations to meet their own needs.

Table 1.3 Potential Impacts Summary

	Construction Phase	Operational Phase	Decommissioning
Human Beings	+	+	X
Flora	X	+	O
Fauna	X	+	O
Geology & Soil	XX	O	O
Hydrology and Hydrogeology	X	O	O
Effluent	O	O	O
Cultural Heritage (Archaeological and Architectural Heritage)	O	O	O
Air	X	O	X (O)
Climate	O	O	O
Ambient Noise	XX	X	X (O)
Landscape & Visual	XX	X	O
Material Assets: • Solid Waste • Road & Traffic	 X XX	 X O	 X (O) X (O)
Sustainable Development	X	+	O

Key

+	Beneficial
(O)	After decommissioning
O	Negligible
X	Minor Adverse
XX	Moderate Adverse
XXX	Significant Negative Impact

Any development can bring about many indirect effects along with the direct effects of construction. The potential impacts that the proposed development may have on each aspect of the environment were sub-divided into the following categories, and analysed separately:

- potential impacts during the construction phase of proposed development;
- potential impacts during the operational phase of proposed development; and
- potential impacts during decommissioning.

An adaptation of the Leopold Matrix used to assess developments has been developed to summarise the magnitude and nature of any potential impacts (see Table 1.3).

1.6.1 Consultation

The scoping exercise has continued throughout the history of the project and has included:

- exhibitions hosted for members of the local community during June 2000, November 2000 and November 2003;
- consultations with both statutory and non-statutory consultees associated with the ongoing planning process for Bellanaboy Bridge Terminal (December 1999 to December 2003);
- advice and inputs obtained from consultees associated with the Plan of Development, Foreshore Licence and Pipeline Consent; and
- ongoing consultation with the Environmental Protection Agency associated with the IPPC Licence Application.

1.7 Surveys and Predictive Techniques

A combination of field surveys, desktop studies and modelling techniques as well as information gained during the public consultation process were used to assess the potential impacts of the terminal and its associated facilities. In many cases more than one assessment technique was used for each environmental parameter.

The principal surveys/predictive techniques undertaken were:

- extended Phase 1 habitat (vegetation), protected flora and fauna species and breeding/migratory bird field surveys;
- mammal surveys including badger, bat and otter surveys;
- water quality sampling;
- electrofishing;
- noise monitoring and modelling;
- water discharge/dispersion modelling;
- air quality monitoring/dispersion modelling;
- archaeological desk based assessment and field visits;
- traffic surveys, modelling and road condition surveys;
- hydrological and hydrogeological surveys;
- Geofilm aerial video; and
- photomontage studies.

1.8 Format of the Environmental Impact Statement

An EIS requires the assimilation, co-ordination and presentation of a wide range of relevant information in order to allow for the overall assessment of a proposed development.

To allow for ease of presentation and consistency when considering the various elements of the environment, a systematic structure is proposed for the main body of the statement. The structure used is a "Grouped Format". The structure is used for each particular environmental aspect as given below:

- receiving environment;
- characteristics of the proposed development;
- potential impact of the proposed development;
- do nothing scenario;
- mitigation measures;
- predicted impact of the proposed development;
- monitoring; and
- reinstatement and residual impacts.

1.8.1 Receiving Environment

In describing the receiving environment, an assessment is made of the context into which the proposed terminal will fit. This takes account of any other proposed and existing developments.

1.8.2 Characteristics of the Proposed Development

Consideration of the *Characteristics of the Proposed Development* allows for a projection of the Level of the Impact on any particular aspect of the environment.

1.8.3 Potential Impact of the Proposed Development

This Section allows for a description of the specific, direct and indirect impacts which the proposed terminal may have. This is done with reference to *Receiving Environment and Characteristics of the Proposed Development*, while also referring to the magnitude, duration, consequences and significance of the impact during both construction and operational phases of the development. Throughout this EIS, the significance of impact has been assessed using the criteria presented in Table 17.1.

1.8.4 Do Nothing Scenario

In order to provide a qualitative and equitable assessment of the proposed terminal, it is imperative to consider the impacts should the development not take place.

1.8.5 Mitigation Measures

This includes a description of any remedial, or mitigation measures that are either practicable or reasonable having regard to the potential impacts.

1.8.6 Predicted Residual Impact of the Proposed Development

This Section allows for a qualitative description of the resultant specific, direct and indirect impacts, which the proposed terminal may have, if all mitigation measures are applied. This is done with reference to both Potential Impact of the Proposed Development and Mitigation Measures, producing a definitive and concise statement of impact for the development.

1.8.7 Monitoring

This involves a description of monitoring proposed during the development and post development phase, if required. It also addresses the effects, which require monitoring, along with the methods and the appropriate agencies which are responsible for such monitoring.

1.8.8 Reinstatement

While not applicable to every aspect of the environment considered within this EIS, certain measures need to be proposed to ensure that in the event of the proposed activity being discontinued, there will be minimal impact to the environment.

1.9 EIS Layout

This EIS has been written in accordance with legislative requirements referred to in Section 1.10, and comprises the twenty Sections shown below in Table 1.4.

Table 1.4 EIS Regulations and EIS Sections

The Regulatory Requirements	Section No and Title
	Preamble
	1 Introduction
	2 Description of the Proposed Development
	3 Construction
	4 Alternatives
Human Beings	5 Human Beings
Fauna and flora	6 Terrestrial Flora and Fauna
	7 Aquatic Flora and Fauna
Soil	8 Soils and Geology
Water	9 Hydrology and Drainage
	10 Effluent
Air	11 Air
	12 Noise
The Landscape	13 Landscape and Visual Impact
Climatic Factors	14 Climate
Architectural and Archaeological Heritage and the Cultural Heritage	15 Cultural Heritage (Archaeological and Architectural Heritage)
Material Assets	16 Material Assets
	17 Mitigation and Impacts Summary
The inter-relationship between the above factors	18 Cumulative Impacts
Human Beings	19 Sustainable Development
All media	20 Environmental Management

1.10 Legislative Requirements

1.10.1 European Legislation

An Environmental Impact Assessment is required under Council Directive 85/337 (amended by 97/11/EC). This Directive relates to the assessment of the effects of certain public and private projects on the environment. The Directive specifies the developments for which an Environmental Impact Assessment (EIA) will be required and the information which must be furnished in an Environmental Impact Statement.

1.11 The Environmental Protection Agency Acts 1992 and 2003

The Environmental Protection Agency Acts require that application for an Integrated Pollution Prevention and Control (IPPC) Licence be made to the Environmental Protection Agency in relation to the terminal. Therefore an application for an IPPC Licence will be made for the terminal. The Environmental Protection Agency (Licensing) Regulations 1994 require that if the activity is one for which an EIS will be required on the application for planning permission then an EIS must also accompany the application to the EPA for an IPPC Licence. This EIS will be submitted with the IPPC Licence Application. Volume II of the EIS will be submitted to the EPA with the Waste Licence Application in respect of the Srahmore site.

The Protection of the Environment Act 2003 amends the Environmental Protection Agency Act 1992 and will implement the provisions of the IPPC Directive (EU Directive 96/61/EC) in Ireland. While some Sections of the Act have commenced already, the commencement order for Section 15 of the Act, which relates to IPPC licensing is not expected to be made until December 2003. The Bellanaboy Bridge Terminal will require an IPPC Licence to operate.

In considering the IPPC Licence Application, the EPA must not grant an IPPC Licence unless it is satisfied in relation to a number of matters including the following:

- use of Best Available Techniques to prevent pollution;
- energy efficiency;
- emissions will not cause significant environmental pollution
- noise and vibration;
- raw materials consumption;
- accident prevention
- waste minimisation;
- air emissions and aqueous emissions; and
- management plan for cessation of activities.

Shell is therefore preparing the IPPC Licence Application in order that it will meet the requirements of the Environmental Protection Agency Acts 1992 and 2003.

It is expected that the IPPC Licence format will be similar to the current IPC Licences. Licensees must comply with a wide range of conditions to ensure safe management and operation of the terminal facility.

1.12 Control of Major Accident Hazards Regulations

The terminal will be an establishment to which Council Directive 96/82/EC and SI 476 Control of Major Accident Hazards Regulations apply due to quantities of flammable and toxic materials to be stored on site. Articles 6 and 4 of the Directive will apply, i.e. the terminal will be a 'lower tier' establishment under the Directive.

Two

Description of the Proposed Development

2 Description Of The Proposed Terminal Development

2.1 Bellanaboy Site Context

This section describes the proposed development at the Bellanaboy Site. It also provides a description of the part of the proposed development at Srahmore.

The Bellanaboy site lies in the north-western part of County Mayo. The landscape contains a mixture of dramatic coastal scenery ranging from extensive rocky cliffs (Achill and Erris) to low coastal dunes and sandy bays (Belmullet and Broadhaven) (see Figures 2.1a - c). Extensive blanket bog and dramatic upland terrains (Nephin Beg/Owenduff area) and numerous lakes of varying sizes (Loch Conn and Carrowmore Lake) are found inland in this area. There are many areas designated as Special Areas of Conservation (SACs), Special Protection Areas (SPAs) and Natural Heritage Areas (NHAs). None will be affected by the proposed development.

The area comprises a mixture of isolated properties, small groups of farms, villages and, less frequently, larger towns such as Belmullet, Ballina, Westport, and Castlebar. Castlebar is the location of the County Council offices, the regional EPA offices, and the regional hospital and fire service.

The average population density in the area of the proposed terminal is 10.5 persons per square km, compared to a density for Mayo of 21 persons per square km (2002 Census). The population of the coastal area is ageing due to out-migration and a reduction in the birth rate. Some local communities in County Mayo may not be sustainable if this decline continues.

2.2 Proposed Development

The proposed terminal will be constructed near Broadhaven Bay, in the townland of Bellagelly South (see Figure 2.1).

The site selected for the terminal was previously a Peatland Experimentation Station run by An Foras Taluntais (the agricultural institute, now Teagasc). The station was a grass production experimental site and was operational between 1955 and the late 1970s. The grass was sown directly on to the virgin blanket bog, which was later modified by the introduction of a land drainage system.

The residences closest to the centre of the site are located at Bellanaboy Bridge (0.5km), Leenamore (1.5km), Aghoos (2.5km), Muingingaun (2km), and Glenamoy (4.0km).

In terms of upland terrain, Carnhill (264m) is approximately 5km to the north-west, Slieve Fyagh (330m) 7.5km to the south-east and Benmore (349m) 12km to the east. Major water features are Sruwaddacon Bay, which is 2.5km to the north, Carrowmore Lake 3.5km to the south-west and Broadhaven Bay 9.0km to the north-west. These features are all indicated on Figure 2.1.

The proposed terminal site will lie within a 160 hectare (ha) partially wooded area to be acquired by Shell from its present owners Coillte Teoranta (see Plate 2.1). The existing mature coniferous trees on the site will provide visual screening for the terminal plant. Within the overall landholding, an area will be excavated to provide a level site for the terminal. The terminal footprint will occupy an area of approximately 13ha. A further 1ha will be used to accommodate temporary construction facilities. The site layout is shown in Figure 2.2.

Plate 2.1: Mature Plantation and Existing Access Track

There will be the need to excavate up to 650,000m^3 of peat, rock and unsuitable mineral soil in order to create a flat platform on which to build the terminal. Of this approximately 450,000m^3 will be transported by road to a cutover peatland at Srahmore which is owned and operated by Bord na Mona. Approximately 200,000m^3 of excavated material will be re-used on the site. The site for the transportation and deposition of peat on the cut over peatland is the subject of a separate volume of this EIS (Corrib Field Development, Peat Deposition Site EIS).

The terminal will consist in general of gas, conditioning and power generation equipment, utilities including water treatment, firewater ponds, pipe-racks, flare, control room, administration block, maintenance building, equipment plant buildings, paved areas, walkways, plant roads and open areas including landscaping.

Figure 2.1 Overview Plan of the Proposed Development

Figure 2.2 Aerial Photo Site Layout

The terminal facility will contain equipment to carry out the processing of the incoming gas that is required for it to meet Bord Gáis Éireann quality requirements. The main elements of the treatment will be:

- gas/liquid separation;
- gas conditioning and compression;
- condensate recovery; and
- methanol regeneration and injection.

The terminal is designed to handle a throughput of up to 10 million cubic metres per day (350mmscfd Million Standard Cubic Feet per Day), of natural gas, which will be exported into the Bord Gáis Éireann network directly from the terminal. The offshore subsea production system in the Corrib Field will be controlled and operated from the terminal via an undersea cable, the control umbilical. Therefore, associated with the terminal development will be the construction and operation of the incoming gas pipeline, the control umbilical system and a produced water outfall pipe (subject to a separate EIS which was submitted with the application for a Foreshore Licence).

The incoming gas pipeline will be 508mm (20 inches) in diameter, made of high grade carbon steel with a wall thickness of 25.4mm (1 inch). It will carry the gas from the wellhead manifold to the terminal. It will be buried below ground level throughout the section between the landfall and the terminal as indicated on Figure 2.1.

The control umbilical will be 150mm (six inches) in diameter and contain electrical power cables, signal cables, a hydraulic fluid line and five methanol lines. This umbilical, as its name suggests, provides the operating lifeline to the wellhead systems that sit on the seabed at the Corrib field, approximately 80km west of the landfall at Glengad.

The water outfall pipeline for treated drainage and produced water will be a 254mm (10 inches) diameter high density polyethylene pipe. It will be buried throughout its length from the proposed terminal to the landfall in the same trench as the gas pipeline. It will have a diffuser element on the end, which will assist in the mixing of the discharged water as it enters the sea.

2.3 Site Layout and Design

The majority of the terminal facility will be constructed on a level area at 33.4m above ordnance datum (AOD) (Malin), the footprint of which will be 11ha. The warehouse, maintenance and administration buildings will be founded at 34.1m AOD. The principal buildings on the site will be up to 13m high.

The highest feature on the site (the flare stack) will be 40m high. The flare stack will be founded at 35.08m AOD, which is the current grade level.

The layout of the proposed terminal site is shown on Figure 2.2.

A proportion (approximately 10%) of the site will be paved whilst the remainder will be covered by gravel.

A stock-proof property fence will be installed around the perimeter of the terminal land holding. The terminal itself will be enclosed within a security fence.

The design of the site layout has been influenced by the following factors.

External Factors

- proposed pipeline routing (terminal inlet and outlet pipes);
- local infrastructure, such as access roads;
- local environmental issues such as noise and visual impact;
- distance to local residences;
- prevailing wind direction (for positioning of flare, fire pond and personnel areas etc.); and
- geometry and topography of proposed site.

Internal Factors

- plant safety (e.g. positioning of ignition sources relative to treatment units, position of fire water ponds (storage and retention), fire pumps and control room);
- plant maintenance and operability (ergonomics and efficiency);
- process and utility systems considerations;
- constructability; and
- cost.

The layout has been designed to make best use of the external screening provided by the surrounding coniferous plantations. This will reduce the visual impact on the landscape, whilst ensuring an efficient layout in terms of treatment function and safety.

Access to the site will be from the main Belmullet – Glenamoy Road (R314) via an entrance designed to allow vehicles to turn in without interfering with other road users. The access road will lead to a security gate.

The plant can be divided into three zones. They are

- hydrocarbon areas;
- utility areas; and
- offices, labs etc.

The arrangement of the plant provides the maximum separation between hazardous and safe areas. The location of the first and the last of these has been designed so that they are separated as widely as possible within the plant as follows:

- high-pressure (HP) process systems have been located the maximum distance possible from the administration and workshop areas;
- the liquid treatment process area (low pressure) has been located between the HP area and the administration and workshop buildings; and
- equipment layout has been designed such that prevailing winds will blow any escaping hydrocarbon gases away from safe areas of the facility.

In addition, a number of other important safety factors have dictated the site layout:

- there will be two entrances to the site for emergency vehicles in case one is blocked during an incident; and

- the bunded areas of storage tanks are sized to retain 110% of the contents of the largest tank in the bunded area. Intermediate dwarf walls will be included to contain minor spills.

The site will have a perimeter road wide enough to allow two emergency vehicles to pass. Additional internal roads will allow access to all the main process operations to allow ease of maintenance, access for fire fighting equipment and escape routes for personnel from all areas.

In terms of baseline environmental conditions, drainage has been given significant consideration in the site layout and overall design. A perimeter drain will be constructed around the site in order to collect all uncontaminated rainwater that runs off the site surface. This perimeter drain will in turn feed into silt ponds in order to ensure that any runoff from the site does not introduce silt into the local watercourses. Interceptors will be installed upstream of the silt ponds. The water quality in the silt ponds will be monitored regularly and in the event of abnormal conditions, flow to the external watercourse can be shut off until the quality is suitable for discharge. The silt ponds will be cleaned out and maintained on a regular basis, with deposition of the residue.

The site will require some lighting at night. However, under normal operating conditions there will be no need for outside work to take place on the plant at night and thus extensive lighting is not required. The lighting system has been designed in order to keep light emissions to the lowest level necessary for safety purposes. This is achieved by restricting the number and height of lights. Extensive use will be made of downlighting in the plant and maintenance areas with low level bollard lighting along paths and site roads. Where possible lighting on the operating plant will only be activated when personnel access an area. In the event of an emergency, the low light system can be overridden in order to provide safe working conditions.

2.3.1 Terminal Buildings

General

The buildings and associated facilities on the terminal fall into the following categories:

- control room;
- administration and maintenance building;
- warehouse building;
- power generation and electrical switchgear building;
- gas export compression building;
- water treatment plant building;
- minor equipment housings; and
- car parking facilities.

These are shown on Figure 2.3.

Each of these buildings has been designed to take into account the key aspects of:

- safety;
- minimum environmental impact (including noise); and
- minimum size commensurate with suitability for purpose intended.

The details of these buildings are shown on the drawings for the Planning Application for the scheme and a brief description is provided here to aid understanding.

Administration, Warehouse and Maintenance Buildings

The administration, maintenance and warehouse buildings are all situated in the same part of the site, to the southeast of the terminal footprint and close to the site entrance. The control building is sited just outside of the main plant area, at the southern edge of the terminal footprint.

The administration and maintenance building controls access to the terminal area and provides accommodation for the staff who work there (see Plate 2.2.)

The buildings range in height with the warehouse and maintenance building being the highest and the administration building being the lowest.

Visitor and staff car parking is located beside the security gate, in view of the gatehouse.

The offices and staff accommodation areas are organised around landscaped courtyards, and are connected to the warehouse building. By dividing the warehouse and office accommodation into individual blocks organised around courtyards, staff are allowed access under cover to all parts. This facilitates ease of internal movement and fosters good communication for administration and process area personnel (see Plate 2.3).

The inner courtyards provide screened areas for external storage of equipment and refuse bins and are out of view from all sides. The courtyard arrangement provides outdoor landscaped areas for staff and visitors to enjoy and creates a more favourable building microclimate with protection from the elements.

Figure 2.3 Terminal Buildings

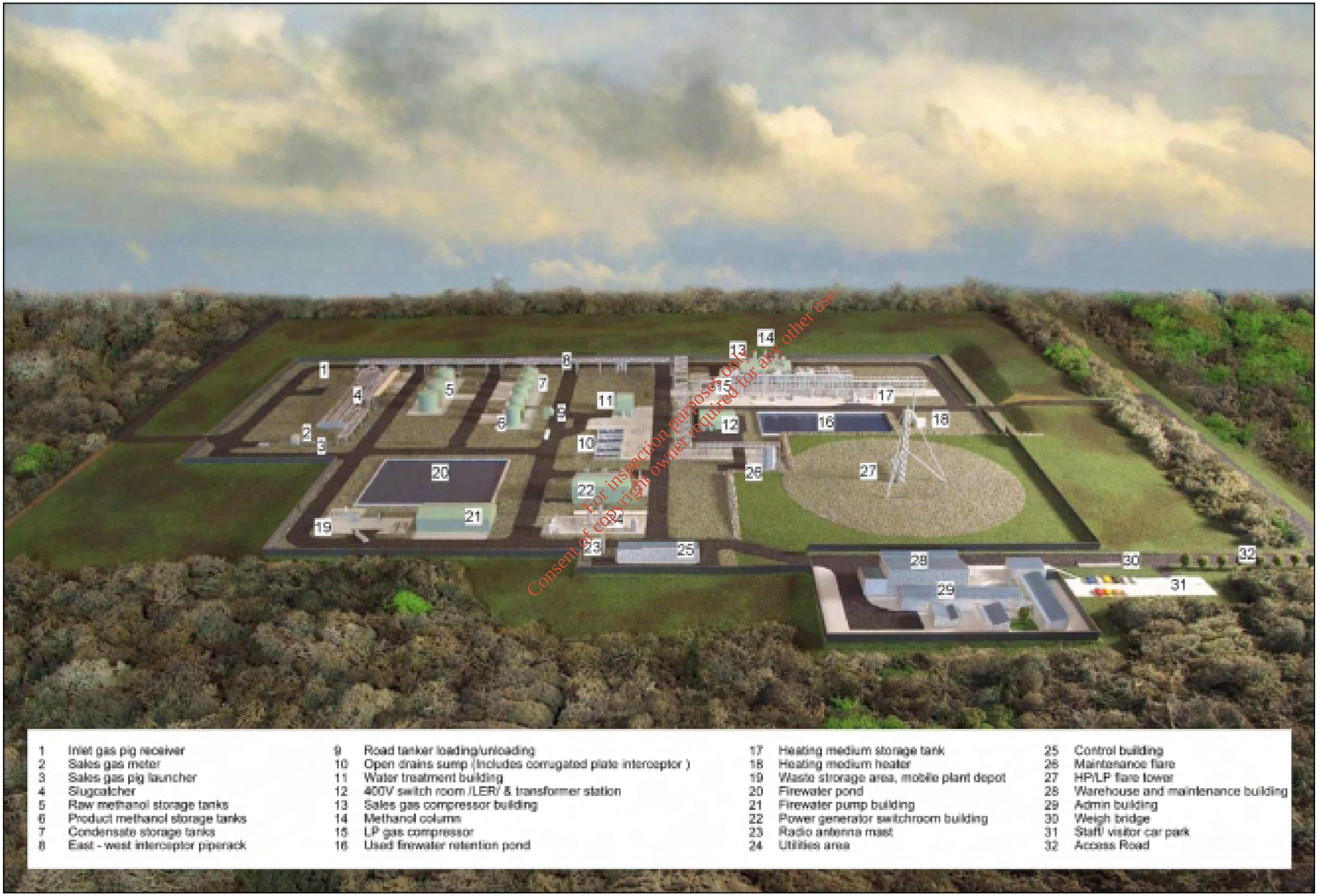


Plate 2.2 Image of Proposed Site Entrance and Administration Buildings

Plate 2.3 Image of Proposed Courtyard Area

Wrapping the smaller scale administration areas around the larger elements lessens the apparent mass of the building so that it sits better in the landscape.

The plant and equipment rooms have detailed technical and operational requirements which determine their relative locations. These rooms are designed to be blast resistant.

The complex includes a laboratory housing the specialised analysis and test equipment required to ensure that the plant performs according to specification.

The building finishes have been selected to merge with the landscape and refer to the traditional forms of agricultural and industrial vernacular buildings in the region.

Power Generation and Electrical Switchgear Building

This building is located within the terminal treatment and utilities area and houses the gas engine driven power generators and associated electrical switchgear. The building together with an associated transformer building of similar construction is designed to meet noise attenuation requirements.

Sales Gas Compressor Building

The sales gas compressors are to be housed in this building which will be of similar construction to the power generation building.

Minor Equipment Housings

The site will also contain a small number of dedicated equipment housings, the main one being for fire pumps (660m^2). This will be a 6 metre high, steel framed, low pitched roof building clad with profiled steel sheeting. Where required, noise mitigation measures will be applied.

There will be car parking for 40 cars.

Liquid loading and unloading facilities will be provided for the use of road tankers which will deliver methanol, diesel and other liquids (see Section 16). to the terminal. These areas will be bunded to ensure that any spilled materials are prevented from escaping into the environment.

A designated route for tanker traffic will be strictly controlled within the site from the main entrance at the R314. This route will also have a road drainage system to ensure any spillage does not escape into the environment.

These areas will be connected to the terminal open drains system via an interceptor thus ensuring that all contaminated spill wash water will be directed to the water treatment plant. Traffic movements on all other plant roads will be restricted to emergency and maintenance vehicles, and drainage from these roads will be to the settlement ponds via interceptors.

2.4 Plant Design

2.4.1 General

The terminal has been designed to receive, process and export natural gas.

Natural gas varies considerably in its characteristics. Gas from the Corrib field reservoir contains no hydrogen sulphide and is termed sweet gas. The Corrib field also contains a small amount of hydrocarbon condensate, which is a naturally occurring fluid, which has characteristics comparable with gasoline when it is condensed out of the gas in the terminal. The gas has a very low water content.

The peak throughput design capacity of the plant is 350mmscfd.

In addition to its primary function of a gas receiving terminal, it has also been designed to be the control centre for all the offshore (subsea) facilities in the Corrib field.

The terminal has a design life of approximately 30 years. Without modification it would not be possible to extend the plant to cater for reserves from other gas fields.

2.4.2 Export Gas Specification

The gas in the terminal will be treated to satisfy the export gas quality required by Bord Gáis Éireann for the Irish natural gas distribution network.

This means that the gas needs to satisfy technical criteria, such as:

- calorific value (heating value);
- density;
- water content;
- hydrocarbon dewpoint;
- pressure; and
- temperature.

2.4.3 Manning

The terminal will be manned 24 hours per day on a four shift system. The total complement of staff will be approximately 50 people. For the purpose of design, it has been estimated that there will be 18 staff and up to 8 visitors on site during normal working periods.

2.5 Facilities Description

2.5.1 Introduction

Main Processes

The main steps involved in achieving the above are as follows:

- control of the operation of the Corrib subsea equipment and wells such that gas production meets gas demand;
- monitoring;
- essential safety systems;
- reception of the fluids produced from Corrib and separation of gas from liquid (condensate and water/methanol); and
- gas treatment to meet Bord Gáis Éireann's specification and export of gas to the Bord Gáis Éireann gas distribution system.

Other processes involved are:

- hydrocarbon liquid (condensate) recovery and storage for use as fuel;
- injection and recovery of methanol and other chemicals to the subsea system to allow it to operate efficiently; and
- treatment of produced water.

Control

All subsea facilities, and in particular the flow of gas from each of the Corrib wells, will be controlled and monitored from a control room in the terminal. The remote control system takes the form of an electro-hydraulic system, along with chemical injection fluids, carried in a buried umbilical cable between the terminal and the Corrib wells.

Injection of Methanol and Other Chemicals

Methanol, together with corrosion and scale inhibitor (if required), will be pumped from the terminal through the umbilical to the subsea equipment. The purpose of each of these is as follows:

- methanol - to prevent freezing within the subsea facilities (i.e., the wells, subsea system, gas pipeline and the terminal). In essence, the methanol acts as an anti-freeze;
- corrosion inhibitor - to prevent corrosion in the field facilities; and
- scale inhibitor - to prevent the possible precipitation of natural mineral salts such as calcium carbonate and barium sulphate within the field facilities.

Fluids Arriving at the Bellanaboy Bridge Terminal

The fluids from the Corrib field received at the terminal will be mainly gas, but some liquid will also be present. This liquid will primarily consist of:

- water of condensation (water that condenses from the gas as its temperature and pressure fall); and
- methanol (injected from the terminal).

The liquid will also include small volumes of:

- condensate (liquid hydrocarbons that condense from the gas as its temperature and pressure fall); and
- corrosion inhibitor and scale inhibitor (both injected from the terminal).

Formation water (water present in liquid form within the Corrib reservoir) may also be produced.

Fluid Reception

The liquid produced with the gas does not arrive at the terminal in a uniform manner, but rather arrives in varying quantities as bursts or 'slugs'. On entry to the terminal, the incoming gas and the accompanying slugs of liquid are passed through a 'slugcatcher'. This is an arrangement of large pipes in which the incoming fluid is calmed by substantially reducing its velocity and the two liquid phases are separated from the gas by gravity. The condensate (liquid hydrocarbon phase) and water/methanol (water phase) that separate out from the gas in the slugcatcher pass to the condensate recovery and methanol regeneration systems respectively.

Treatment and Export of Gas

Because Corrib gas is so pure, very little treatment is required to satisfy Bord Gáis Éireann's export gas specification. Gas from the slugcatcher flows to the 'inlet separator', which separates finer droplets of liquid from the gas. The gas passes through a mercury removal unit to ensure that any traces of mercury, if present, are removed. The gas is then fed to a pressure valve where it is allowed to expand. This expansion cools the gas and condenses out any remaining traces of condensate, methanol and water, resulting in gas that meets Bord Gáis Éireann's specification.

The gas is finally compressed (so it leaves the terminal at the pressure required for the export pipeline) and an odorant is added (to assist leak detection in the gas distribution network). The gas is metered as it leaves the terminal so the quantities sold into the gas distribution network are monitored.

Methanol Recovery

The methanol recovered from the gas has a high water content. The methanol is separated from the water by distillation. The methanol is then recycled for use in the offshore system.

Condensate Stabilisation and Storage

Condensate received and separated as described above is stabilised by a series of pressure reductions and heating processes. It is then cooled and transferred to storage tanks. Produced condensate will be used as fuel in the terminal. Small quantities of gas released from the condensate during stabilisation will be recovered and reinjected into the main gas system.

Treatment of Water Prior to Disposal

The water recovered from the methanol distillation column is treated in the water treatment plant to meet the terms of the Integrated Pollution Prevention and Control Licence (IPPC). It is then discharged offshore, outside of Broadhaven Bay through an outfall pipeline.

2.5.2 Treatment Facilities

The terminal will have the following process systems:

- production fluids reception;
- gas conditioning;
- sales gas compression;
- sales gas metering and odorisation;
- condensate stabilisation;
- methanol recovery; and
- produced water treatment.

These systems are explained further in the sections below. A brief explanation of the fire-fighting strategy proposed for the terminal is also provided in Appendix 2.1.

2.5.3 Production Fluids Reception

As part of the recovery of natural gas from the reservoir some fluids will also arise in the form of water of condensation (similar to distilled water) and formation water, which comes from the rock reservoir in which the gas occurs. The condensed water often contains traces of organic compounds and some metals. The formation water, should it occur will contain natural salts and minerals which have leached from the rock in which the water has been resident over geological time. The actual composition will vary from location to location (well to well) and over time. Indications of the likely constituents have been determined from industry experience and from the testing of water recovered from the exploration wells.

The fluids initially pass into the slug catcher where gas and liquid fractions (e.g. water, production chemicals and condensate) are separated. This is known as primary separation. The liquids are routed for further treatment and storage.

The gas from the slugcatcher passes through a pressure control valve to the inlet filter separators. The inlet filter separator ensures that the remaining free water, production chemicals and condensate are separated out from the gas before it passes for further treatment. The gas from the inlet separator is routed through a mercury removal bed to remove any trace quantities of naturally occurring mercury that may be present in the gas stream.

During start-up, the gas from the slug-catcher is routed through the inlet heater to prevent excessive chilling and thereby prevent the formation of hydrates.

A block diagram is provided in Figure 2.4

2.5.4 Gas Conditioning

Gas from the inlet separator is passed through a Joule-Thomson (J-T) valve where the pressure of the gas is reduced causing the gas to cool. This is known as gas conditioning. This cooling effect enables water and hydrocarbons to condense and separate out in a separator. Compression units, known as sales gas compressors then pressurises the dry gas.

As the reservoir pressure declines over time, the arrival pressure will gradually decrease to a point too low to sustain this mode of operation. A gas / gas heat exchanger will then be used upstream of the J-T valve. Further depletion of reservoir pressure will require installation of a gas chiller between the gas / gas heat exchanger and the J-T valve. The gas chiller will be cooled by a mechanical refrigeration system.

A block diagram is provided in Figure 2.5.

2.5.5 Sales Gas Compression and Export

'Sales gas' - conditioned gas which is ready for distribution is compressed to a pressure sufficient to enter the Bord Gáis Éireann system. Compressed sales gas is metered for fiscal reasons, odorised and routed to the tie-in to the Bord Gáis Éireann system.

Compression of the gas for export will occur through the use of the two (one normally operating and one stand-by) sales gas compressors, each capable of handling the full capacity of the terminal.

Figure 2.4 Production Fluids Reception and Primary Separation

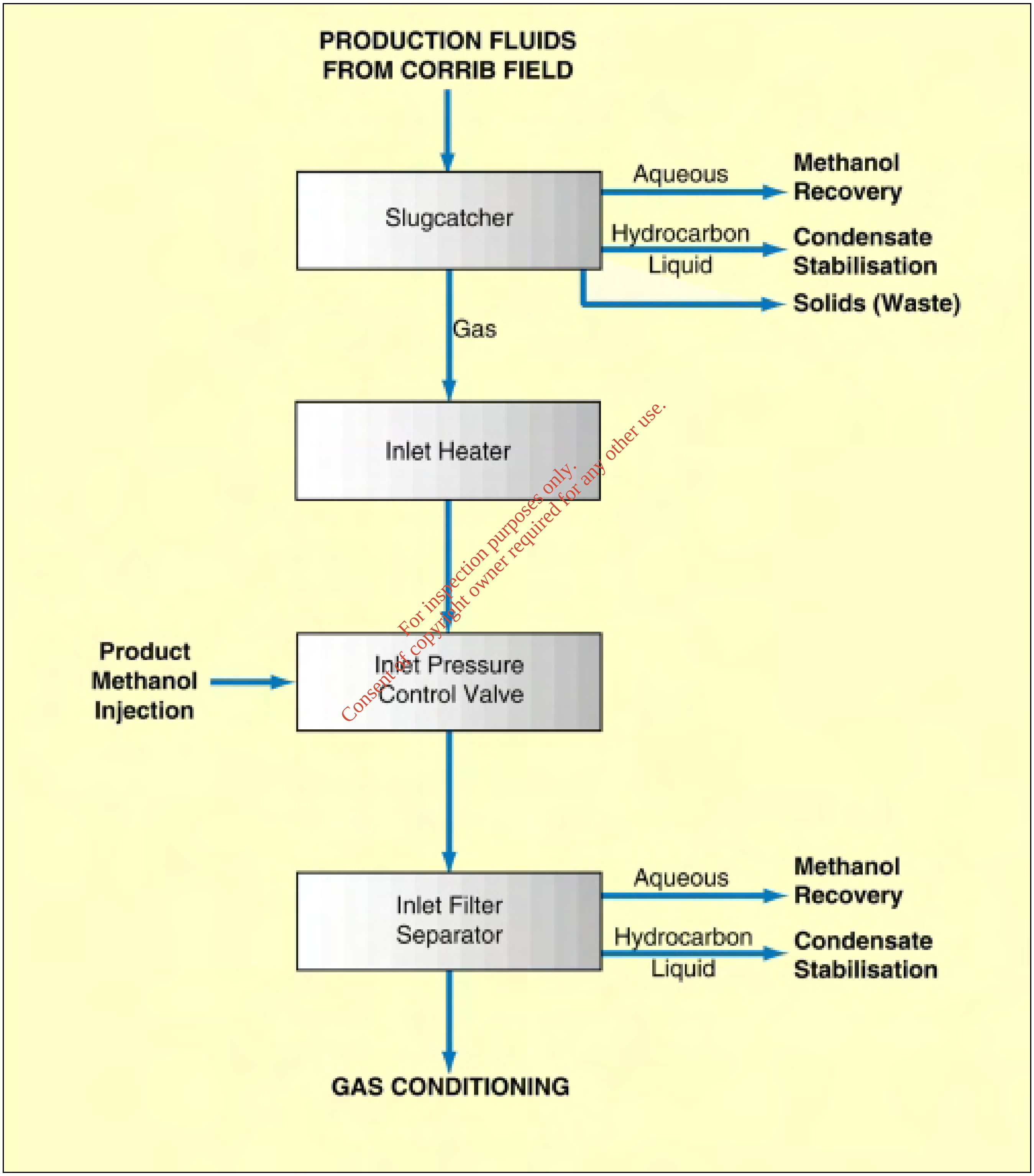
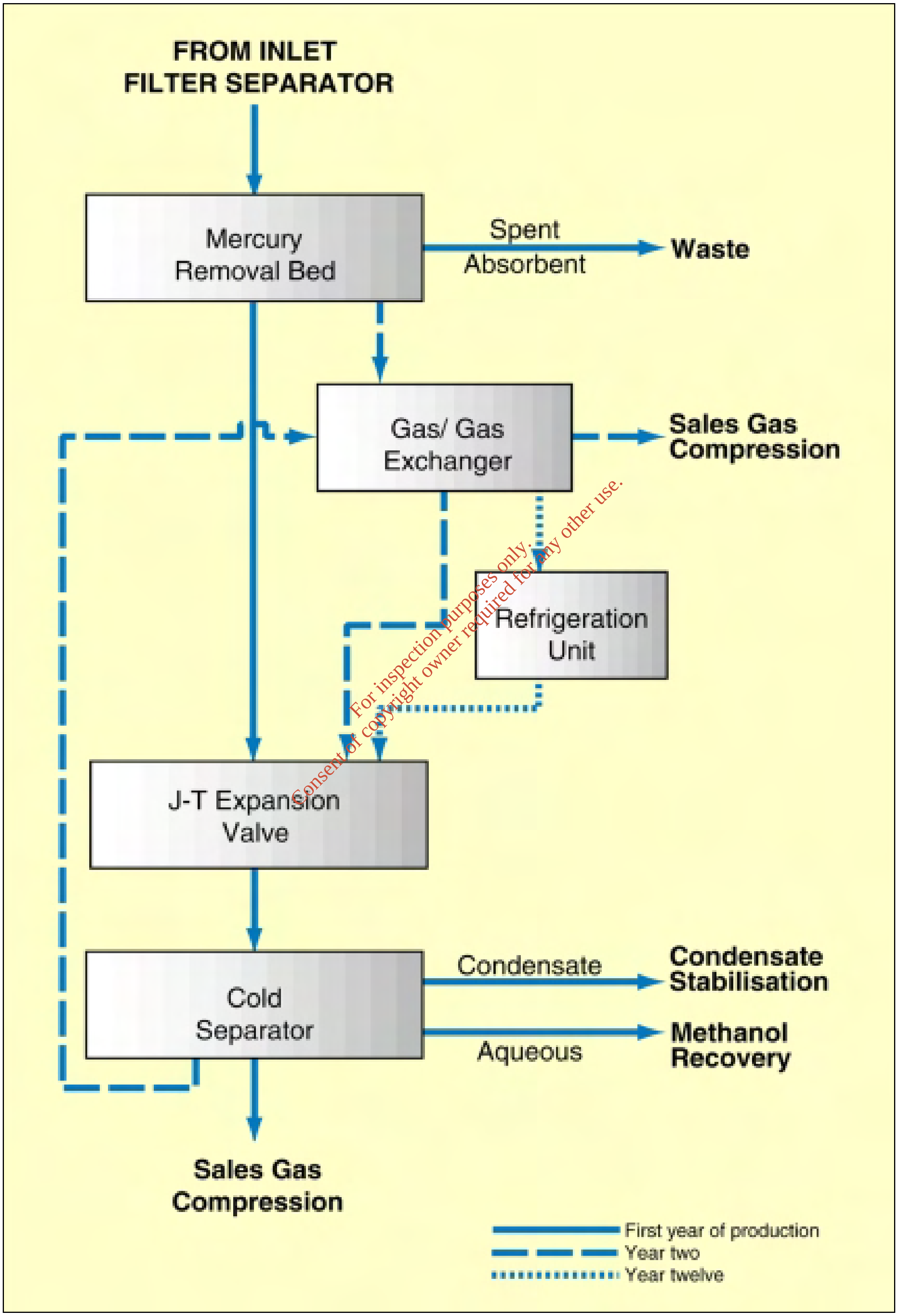


Figure 2.5 Gas Conditioning



A turbine fuelled by natural gas provides the energy to drive each compressor.

A very small quantity (1.5 – 2.5ppm) of odorant consisting of Tertiary Butyl Mercaptan (80%) and Di-Methyl Sulphide (20%) will be added to the natural gas to odorise it to Bord Gáis Éireann's specification. The odour enables detection of possible leaks in the low pressure gas distribution network and provides improved safety for consumers.

A block diagram is provided in Figure 2.6.

2.5.6 Condensate Stabilisation

Condensate is recovered from the slug catcher, inlet separator and by the gas conditioning system. The condensate is filtered to remove any solids, it is then routed to the stabilisation system through a vessel known as a Flash Drum, where the lighter hydrocarbons (gas) are removed. This gas, known as flash gas, is used as fuel gas in the plant. Any methanol present is also removed at this stage and is sent for regeneration (see below).

The condensate is then heated and stabilised in the Low Pressure Flash Drum and then cooled. After cooling, the condensate is passed through a mercury removal unit to remove traces of naturally occurring mercury (if any), before being sent to the condensate storage tanks. The condensate is used within the terminal as a fuel for the heating medium heater. Any off-spec condensate will be recycled for further treatment.

Only a small quantity of condensate is expected to be produced. The rate of production of condensate will be proportional to the gas throughput. Storage of stabilised condensate is provided to act as a buffer to even out potential fluctuations in arrival rate. The sizing of the storage tanks has been based on the assumption that the condensate is utilised on an intermittent basis as fuel, the balance being provided by natural gas. Any excess condensate not required for fuel will be sold and transported off site by road tanker. It is unlikely that this will ever be necessary.

A block diagram is provided in Figure 2.7.

2.5.7 Methanol Recovery

The water phase ("aqueous methanol") separated from the gas in the separation facilities is routed to the Methanol Recovery Unit. "Aqueous" methanol is filtered prior to passing to wet methanol storage. Any hydrocarbon condensate that separates out in the Methanol Flash Drum is drawn off and directed to the condensate treatment unit.

The aqueous methanol solution is pumped from storage to the methanol still (distillation column) for separation of water and methanol. A re-boiler heats the solution, with a glycol water based heating medium.

The product, comprising 96-98% methanol, evaporates, is condensed by air coolers and flows to an overhead accumulator. Product methanol from the accumulator is pumped back to the methanol still as reflux and also to production methanol storage tanks.

Solids (e.g. sand from the Corrib gas reservoir), if they are produced, can be recovered in any of the liquid filters within the condensate and aqueous methanol systems. These solids will be disposed of as a waste via an appropriately licensed carrier. Salts and scale may be recovered from tankage and through the acid wash process on the methanol still. Recycled and make-up methanol is combined and then filtered prior to injection into the umbilical.

A block diagram is provided in Figure 2.8.

Although the total produced (i.e. condensed and formation) water is not expected to exceed an average of 3.3m³/h, the produced water treatment systems are designed for a nominal 6.0m³/h throughput. Produced water from the subsea pipeline is likely to arrive at the terminal intermittently, as liquid hold-up within the pipeline can be several thousand cubic metres with slugs of up to 3,200m³.

To maintain flexibility and ensure methanol is recovered for reinjection, the methanol recovery facilities are designed with an increased capacity. This is to provide a substantial design margin to cater for a 'worst case' production profile scenario and to allow catch-up operations following receipt of a large aqueous slug from the subsea pipeline.

2.5.8 Produced Water Treatment

The treatment system has been designed to reduce the maximum concentrations of metals, salts and other substances likely to occur in the produced water to levels that ensure no harm to the environment prior to discharge to sea.

A number of the unit operations on site will aid in the removal of contaminants from the produced water. Oil removal will occur in the slugcatcher, the Methanol Flash Drum, the aqueous methanol storage tanks and the methanol coalescer. The methanol still (distillation column) can be considered the first stage in the treatment of the produced water. The methanol still will significantly reduce the methanol and oil content in the produced water.

Figure 2.6 Sales Gas Compression and Export

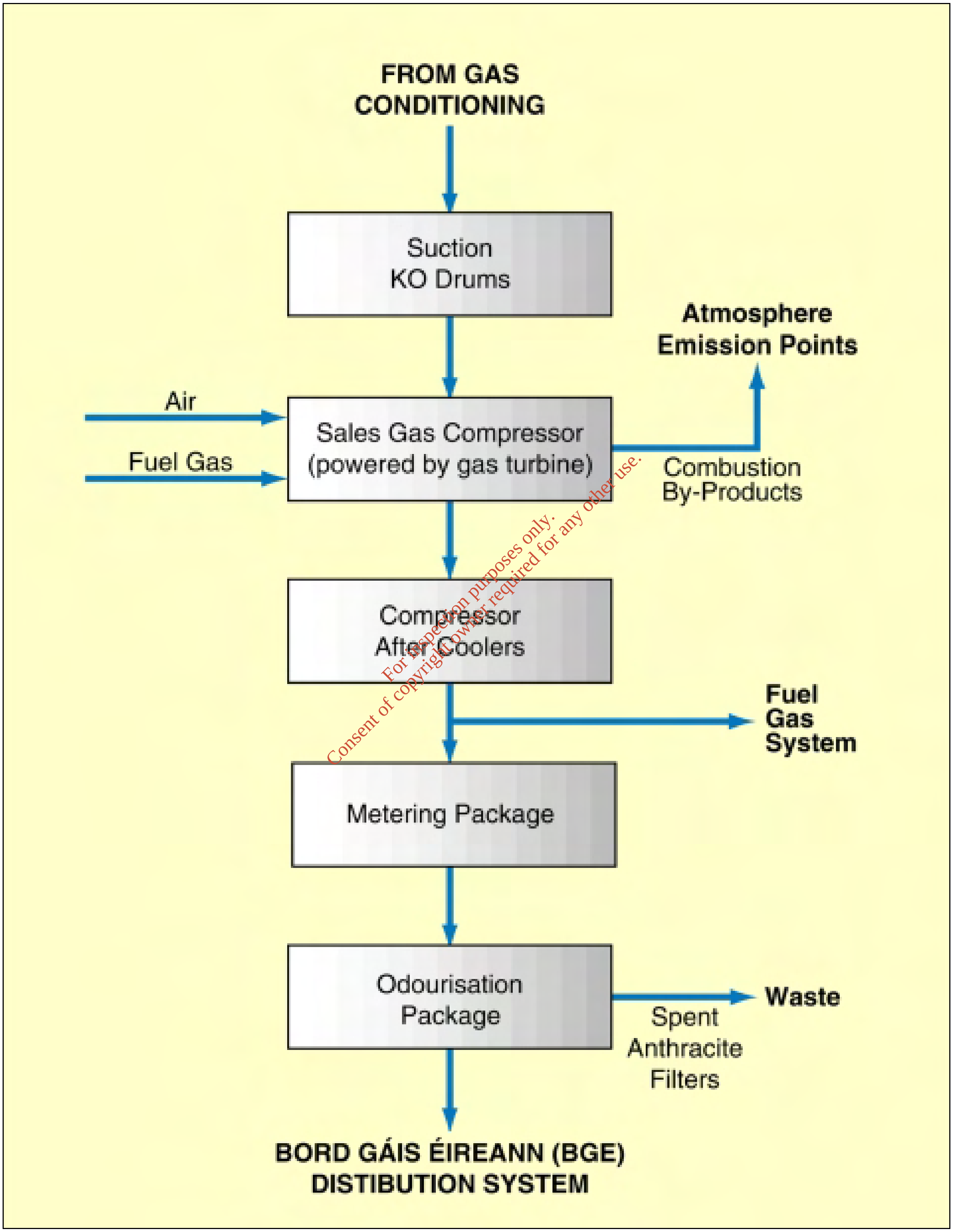


Figure 2.7 Condensate Recovery and Stabilisation

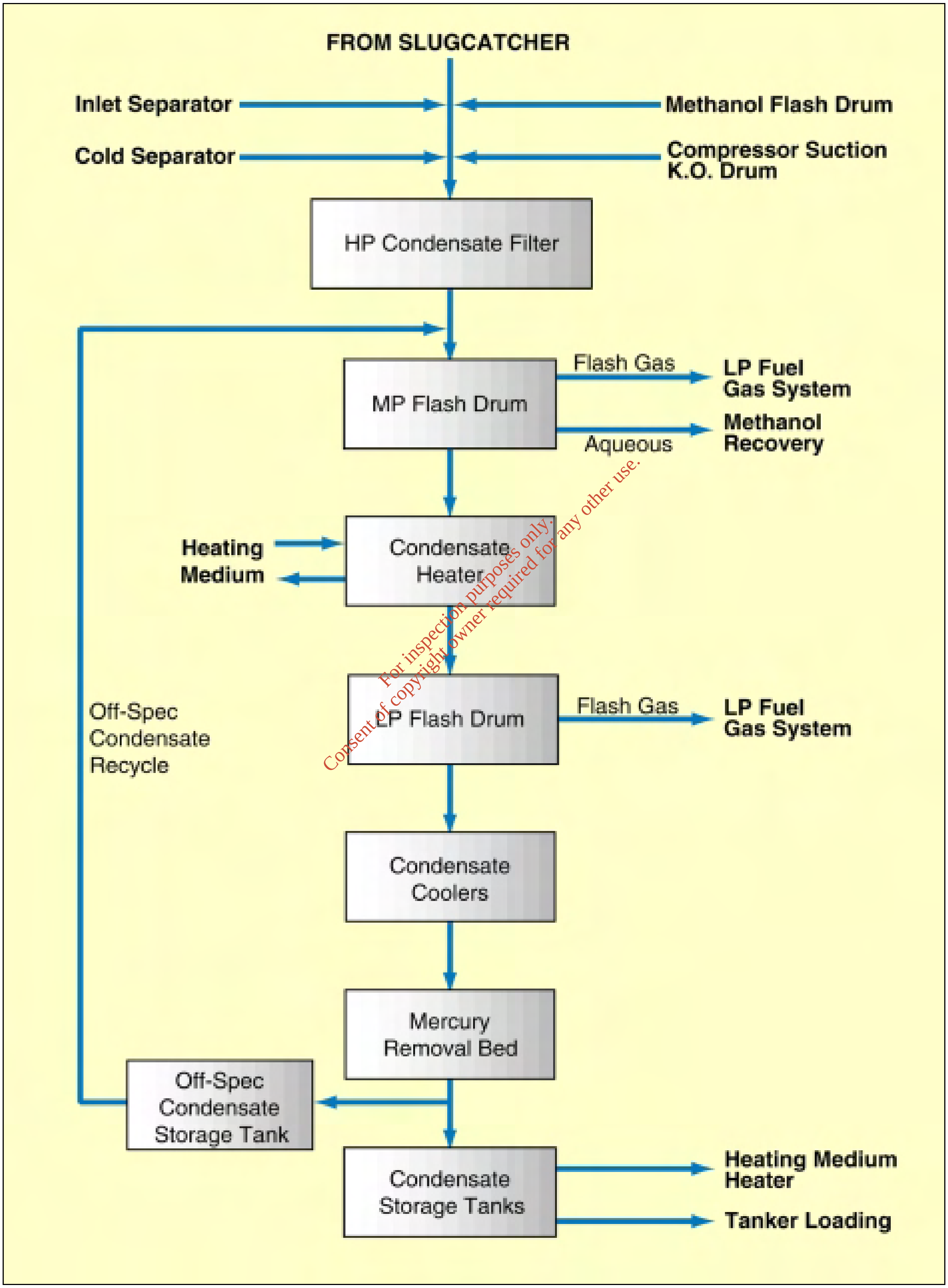
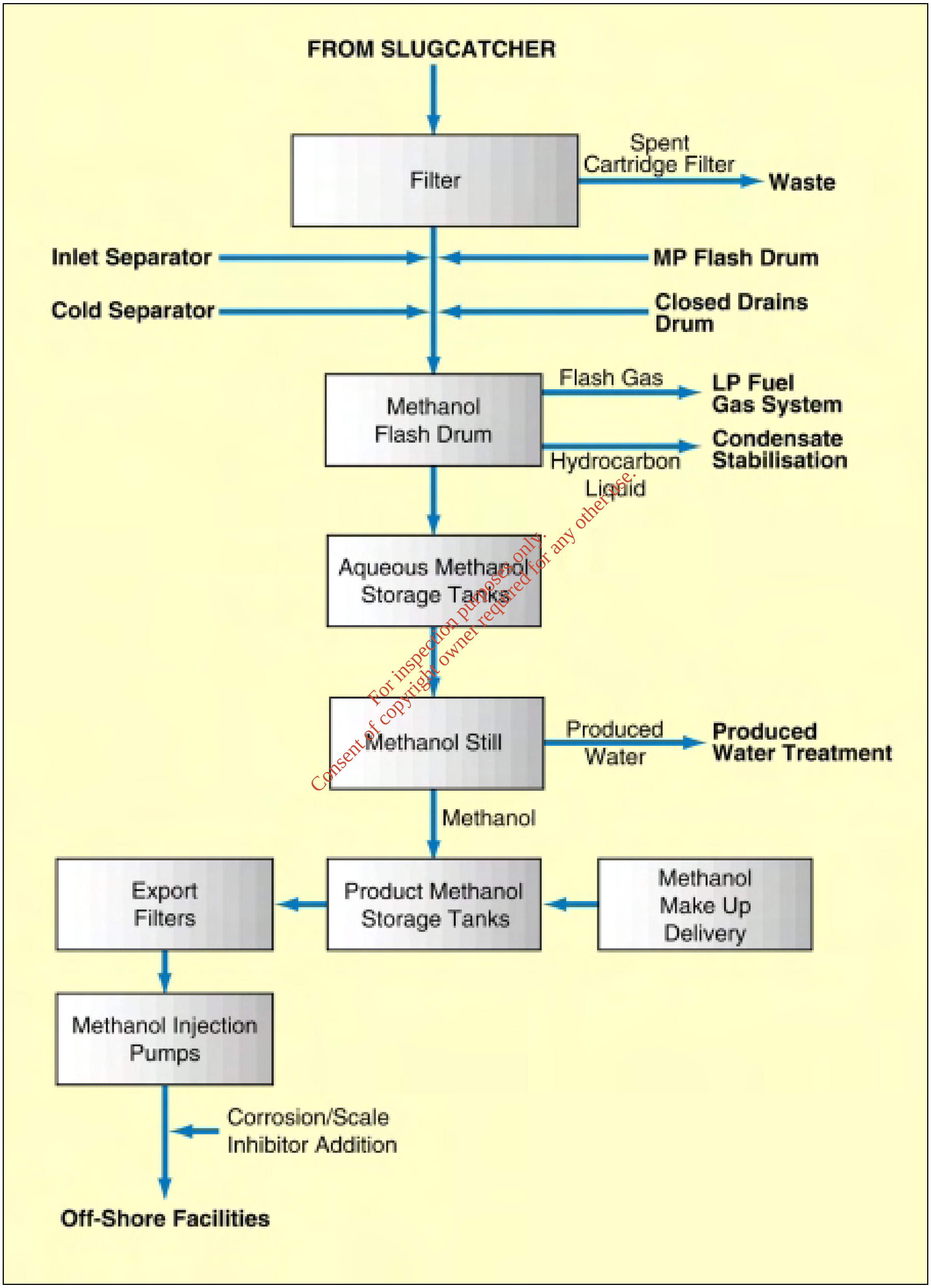


Figure 2.8 Methanol Recovery and Regeneration



The produced water that has been stripped of methanol will drain from the methanol still to the Effluent Feed Sump (66m^3 capacity) and from there will be pumped to the Produced Water Treatment System. If the water in the Effluent Feed Sump is found to contain a high concentration of methanol (>150mg/l) it will be pumped to the raw methanol storage tanks, otherwise it will be pumped to the Produced Water Treatment System.

The Produced Water Treatment System will comprise the following treatment units:

- Corrugated Plate Interceptor;
- Ultrafiltration;
- Nano Filtration;
- Granular Activated Carbon;
- Ion-Exchange; and
- pH adjustment.

The Tilted Plate Separator will remove suspended solids and free oil.

The Ultra Filtration unit will remove emulsified oil and certain organics.

The Nano Filtration (NF) unit will remove the heavy metals. The permeate (semi-treated water) from the NF unit will be passed through an activated carbon filter to remove soluble organics. Any residual heavy metals (mercury, nickel, lead, zinc) will then be absorbed onto a selective ion exchange resin. The treated water will be pH adjusted as required (NaOH/HCl dosing) before discharging to the Treated Produced Water Sump.

The treated effluent will drain to the Treated Produced Water Sump (144m^3 capacity). Continuous monitoring of flow, pH, and conductivity along with daily sampling and analyses of other parameters in the treated produced water stream will be provided. A description of the proposed monitoring regime is provided in Section 10. This will be subject to the terms of the IPPC Licence. If the quality of treated effluent in the sump does not meet the IPPC Licence requirements, it will be pumped to the aqueous methanol storage tanks for recycling through the Produced Water Treatment System. If the quality of the water in the sump meets the licence requirements, it will be pumped to the Treated Water Sumps (2 x 105m^3 capacity) where it will be combined with the treated Surface Water stream. The combined treated streams (produced water and surface water) will then be pumped to the sea outfall.

The Produced Water Treatment System will produce a number of waste streams (see Figure 2.9).

The oil from the Corrugated Plate Interceptor will be discharged to the Oil Sump (5m^3 capacity) and then pumped to the Offspec Condensate Storage Tank for reprocessing. All of the other waste streams, together with the sludge from the Surface Water Treatment System will be discharged to the Balance Water Sump (30m^3 capacity) which will be fitted with an agitator. The waste stream will be pumped from the Balance Water Sump to the Reaction / Flocculation Tank where it will be subject to the following treatment stages:

- first stage precipitation by pH adjustment using lime slurry;
- second stage precipitation by pH adjustment and TMT-15 dosing;
- coagulation by Ferric Chloride dosing; and
- flocculation by polyelectrolyte dosing.

The resultant waste stream will then be pumped to a filter press for dewatering to produce a filter cake suitable for disposal. This cake will be discharged to a sludge skip and treated / disposed off-site by a licensed waste contractor. The filtrate from the filter press will be pumped to the Effluent Feed Sump for recycling through the Produced Water Treatment System.

Parts of the Produced Water Treatment System will be within a building.

It is possible that an additional Ion Exchange unit may be required for the Produced Water Treatment System in the future to remove the metal boron (present in formation water). However as formation water is not expected to be produced, and if at all very late in field life, this additional unit will not be installed until a later date. A tie-in point for the unit will be provided during the initial installation. Provision has also been made for the incorporation of additional chemical injection into the treatment system at a future date if it should be needed.

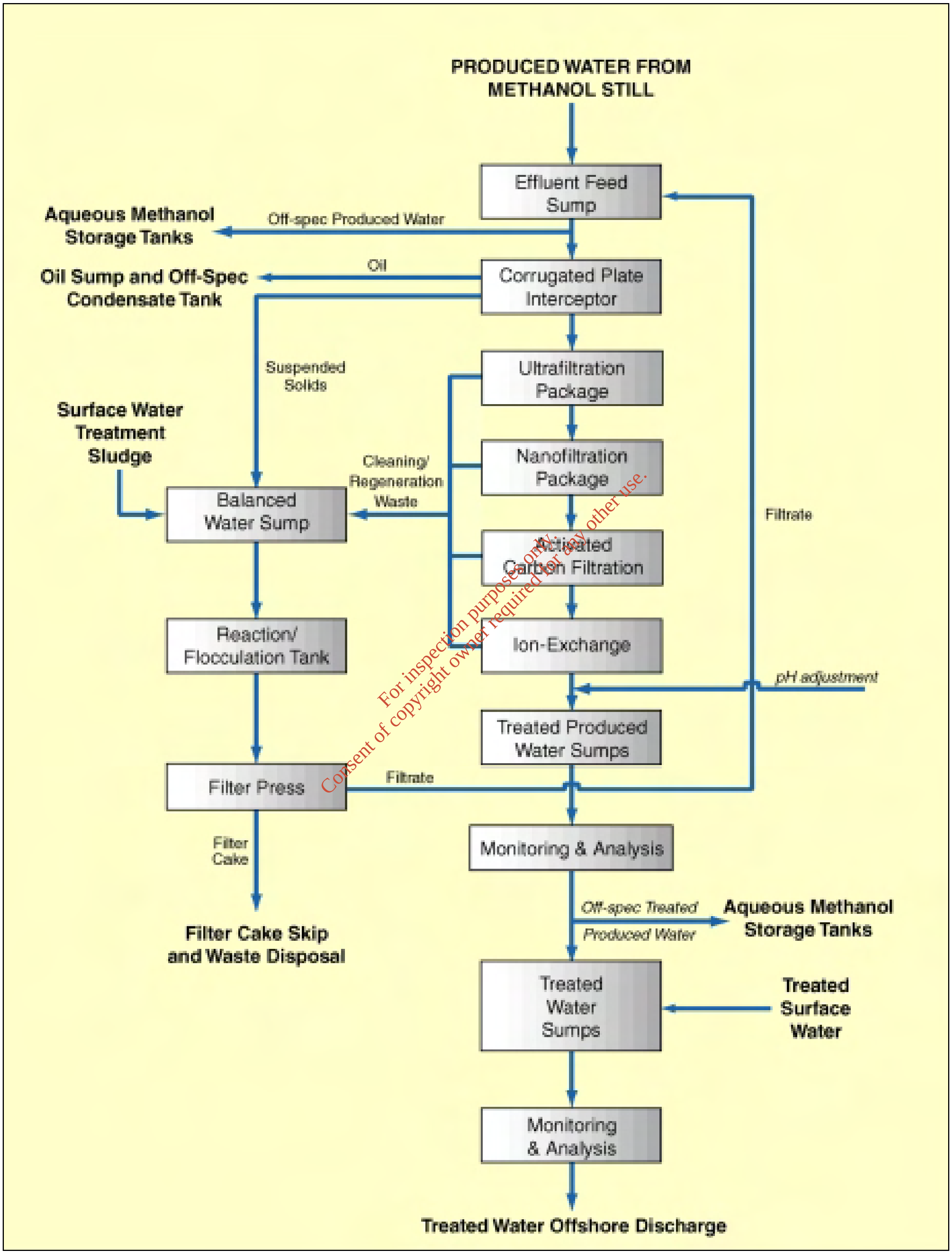
The produced water treatment system and quality monitoring facilities will be fully automatic. This will prevent the accidental pumping of out-of-specification effluent to sea.

A block diagram is provided in Figure 2.9.

The Produced Water Treatment System has a design capacity of 6m^3/hr.

For initial operations, the facilities are oversized. It is likely that the facilities will be operated with varying flow rates and compositions.

Figure 2.9 Process Flow Diagram – Produced Water Treatment System



2.5.9 Combustion Plant

The following combustion plant will be installed:

- sales gas compressor turbines (2 x 100% capacity);
- power generation compression engines (3 x 50%);
- heating medium fired heater;
- emergency generator; and
- fire pumps.

Two gas powered turbines drive the sales gas compressors. They are installed as duty and stand-by respectively.

Gas compression engines fuelled by low-pressure fuel gas are installed to generate power for the terminal. A diesel driven emergency generator is also provided.

The heating medium heater is a fired heater which heats the glycol water mixture (heating medium). This heating medium is circulated in the process to provide heating to various operations including the Methanol recovery system.

The fire water pumps are fuelled by diesel.

The sources of combustion plant on the terminal are shown in Table 2.1.

Table 2.1: Power and Energy Requirements of Combustion Plant

Unit	No.	Indicative Duty, MW (each)	Indicative Thermal Input MW (each)
Sales Gas Compressor Drivers	2	7.7	25.7
Heating Medium Fired Heater	1	5	6.3
Power Generator	3	1.0	2.6
Compressors are 2 x 100% units. Power generators are 3 x 50% units			

2.5.10 Support Systems

To support the gas treatment facilities the following utility systems will be provided:

- drainage systems (including treatment);
- firewater supply;
- fire fighting;
- fire water retention;
- emergency response including spill response;
- emergency and maintenance flaring;
- Instrument/service air and nitrogen;
- hydrate inhibitor injection;
- corrosion inhibitor injection;
- tanker loading; offspec water storage facilities;
- solid waste management and storage; and
- service and potable water.

2.5.11 Drainage Systems

Introduction

The different sources of water and their associated drainage systems have been segregated to minimise the unnecessary treatment of less contaminated or uncontaminated systems. The various drainage systems, their sources, characteristics and treatment/disposal systems are listed in Table 2.2.

Closed Drains System

Operational and maintenance drainage from the process and utilities equipment is collected via a piped closed drain collection network and drains to the Closed Drains Drum. It is then pumped back to the process or to a road tanker for disposal.

Open Drain System

The open drain system collects rainwater run off from the areas, which could potentially become contaminated with spills or leaks of chemicals. These areas include the waste storage areas, chemical storage areas, tanker loading areas, paved process areas, the car park, and access roads to the car park and tanker loading areas.

Containment bunds around storage tanks will collect rainwater that may be contaminated with the materials stored there. The bunds do not have any internal drainage outlet. Any rainwater that collects will be removed by bailing/pumping under controlled conditions and the product will be disposed of following analysis to determine if it is contaminated. If it is contaminated it will be discharged to the open drain treatment system.

Contaminated Firewater

Firewater which could be contaminated during fire-fighting will be collected in the open drains system and routed to the used Firewater Retention Pond. The contents of the pond will be tested. If found to be contaminated it will be sent off-site for treatment and/or disposal. If un-contaminated, the water will be routed through the surface water treatment system for disposal through the sea outfall.

Table 2.2: Waste Water Segregation, Pre-Treatment and Discharge

Effluent		Characteristics	Pre-treatment	Discharge To
1	Process Drainage	Hydrocarbon and Aqueous	Retained in Closed Drains Drum	Hydrocarbon to condensate tanks; aqueous to raw methanol tanks
2	Process Drainage	Tri-Ethylene Glycol Spills	Retain and reclaim	Heating Medium Storage /Offsite in container.
3	Produced Water	Reservoir water with possible high salts and metals content, methanol and some dissolved hydrocarbons	Methanol still and coalescer.	Open Drains Sump Self-contained treatment facility and to outfall line*.
4	Chemical Storage Drains	Acid and caustic spills Storm Water	Neutralise & settle within local bund	Open Drains Sump Self-contained treatment facility and to outfall line*.
5	Laboratory Waste	Spent chemicals	Retain within chemical sump	Offsite in containers.
6	Paved Area Drainage	Storm Water/Wash Down Water	None	Open Drains Sump Self-contained treatment facility and to outfall line*.
	Paved Area Drainage	Hydrocarbon Spills	Retain and reclaim	Open drains sump and oil sump and return to Condensate System
	Paved Area Drainage	Diesel Spills	Retain and reclaim within open drains sump	Open drains sump and Raw Methanol Storage Tank
	Tank Bund Drain	Storm/Wash Down Water Foam/Firewater	Retain and Control Discharge	Open Drains Sump Self-contained treatment facility and to outfall line*.
7	Sanitary Waste Water	Suspended Solids		Puraflow System
8	Potable Water Tank Overflow	Non Specific		

Firewater flows are based on the maximum capacity of the firewater system. It is assumed that the peak rainwater and firewater flow rates are not co-incidental.

The pond will provide storage for a peak flowrate of 1200m^3 per hour for up to 6 hours. The open drains header will be sized to accommodate the peak firewater flow rate. The surge volume to be held within the open drains sumps will accommodate a minimum of one hour's peak firewater flow.

Laboratory Drain System

A chemical drain is provided to collect spent chemicals from the on-site laboratory with a local sump for off-site disposal. Dosing, injection and cleaning chemicals will be stored in small quantities at the site. Any spillage will be contained locally in bunding and/or drip trays for re-use/disposal.

Clean Surface Water System

Rain water run off from areas, which will not become contaminated from spills or leaks, such as the roofs of buildings and site roads not used by tankers, will be collected by a system of pipes and concrete lined channels. This will be discharged via settlement ponds to minor watercourses in the vicinity of the terminal.

Terminal Perimeter Surface Water Drain System

To control surface water during the earthworks period, runoff will be collected by temporary falls and grips to lead the water to sump areas. At the earliest opportunity it is planned to install permanent surface water drains along the top and toe of cut slopes. The cut slope toe drains will eventually form part of a continuous perimeter drain around the footprint of the terminal. This drain will collect any runoff and groundwater which escapes from the cut face of the excavation and from within the peat during its excavation. The perimeter drain will discharge to the settlement ponds, described below, in order to allow silt or peat in the runoff waters to settle out prior to releasing the water into the local watercourses.

It is anticipated that the cut slope toe drainage will provide sufficient in the way of draw down of water level to prevent seepage from the cut face. However, this may not be sufficient in the north-east corner of the site, where the cut slope will be in rock. Existing bedrock groundwater levels are highest in this area and localised seepage may occur from individual fissures. This will not affect the stability of the rock slope and the rate of flow will be relatively minor. A system of herringbone drains will be constructed in the face to handle this water. The herringbone drains will be connected into the toe drain at the base of the face.

Where the cut slope is in mineral soil, localised seepage may occur due to locally higher permeability zones. The herringbone drains will also be designed to deal with this water.

The surface run off draining towards the terminal perimeter from the surrounding ground, where it will be higher, will be collected in the drain at the top of the slope. This drain will be connected to the toe drain.

Both the top drain and the toe drain will be in the form of an open channel drain.

Terminal Perimeter Ground Water Drain

A deeper drain will be constructed around the terminal perimeter, in the area where fill is required to bring the formation levels up to the required platform level. This deep drain will capture the groundwater that is expected to seep from the cut rock face or percolate through the unpaved areas of the terminal.

In order to disperse any naturally occurring iron, which may precipitate from the groundwater, an aeration chamber will be incorporated into the deep perimeter groundwater drain.

Sewage System

Waste water from toilets and washrooms in the administration building, workshops and stores will be treated with a commercial 'Puraflo' waste treatment system, as illustrated in Plate 2.4.

Open Drain Treatment System

Water collected in the open drain system will be treated by Corrugated Plate Interceptor / Multimedia Filtration and Ultra Filtration prior to discharge.

The inlet sump to the Corrugated Plate Interceptor will be sized to contain one hour of continuous heavy rainfall. After one hour the liquid level will be sufficiently high that the excess rainwater will overflow under an oil control baffle into the outlet sump and be pumped, treated and discharged via the outfall.

The Open Drains Sump (1346m^3 capacity) consists of two chambers, the first of which contains an Oil Skimmer, which will remove floating oil and discharge it by gravity to the Oil Sump. The water then flows out of the first chamber under an oil control baffle into the second larger chamber. The water is then pumped at a controlled rate to the Surface Water Treatment System.

The primary treatment stage comprises a Corrugated Plate Interceptor to remove the bulk of separable oil and suspended solids from the water. The separated oil is discharged to the Oil Sump and pumped from there to the Offspec Condensate Storage Tank.

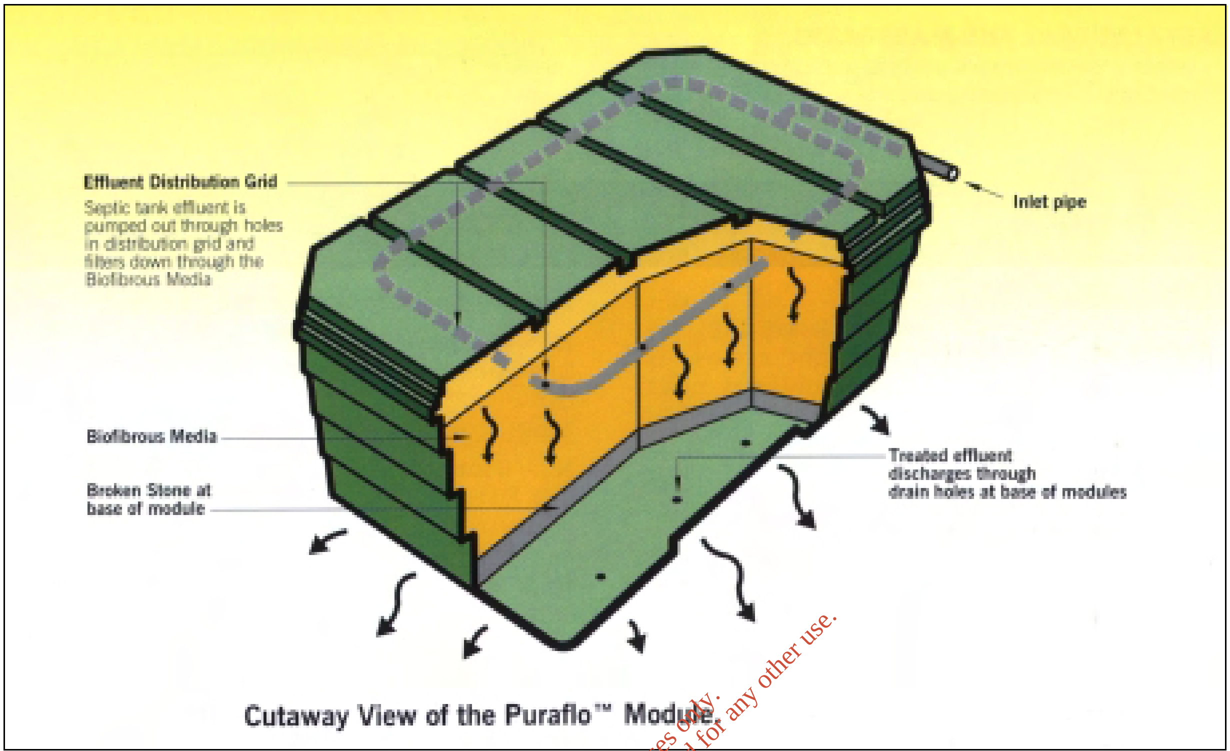
The separated solids are collected in the Sludge Tank and then pumped to the Balance Water Sump where they are combined with the solids/sludge from the Produced Water Treatment Plant. The treated water drains by gravity to the Clarified Water Tank and from there is pumped to the secondary treatment stage.

The secondary treatment stage is designed to reduce the concentration of trace hydrocarbons, suspended solids and oil/condensate to EQS level and comprises a Multimedia Filter (media is a mixture of anthracite, sand, garnet and gravel) to remove particulate suspended solids followed by an Ultra Filtration (UF) unit to remove residual free and emulsified oil. The Multimedia Filter backwash is recycled to the Open Drains Sump and the UF backwash is recycled to the primary treatment stage.

Continuous monitoring of flow, pH, and conductivity along with daily sampling and analyses of other parameters in the treated produced water stream will be provided. A description of the proposed monitoring regime is provided in Section 10. This will be subject to the terms of the IPPC Licence.

If the quality of treated effluent in the sump does not meet the licence requirements, it will be recirculated through the Surface Water Treatment System.

Plate 2.4 'Puraflo' Waste Treatment System



If the quality of the water in the sump meets the IPPC Licence requirements, it will be pumped to the Treated Water Sumps (2 x 105m^3 capacity) where it will be combined with the treated Produced Water stream. The combined treated streams (produced water and surface water) will then be pumped to the sea outfall.

Parts of the Surface Water Treatment System will be housed.

A block diagram is provided in Figure 2.10.

Settlement Ponds

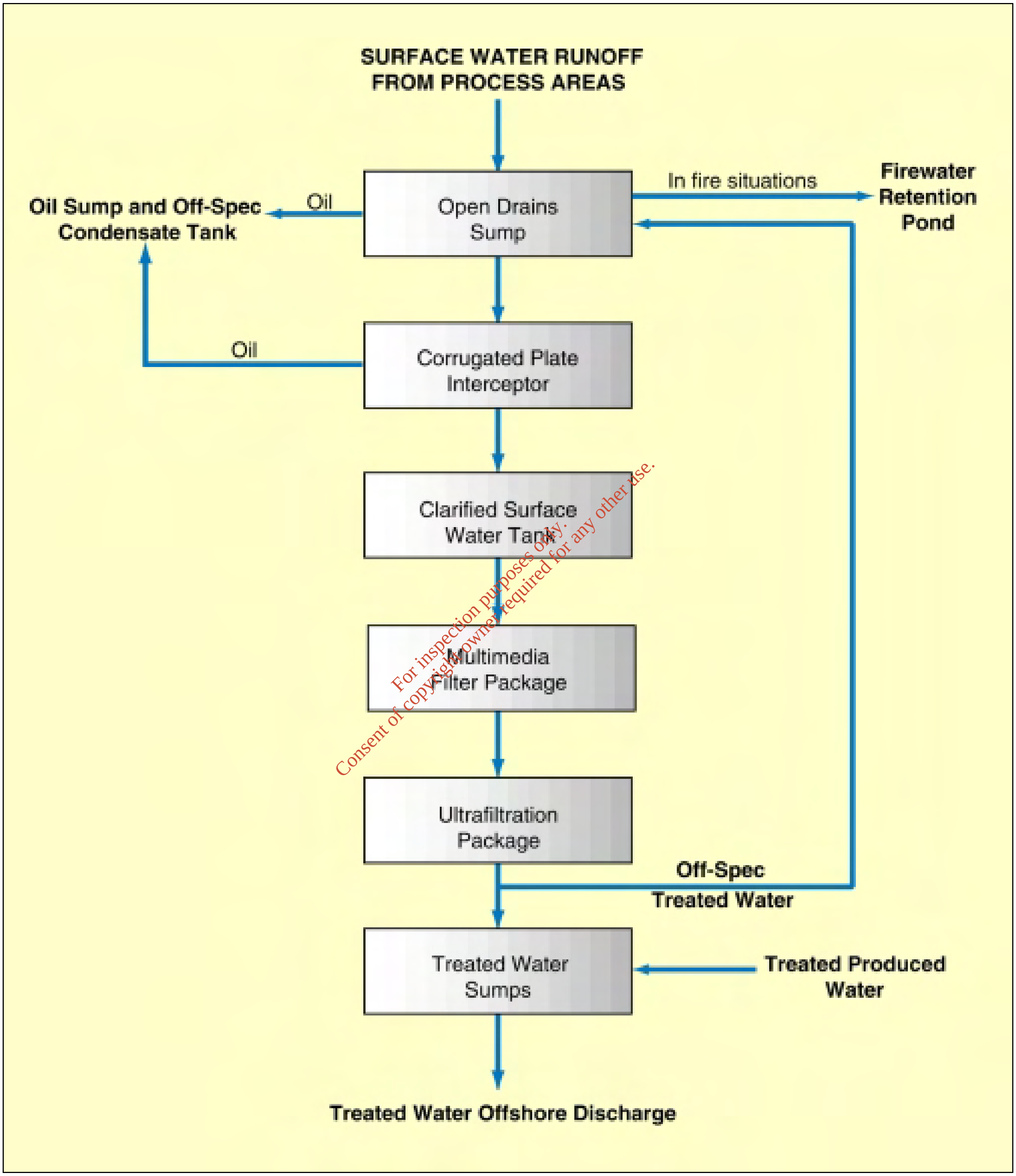
The settlement ponds will treat the water from the clean surface water drains and the terminal perimeter drains. This water is expected to contain significant peat fragments, during the construction phase, and some silt. On completion of construction, the peat content will be significantly reduced. It is proposed that a set of ponds will be constructed to treat the run-off. The set of two ponds will be located in the south-western corner of the terminal plant site. They will deal with runoff from the terminal.

As well as allowing peat and silt to settle out, the ponds have been designed to store run-off water resulting from high rainfall events. Water collected in the ponds following a high rainfall event will be released slowly and in a controlled manner, thus minimising erosion damage that could occur downstream from the pond outfall.

Control of input to these ponds will also be by weir. Contingency will be given for emergency overflow from the pond, by way of a spillway, to the watercourse. All ponds will be inspected on a regular basis, at least weekly, but daily initially, and de-silted when necessary. Silt removing operations will be undertaken only at minimal flow conditions and a bypass structure will ensure that disturbed silt is not carried downstream.

The pond design is based upon the design principles and discharge quality requirements for the Bord na Mona's settlement ponds at the Oweninney Works, which have been shown to perform to the terms of the IPPC Licence.

Figure 2.10 Surface Water Treatment System



The settlement ponds will be monitored electronically for turbidity and phosphate in order identify any upset condition that might occur. The ponds are designed so that they can be run in series in the event that recirculation of the water is required before release. Under normal operating conditions they will run in parallel to allow the cleaning of one pond whilst still keeping the other pond online. The accumulated silt when cleaned from the pond will be disposed of to the peat deposition area at Srahmore.

The potential impacts of surface water siltation and eutrophication resulting from any dewatering of the peat during construction will be managed by the pond system.

With regard to potential eutrophication, the mixing of incident rainfall may well be sufficient to dilute any elevated nitrate and phosphate arising from the peat water. However the settlement ponds will also have internal sieves and an iron oxide system to reduce the phosphate levels. If necessary flocculents will be introduced, the composition of which will be discussed and agreed with North-Western Regional Fisheries Board and Mayo County Council prior to use.

Groundwater Protection Measures

The bedrock, overburden and peat under the terminal footprint are of relatively low permeability (see Section 8). The groundwater is not particularly vulnerable to the transmission of any aqueous contamination from terminal activities. Nevertheless, measures to protect groundwater will be incorporated into the facility design. These include the bunding of all storage tanks, where appropriate the use of continuously welded piping for process fluids, the provision of paving under any process equipment where there could be leaks, and paving of the tanker unloading area and site roads.

The Environmental Management System and Emergency Response Plan will include procedures to respond to spills or leaks which could potentially impact on groundwater.

2.6 Process Control

The terminal facilities are designed to operate over a range of flow and pressures determined by the production profiles and gas reservoir characteristics. Conditioned or "Sales" gas is exported directly into the BGE distribution network at a defined pressure. The delivery rate of gas, fiscally measured, from the terminal will be controlled according to daily nominations from the customer(s).

The whole Corrib field development (onshore and offshore) will be controlled from the onshore terminal control room. A Distributed Control System (DCS) will control the onshore facilities and an Electro-Hydraulic System will control the offshore facilities. Based upon a manning philosophy that is sufficient for safe operation, the terminal control room will provide all the necessary information to safely control the offshore facility, gas and liquid processing at the onshore terminal and gas export to the natural gas distribution network.

The control system will provide for the continuous processing and production requirements of the facility on a 24 hour, 365 day per year basis.

Routine automatic control will allow smooth operation of the whole facility. In the event of process upsets and/or hazards, manual or automatic predetermined sequences will bring the terminal to a safe state, ranging from unit shutdowns to total plant shutdown.

The control system will allow the control room operators to view all the necessary process variables and make adjustments to controller set points from the displays provided. The displays will allow rapid recognition of process upsets via the system alarm handling routines and will contain the required pre-configured logic steps to implement the overall cause and effect sequences for routine process control.

The control system will have standard features to provide alarm and event management, historical data storage and trending, with the facility to provide free format reports and logs and certain other user definable features.

The control system will have built in redundancy to allow for on-line maintenance.

Safety systems will be provided which are separate from the control system. The systems provided will recognise predicted hazards and will automatically bring the Corrib facility to a safe state.

The Emergency Shutdown system at the terminal will ensure the safe isolation and shutdown of equipment under fault or fire conditions and will provide for the safe and efficient shutdown of process operations and the isolation of flammable / toxic materials within the facilities. Emergency shutdown and isolation will be initiated by fire and/or gas detection or by process deviations.

Emergency shutdown can also be initiated manually.

2.7 Site Status in Relation to the EU Control of Major Accidents Hazards Involving Dangerous Substances Directive

2.7.1 Background to the 'Seveso' Directive

The European Union Council Directive 96/82/EC on the Control of Major Accident Hazards Involving Dangerous Substances ('Seveso II Directive) came into force in February 1997 was implemented in Ireland under SI 476 of 2000.

The new Directive required the repeal of the original 'Seveso' Directive (82/501/EC) which was adopted following a series of accidents involving dangerous substances, such as the accident which occurred at Seveso, Italy in 1976.

The Directive defines a major accident as:

'an occurrence such as a major emission, fire, or explosion resulting from uncontrolled developments in the course of the operation of any establishment covered by this Directive, and leading to serious danger to human health and/or the environment, immediate or delayed, inside or outside the establishment, and involving one or more dangerous substances.'

Hazard is defined as:

'the intrinsic property of a dangerous substance or physical situation, with a potential for creating damage to human health and/or the environment.'

This second Seveso Directive revises the previous Directive on the basis of experience acquired during its implementation with the aim of preventing major accidents, limiting their consequences and ensuring a high level of protection throughout the European Union in a consistent and effective manner. The Directive covers all establishments having quantities of dangerous substances equal to or in excess of the thresholds.

Some of the requirements, which the Directive places on the operators of establishments, are briefly outlined below.

General Obligations (Article 5)

The Directive obliges every operator to take all measures necessary to prevent major accidents and limit their consequences for man and the environment, with an obligation to prove at any time to the regulatory authorities that such measures have been taken.

Notification (Article 6)

Operators of establishments covered by the Directive are required to notify nominated competent authorities of their existence and give clearly specified details in relation to the operator, relevant dangerous substances, inventories, type of activity and the immediate environment of the establishment. Any significant changes in the quantity, nature or physical form of dangerous substances or in their processing, or the permanent closure of an installation must also be immediately notified.

The central competent authority for Ireland is the National Authority for Occupational Safety & Health (NAOSH), also known as the Health & Safety Authority (HSA).

The notification requirement is to enable the regulatory authorities to manage their inspection programmes more effectively, identify possible domino effects, monitor implementation by operators and advise local authorities in respect of land-use or planning considerations.

Major Accident Prevention Plan (Article 7)

All operators of establishments subject to the Directive are required to prepare a major accident prevention plan (MAPP) and ensure it is properly implemented. The major accident prevention plan established by the operator must be designed to guarantee a high level of protection for human beings and the environment by appropriate means, structures and safety management systems.

In planning for emergencies the operator is required to adopt and implement procedures to identify foreseeable emergencies by systematic analysis and to prepare, test and review emergency plans to respond to such emergencies.

Article 18

Article 18 deals with the requirement of competent authorities to organise a system of inspections, or other measures of control appropriate to the type of establishment concerned.

2.7.2 Status of the Corrib Terminal

The developer determined at an early stage that the terminal would come under the European Communities (Control of Major Accident Hazards Involving Dangerous Substances) Regulations, S.I. 476 of 2000, due to the quantity of toxic and flammable materials that will be stored on the site (see Section 16).

Based on the maximum expected inventory levels of these materials the developer concluded that Articles 6 and 7 of the "Seveso II" Directive (lower tier requirements) will be applicable. Thus the provisions of S.I. 476 of 2000 will apply to the facility.

A detailed study of the hazards associated with the operation of the site has been completed in consultation with the HSA.

2.8 Hazard Protection

The following section describes the procedures, equipment and arrangements in place to mitigate against operational hazards and to ensure that terminal operations are safe. A description of the fire fighting strategy proposed for the terminal is also provided in Appendix 2.1.

2.8.1 Hazard Detection and Monitoring

Hazard identification and prevention has been a key component of the terminal design and will minimise the risk of accident/ hazardous and emergency situations arising during the operation of the terminal. The Emergency Plan to be prepared for the terminal will be regularly tested and reviewed and will detail the emergency response including the organisation and facilities in place and the measures to be taken to minimise the consequences of any accident/emergency situations on human health and the environment.

Specific measures incorporated into the terminal design to detect and respond to hazardous situations are described in the following sections.

The purpose of the hazard detection and monitoring is to detect any hazard at the earliest possible moment. The principal detection and monitoring measures at the terminal will include the following:

- controls and instrumentation will be provided to ensure that the plant operates normally, i.e. within its intended operating range in terms of flow, temperature, pressure and liquid level. If any of these parameters stray to the intended limit of the normal operating range, then an alarm will attract the operator's attention;
- further independent instrumentation will be provided to detect deviations outside normal operation and to initiate additional alarms and shutdown;
- gas detectors will be installed at strategic locations in the process areas and at air intakes to buildings and to any equipment with ignition sources, i.e. gas turbines, engines and the heating medium heater. These detectors will give early warning of potentially explosive atmospheres. An explosion could only occur if a gas cloud, first were to have a concentration above the lower explosive limit and, secondly, were to be ignited by a flame or spark. Detection of flammable gas near an ignition source would immediately shut down that piece of equipment so as to eliminate the potential source of ignition;
- smoke detection in all buildings. High Sensitivity Smoke Detectors (HSSDs) will be used for the very early detection of electrical fires. These are one thousand times more sensitive than a typical domestic smoke alarm and enable incipient electrical fires to be extinguished before they develop;
- fire detectors will be installed at strategic locations in the plant and in all buildings. Fire, gas and smoke detectors will all be integrated into the fire and gas monitoring system, which provides executive shutdown action and warnings in the control room as appropriate. Fire detection in the storage tank area will automatically initiate the tank deluge systems; and
- CCTV will be used to monitor critical areas.

2.9 Hazard Mitigation and Protection

In the event of a hazard being detected, the aim is to isolate the affected section of plant and depressurise it safely to flare as rapidly as possible. All control and shutdown systems have been designed to default to a safe condition in the event of failure. The principal mitigation and protection measures will include:

a) Emergency shutdown (ESD) and isolation initiated by fire and/or gas detection or by process deviations (outlined above). The ESD system at the terminal will ensure the safe isolation and shutdown of equipment under fault or fire conditions and will provide a basis for the safe and efficient shutdown of process operations and the isolation of flammable / toxic materials within the facilities. The principal aims and objectives of the system are:

    - the protection of personnel;
    - the prevention and/or minimisation of pollution to the environment; and
    - the protection of plant and equipment; and
    - continuity of production by minimising spurious shutdowns.

    The objectives will be achieved by providing a system that:

    - warns of an abnormal operational or equipment condition;

- provides manual and automatic initiation for shutting down and/or isolating sections of the plant, with the objective of mitigating any consequential effects of abnormal operation;
- provides remote manual or automatic isolation; and
- provides facility for remote manual depressurising of each plant section once isolated.

The ESD system will be a fully fail-safe design incorporating duplicated control electronics with continuous, self-checking diagnostics and fully automatic isolation of the relevant sections of plant by ESD valve closure. The terminal ESD system will operate on four levels depending on the situations, which are outlined below (the offshore subsea system follows the same philosophy).

Table 2.3: Terminal ESD Operating Levels

ESD Level	Operation
Level 0	Total field shutdown
Level 1	Terminal shutdown, excluding the emergency generator
Level 2	Shutdown of a terminal system (e.g. gas, condensate or methanol)
Level 3	Shutdown of a section of equipment within a system (e.g. gas compression, condensate tankage, or methanol injection)

b) Depressurisation of an isolated section or sections of plant or, if appropriate, the entire plant, during an emergency, by venting to flare (blowdown).

c) Pressure relief valves to provide safe and automatic venting of pressure to the high level flare before equipment becomes over-pressured.

d) A self-sufficient and comprehensive fire protection / fire-fighting system.

e) Design of the control building to withstand the consequences of an extremely unlikely over-pressure event, to protect the operators and to ensure no damage to the control and shutdown systems.

f) Secondary means of egress from the plant to the west in addition to the main exit to the south and east.

g) Emergency Response Facilities.

In an emergency, the control room (manned on a 24-hour basis) at the terminal will remain the operational hub. Emergency response facilities will be provided in the terminal administration building near to the control room. Information will be repeated in Shell's Emergency Response Centre (ERC) in its Dublin headquarters via duplicated and secure telecom connections to the Dublin ERC. There will also be video-conferencing to the Dublin office. The emergency response facilities on-site will include:

- full telecom connections with dedicated lines to the ambulance, fire and police services;
- offsite storage of details of personnel on site;
- monitoring of high level plant information repeated from the control room, e.g. ESD and fire and gas detection status, subsea system status, power supply status, wind speed and direction, etc; and
- monitoring of plant CCTV camera images.

In summary, hazard identification and prevention is a key component of terminal design and will minimise the risk of accident and emergency situations arising during operation. In the unlikely event of accident or emergency situations arising the detection and control/response systems to be employed at the terminal will minimise any consequences on human health and the environment.

2.10 Programme

The programme for the construction of the terminal is described in Section 3.

2.11 Commissioning Activities

2.11.1 Scope

All necessary safety and utility systems to achieve the normal running of the terminal will be completed before hydrocarbons from offshore are introduced into the plant. The Engineering Procurement Construction Management (EPCM) contractor will be responsible for all commissioning activities before gas production starts.

On completion of the construction works, the EPCM contractor will assist the operations team to start-up the terminal with the introduction of hydrocarbons. Shell will integrate the terminal operations team into the commissioning team in order to gain familiarisation with the systems prior to production.

2.11.2 Commissioning

Commissioning is defined as all activities required prior to the introduction of hydrocarbons.

All commissioning activities will be carried out in accordance with procedures representing industry best practice and approved by Shell. All mechanical systems must be completed before commissioning activities are allowed to commence. In order that mechanical completion/commissioning can become a seamless transition, commissioning personnel will be introduced into the project at an early stage to assist in these activities.

Mechanical completion is defined as the point in time when the plant has been constructed and inspected in accordance with engineering drawings, specifications and applicable codes.

The following specific activities will form part of mechanical completion:

- final adjustments will be made and final alignments will be made of the cold equipment;
- final electrical checks will be carried out together with internal vessel inspections;
- hydrostatic and pneumatic tests of equipment and pipework; and
- chemical cleaning and flushing of the process pipework and equipment.

The flow of activities to commission the various parts of the plant process are outlined in a provisional commissioning sequence of tests and activities below:

- introduction of potable water;
- instrument/plant air system;
- emergency power generation (diesel);
- nitrogen system;
- firewater system;
- open and closed drain system;
- heating medium system;
- hydrate inhibitor (methanol) system;
- corrosion inhibitor system;
- inlet facilities system;
- flare;
- fuel gas system;
- power generation system;
- gas conditioning system;
- gas compression;
- fiscal metering;
- sales gas export facilities; and
- condensate stabilisation system.

2.11.3 Start-Up/First Gas and Handovers

The overall responsibility for introducing hydrocarbons into the terminal is that of the terminal manager. Only when he/she is satisfied that all activities identified within the commissioning and safety programme have been completed, to his/her approval, will production commence.

At the completion of the commissioning phase, and prior to start-up, a complete set of signed off documentation will be handed over to Shell for verification of completion.

2.11.4 Final Handover to the Terminal Operator

This will follow successful start-up of the terminal and the completion of a defined performance testing programme.

2.12 De-commissioning

It is expected that the following decommissioning activities will be performed when the terminal is decommissioned:

- decontamination of the process items of equipment;
- analysis of potentially contaminated and toxic materials. An independent consultant will be engaged to identify any contamination and monitor the environment during decontamination and demolition. Agreement with all relevant authorities for disposal routes and methods will be sought;
- demolition of the process items of equipment;
- removal of underground pipework and pipelines to the boundary fence;
- the import pipeline and open drain systems will be stabilised and left in situ, or in accordance with local authority and national requirements; and
- the facilities will be removed to grade level.

At the time of decommissioning, all efforts will be made to recycle and/or reuse plant materials, such as scrap metal, timber and concrete.

The scope of work for decommissioning the terminal will be assessed approximately 5 years prior to the predicted date of decommissioning. This will allow for a detailed assessment on the quantities of materials to be removed from the process items of equipment; a review of the technology available for chemical and abrasive cleaning and a review with all the relevant authorities on potential method statements for this activity.

2.13 Water Outfall Pipe

2.13.1 Description of the Proposed Outfall Pipe

The proposed treated water discharge pipe will be 254mm (10 inches) in diameter. It will be buried throughout its length from the terminal to the landfall in the same trench as the 508mm (20 inch) diameter gas pipeline. From the landfall, it will be strapped to the 508mm (20 inch) pipeline, from which it will gain stability.

The outfall pipeline will follow the gas pipeline route for approximately 12.7km to a point outside Broadhaven Bay (SAC) in over 60m water depth. There, a short distance from the outfall point, it will be laid away from the 508mm (20 inch) line and will rise to the seabed. To ensure that the line will remain in place, it may be necessary to attach concrete saddles to it. It will be fitted with a diffuser element on the end, which will assist in rapid mixing of the waste water as it enters the sea.

2.14 Terminal Management.

The terminal will be managed in accordance with Shell's Health Safety and Environmental principles. An outline of the Environmental Management arrangements for the terminal is provided in Section 20. An essential part of HSE management is the appropriate training and competence of staff. This is addressed in Section 5.

Appendix 2.1 Fire Fighting Strategy

2.1 Fire Fighting

Detection and Fighting of fire for the terminal have been developed based on relevant Institute of Petroleum (IP) and National Fire Prevention Association (NFPA) Codes and Standards.

The main objectives are to ensure that the design of fire and gas detection and protection systems at the terminal reduces the risk to personnel, the environment and asset to an acceptable level.

2.2 Detection And Monitoring

Fire and gas detection equipment will be provided within the terminal to provide an early warning of hazardous or potentially hazardous situations. The fire and gas system is powered from the terminal Un-interruptible Power Supply (UPS), in the event of terminal power failure.

The terminal areas will be sub-divided into fire areas such that a clear and unambiguous indication will be given as to the location of a detected hazard. Equipment with dedicated protection such as compressor / turbines, field equipment rooms will be allocated separate fire areas. If any fire or gas detector or manual alarm push button is activated both visual and audible alarm shall be given at the fire and gas panel in the Local Equipment Room and repeated in the Main Control Room.

2.2.1 Gas Detection

Flammable gas detectors will be provided to detect the presence of flammable gas before it reaches the lower explosive limit and to take appropriate action. The terminal will be provided with two different types of flammable gas detectors. Both types will raise alarm and will initiate executive actions upon coincident operation of two detectors.

Flammable gas detectors will monitor the following areas:

- HVAC air intake;
- within gas turbine and diesel engine combustion air intakes;
- Fired Heater air intake; and
- buildings where gas may accumulate.

Hydrogen gas detectors will be used in the vicinity of battery rooms, if sealed lead acid batteries are used.

2.2.2 Fire Detection

All areas of the terminal where a significant fire may occur will be provided with appropriate fire detection equipment. The objective is to detect a fire hazard, at its early stage of development and to initiate alarms and appropriate executive actions to enable the fire situation to be brought under control.

The characteristic of a fire depends on the fuel source and as such appropriate detectors will be used. They are:

- smoke detector;
- heat detector; and
- flame detector.

The types of detectors used in different areas will vary with the hazard and environmental conditions present.

2.2.3 Alarms

Manual alarm call points will be strategically positioned around the terminal including buildings. Manual initiation of alarm will instigate audible and visible alarm within the main control room.

Site wide alarm will be initiated by:

- coincident fire detection in outside areas;
- manual alarm call points in outside areas; and
- manual activation from the main control room.

Local building alarms will be initiated by:

- coincident fire and gas detection in the building; and
- manual alarm call points associated with the building.

Visual flashing alarms will be located in noisy areas where any audible alarm may be drowned by equipment noise.

2.3 Fire Fighting

The terminal fire protection philosophy is to install fixed fire protection systems which comprise water deluge systems, foam systems, gaseous extinguishing systems, hydrants, hose reels and monitors, in areas where it is most likely for a fire to occur. These systems are supplemented by fire extinguishers. The fire protection system comprises the following:

- Firewater pumps (4 x 50%);
- Firewater Jockey pumps (2 x 100%);
- Firewater Ringmain;
- Deluge systems;
- Foam system;
- Gaseous extinguishing system shall be provided for the gas turbine enclosures;

- Hydrants;
- Hydrant hose cabinets;
- Monitors;
- Foam monitors; and
- Fire extinguishers.

2.3.1 Firewater Supply and Distribution

The capacity of the firewater system shall be 1200m^3/hr. This is based on the worst-case scenario of a fire in the process area with simultaneous deluge of the area on fire and the adjacent areas. For this fire scenario, the deluge water application shall be based on the NFPA 15 application rates.

Considering the remote location of the terminal from the nearest emergency services, a total of 6 hours storage of firewater will be provided in a pond. The pond will be sized for the full design flow rate plus an allowance for evaporation, freezing conditions and firewater jockey pump supply. Make-up water is from the local fresh water supplies.

The fire mains will be arranged as a looped or grid system to supply the design flow at the minimum residual hydrant outlet pressure. The fire main will be installed with sectionalising valves capable of isolating various sections of the fire main for maintenance purposes, whilst allowing the remainder of the system to remain available for fire fighting. The sectionalising valves shall be capable of isolating, any section of pipe without inhibiting more than five protection devices (e.g. monitors and three hydrants). All sectionalising valves shall be lockable.

Spurs will be taken off the fire main to feed the deluge and foam systems. The spurs shall also feed hydrants, monitors and hose reels.

The fire main shall be sized to provide a minimum discharge pressure of 7.0 barg at the furthest monitor or hydrant and the pressure range requirements for the worst-case nozzles of individual deluge/foam systems.

2.3.2 Fixed Roof Tanks

Fixed roof tanks, containing condensate or methanol, will be provided with fixed foam chambers designed to pour foam solution onto the liquid surface. Hydrants will also be provided to deliver foam solution from mobile units to the protected tank.

2.3.3 Deluge Systems

Fixed firewater deluge system will be provided for the protection of hydrocarbon tanks, pumps, compressors, vessels and tanker loading areas.

Each deluge system will be capable of local remote manual operation at the skid and at the control room.

The firewater application rates will be based on NFPA 15.

2.3.4 Foam System

Foam is an aggregate of gas filled bubbles formed from aqueous solution. Foam forms a heat-resistant blanket, of density less than that of a flammable liquid and is able to extinguish fires by cooling, suppression of vaporisation, and by the prevention of access to oxygen.

Surface foam pourer systems will be provided for fixed roof tanks and based on NFPA 11.

Foam system will also be provided for the bunds of the odorant system, methanol tanks and condensate tanks.

In addition to the fixed foam systems, mobile foam trolley systems shall also be provided to tank areas or where there is a risk of flammable liquid release.

2.3.5 Hydrants

Hydrants shall provide a source of firewater for the fire hose, portable monitors, mobile foam units, mobile foam trailers and fire fighting vehicles.

Hydrants shall be located outside bunds and adjacent to roadways.

Pressure at hand held equipment should not exceed 7.0 barg and hose diameter shall be appropriate for hand held nozzles.

2.3.6 Firewater Monitors

Water monitors will be provided for extinguishing and cooling vulnerable parts of equipment, storage tanks and structure throughout the terminal. They will be sited around the terminal and directly connected to the fire main by valve upstands.

Monitors will deliver a stream of water for fire suppression or for cooling equipment exposed to fire.

The monitors used at the terminal will be remote operated. These will be designed to be operated by one person with control achieved through hydraulic, electrical or pneumatic instrumentation.

Some monitors shall be fitted with foam/water nozzles, design for either Fluoroprotein Foam or Aqueous Film Forming Foam (AFFF).

2.3.7 Fire Hose Cabinets

Fire hose cabinets shall be provided for each fire hydrant. Hose lengths, coupling threads etc. will meet the requirements of NFPA 1963.

2.3.8 Gaseous Total Flood Systems

Gaseous automatic systems will be installed in the gas turbine enclosures. The gaseous system will be capable of being initiated automatically on coincident fire detection. Local discharge facilities shall be provided at entrances to the enclosure/room and a mechanical release facility shall be provided at the skid assembly. Manual release shall also be possible from the package and the Main Control Room.

The gaseous system will be provided with a backup reserve to enable a 'second shot'. Change over shall be initiated manually or automatically if pressure switch feed back signal is not received.

Status lights will be provided on each entrance to the enclosure of room to warn personnel of the status of the system.

A facility for manually inhibiting the release will be incorporated into the design to enable safe entry into the area being protected.

2.4 Miscellaneous Fire Fighting Equipment

2.4.1 Hosereels/ Hose Reel Cabinets

Hosereels shall be installed to provide fire fighting in the Control Building and workshops.

A variety of hand held and mobile fire extinguishers will be provided. Where located outside, suitable weather cabinets will be provided. The extinguishers will be positioned in areas of risk relevant to their application as follows:

- dry chemical (9kg and 12kg) suitable for liquid and electrical fires;
- dry chemical (75kg) wheeled units suitable for hydrocarbon gas and liquid fires;
- CO_2 for general use throughout electrical equipment areas; and
- extinguishers suitable for general use throughout electrical and hydrocarbon areas.

2.4.2 Mobile Foam Units

Mobile foam units will be used for rapid deployment of foam extinguishing agent on hydrocarbon spill or fires.

Foam units will be located in the vicinity of where hydrocarbon liquids are present, in large quantities i.e. tank bunded areas, lube oil storage area and slug catcher area. Each foam unit shall be housed in a weatherproof easily accessible enclosure.

2.5 Passive Fire Protection

The primary purpose of fire proofing is to minimise the possibilities of collapse in a fire of steelwork supporting equipment containing flammable or toxic materials, the release of which would add materially to the intensity of a fire and to the problems and hazards of fire fighting.

The degree and extent of fireproofing will be assessed and identified by the fire risk assessment during detail design.

2.5.1 Structural fire proofing

Fire proofing will be applied to major structural steel/pipe racks supporting air coolers where a pool fire could occur. The degree and extent of fireproofing shall be assessed and identified by the fire risk assessment.

2.5.2 Equipment fire proofing

Process pressure vessels and associated pipe work up to and including the ESD valves that contain hazardous inventories will be considered for fireproofing to minimise the pressure build up in the vessel caused by evaporating and expanding hydrocarbons. Fireproofing reduces the loading on the relief and vent system during a localised fire scenario before depressurisation has been completed. Fireproofing also protects the integrity of the vessel by minimising the vessel wall temperature thus avoiding premature failure and escalation of the initial event.

2.5.3 Instrument fireproofing

Double acting ESD/EDP valves, which are located in a fire supporting area, will be fireproofed.

Single acting ESD/EDP valves do not need to be fireproofed as these are inherently fail-safe by design.

2.5.4 ESD & Blowdown Valves

Sensitive ESD Valves and Blowdown Valves will be considered for fire proofing where it can be demonstrated that as a result of failure of the valve due to fire damage the initial event will escalate. The results of the Fire Risk Assessment will specify the affected zones from accidental release events. Where possible, cables and tubing to critical valves will be run in trenches. Where this is not possible, alternative protection from blast will be provided.

2.5.5 Building Fire Proofing

Fire protection for buildings and specific coating systems to be employed will comply with Civil, Structural and Architectural requirements.

Three

Construction

3 Construction

3.1 Introduction

The construction of the terminal is described in this section. It includes an outline of the main activities and operations to be undertaken during the construction project and the phasing of these operations. The construction of the peat deposition site is described in the peat deposition volume of this EIS.

The potential and predicted impacts on the environment, arising from construction activities, have been assessed. The conclusions of these assessments are provided in the chapters of this EIS dedicated to each medium. The mitigation measures, which will be implemented in order to minimise the effects of the construction phase on the environment, are also addressed in this section.

3.2 Construction Management

3.2.1 Project Management and Control

Shell will appoint an earthworks contractor and a civil/mechanical contractor to undertake the activities required for the construction and commissioning of the terminal. Prior to appointment, the contractors will be required to satisfy Shell that they have the technical competence and experience to complete the work in a satisfactory manner.

The Contractors' management will comply with the Safety Health and Welfare at Work (Construction) Regulations 2001, which prescribe the details for proper safety management on site. They will also comply with Shell Group standards.

3.2.2 Environmental Monitoring Group

The Minister for (then) Marine and Natural Resources has placed conditions (Plan of Development Approval April 2002) on the Corrib Field Development as follows:

'The Minister, in consultation with Mayo County Council, will establish an Environmental Monitoring Group (EMG) charged with monitoring development during all stages of construction and development and with ensuring adherence to the approved Environmental Management Plan (EMP)'.

The EMG will include representatives of the Department of the Marine and Natural Resources, Mayo County Council, EEI, Dúchas, NWRFB, local fishing interests, and local residents.

The EMG was established in July 2002, when the initial construction activities associated with the landfall at Glengad commenced. It is expected that liaison will be continued through the already existing EMG with membership expanded to include members of the community local to the development. The purpose of the Group is to ensure that interested parties, including local residents are kept informed of the activities to be carried out on site. The Group will be a forum at which environmental concerns relating to the construction project can be raised and resolved. The Group will meet on a regular basis for the duration of the construction period.

Shell also intends to establish a smaller local liaison forum with local residents around the terminal site and haul route to ensure that local residents have a way of communicating local concerns to Shell and have them addressed in a timely manner during the construction period.

3.2.3 Overview of Construction Activities

The main activities, in order of execution, will be as follows:

- site access and enabling works;
- peat excavation and transport offsite;
- earthworks (site preparation and levelling;
- ground works (piling and civil);
- structural framework (pipe-racks and equipment supports);
- construction of main buildings;
- installation of major equipment items;
- piping fabrication and erection;
- testing of equipment and systems;
- installation of electrical and instrumentation systems;
- commissioning of the plant and process; and
- landscaping of the site including tree planting, compensation habitat development and environmental conservation of the surrounding areas.

The civil activities are expected to commence before the excavation and filling of the terminal platform has been completed.

A more detailed description of the construction activities is given in Section 3.3.

3.2.4 Health and Safety Management Strategy

Shell will establish a joint Health and Safety Management System with all contractors engaged in construction activities on the terminal site. Similarly for all road haulage activities the safe operation of the haulage trucks and the safety of the local population will be addressed in the Traffic Management Plan.

The site Health and Safety Plan will be compiled through discussions with Shell and the contractors. It will be the responsibility of the contractor to execute the planned activities safely and in accordance with national legislation, industry and Shell standards and specifications and good industry practice. Shell will manage and audit the compliance of the contractors on a regular basis to ensure that a consistent, high level of attention is given to all safety aspects on site.

Safety performance will be addressed on an ongoing basis throughout the construction phase in several forms.

Management Safety Meetings

Shell's construction management, Health and Safety advisors and the contractor representatives will meet on a regular basis to review the site and haulage safety performance. Incident investigation and reports, and follow up of the main learning points will be discussed between those involved.

Safety Inductions

All personnel working on the site must be in possession of the FÁS Safepass qualification. In addition a site specific Safety Induction will be prepared by the contractors to address all construction safety related aspects. It will be compulsory to attend this before starting any activities on the site.

Toolbox Meetings

Each contractor will organise a daily toolbox meeting to be held first thing in the morning. The planned daily activities will be discussed as well as distributing feedback and learning points from the previous day's activities and safety reports. In addition toolbox meetings will be held when a significant change in work activities occurs.

A site permit to work system (PTW) will be in operation on the site for all activities and risk assessments will be carried out routinely. All incidents, accidents and near misses will be reported and investigated. A medical and emergency response procedure will be established in consultation with the local emergency services.

3.2.5 Environmental Management Strategy

Shell will establish a joint environmental management plan with each contractor for the construction phase. It will be the responsibility of each contractor to ensure strict compliance with all aspects of the environmental management plan. Shell will audit, on a regular basis, the environmental performance of the contractors and all corrective actions will be logged with dates for implementation. The environmental performance of the terminal construction activities will be reviewed regularly by the (already existing) EMG, and modifications will be made to the environmental management plans, if necessary to ensure their effectiveness.

A programme will be established for regular monitoring of construction noise, mud and dust, traffic movements, and water quality. Management of construction wastes will also be an important part of the environmental management plan.

Mud and Dust

Dust monitoring stations will be erected at defined points between the site and local residences. The data collected will be held on file and made available for inspection by Mayo County Council and the EMG. Any operation that generates dust will be subject to dust suppression procedures. These will include water spraying of haul roads and damping down of open areas during dry weather.

Wheel washes will be installed near the site exit points in order to prevent mud being deposited on the local roads. This will be monitored and, if vehicles leaving the site deposit mud, a road sweeper will be deployed to clean the roads. Similarly the haul route for the peat removal operation will be monitored and any spills will be cleaned up

Plate 3.1 Wheel Wash

Noise and Vibration

Noise and vibration monitoring points will be established around the site and at local receptors, by agreement with Mayo County Council. These stations will record noise and vibration parameters to an agreed protocol. Data will be permanently stored and made available to the EMG on request and to the regulatory bodies.

All plant, equipment and vehicles will be maintained, fitted with the correct noise suppression equipment, and operated in accordance with the manufacturers recommendations, statutory requirements and in accordance with BS5228: Noise Control on Construction and Open Sites, and relevant Irish Standards for construction noise as may come into force.

Piling operations will only be permitted to take place by prior notification and within agreed site working hours.

Activities such as rock breaking and drilling will also be notified in advance and will only take place within agreed site working hours. Ripping and pre-splitting of the rock may also be required.

Protection and Compensation of Habitats

The construction phase will involve the removal of the habitats in the terminal footprint and some disturbance to the habitats in the vicinity of the footprint. These habitats have been assessed and where possible compensation will be provided by creating new wetland and bog habitats of equal value, within the land owned by Shell. This compensation plan is discussed in more detail in Section 6 Terrestrial Flora and Fauna.

Transport

All routes for vehicles to and from the site have been assessed as part of the traffic impact assessment, which is described in Section 16 of this EIS. A traffic management plan will be drawn up in conjunction with Mayo County Council, the Garda and the EMG.

All site personnel will be briefed on the driving standards that Shell will require, and on the approved routes to be used when travelling to the site. All cases of dangerous or inconsiderate driving will be reported to the Construction Manager for appropriate action.

Protection of Water Courses

Activities on site will be managed in accordance with CIRIA Guide C532 'Control of water pollution from construction sites, Guidance for consultants and contractors', CIRIA, 2001. Whilst CIRIA is a UK based organisation their guidance documents are widely used in the international civil engineering industry.

Implementation of the CIRIA guide's recommendations will ensure that the risk of pollution of groundwater, soils and surface waters, resulting from the construction activities, will be minimised.

The precautions to be put in place to control the quality of surface water run-off from the site, during the construction phase, are described in Section 3.5 below.

Refuelling

Refuelling points will be established on site. The locations will be bunded in order to contain any spills. Each refuelling point will be equipped with spill kits and all drivers and operators of plant will be trained in the use of the kits. All rubber tyred plant used on site will refuel only at these locations using funnels or refuelling nozzles as appropriate. All tracked and static equipment will be refuelled locally in their area of operation by an on site mobile double skinned fuel bowser. The fuel bowser will also carry a spill kit. All drivers and operators will be responsible for checking their vehicles on a daily basis to ensure that there are no damaged hoses, fuel lines, etc. Vehicles with such damage will not be used until they have been repaired.

Groundwater Monitoring

Additional groundwater monitoring boreholes will be installed around the site, a number of which are currently located down gradient of the site and will be used to monitor the local groundwater during construction. Refer to section 9.7 for details of the monitoring proposed.

Some of these will be permanent monitoring wells and will be left in place to act as long term monitoring points for the operational phase.

Surface Water Monitoring

A water monitoring programme will be agreed in consultation with Mayo County Council and the North Western Regional Fisheries Board. The locations will be sampled on a regular basis to monitor the effect of runoff from the site in the local watercourses. Refer to Section 7 and Section 9.7 for details of the monitoring proposed.

Waste Management

A waste management plan will form part of each contractor's environmental management plan. The waste management plan will have three elements: waste minimisation, separation of waste at source, and appropriate storage and disposal.

Measures to ensure minimisation of waste will include:

- providing training to site staff in the requirements of the waste management plan,
- establishing a re-use and recycle culture on site,
- paying attention to site tidiness,
- ordering appropriate quantities of materials, 'just in time',
- immediate and careful storage of materials delivered to the site,
- storing materials, which are vulnerable to damage by rain, under cover and raised above the ground, and
- careful handling of materials, using appropriate equipment, to avoid undue damage.

All waste materials will be identified and segregated on site and stored in appropriately designed, secure storage containers.

The contractors' site Health, Safety and Environment advisors will monitor the implementation of the waste management plans. Waste management audits will be carried out on a weekly basis and all non-conformances reported to the Shell Health, Safety and Environment representative.

Materials, surplus to requirements, will be returned, disposed of or recovered in accordance with all relevant waste management regulations. Material that is likely to be surplus to requirements and disposed of, off-site, will include excavated material, general demolition debris, scrap timber and steel, machinery oils and chemical cleaning solutions. These are quantified in Section 16.

3.3 Construction Activities

There will be three main phases of construction activity on the site, the enabling works, the peat excavation works and the main civil and mechanical construction works.

3.3.1 General

Before the civil and mechanical construction works can start a number of earthworks activities must be completed.

As outlined in Section 2, the site is at a gentle incline and is overlain by a layer of peat. In order to provide a level platform for the terminal, the peat will be excavated from the footprint of the terminal. In the north-eastern part of the footprint the underlying soil and rock will be removed and, in the south and west parts, fill will be placed in order to achieve the required levels. These operations will be the main activities of the enabling works stage.

The peat will be removed from site and deposited on a cutover peatland, belonging to Bord na Móna, at Srahmore. The process by which the peat will be managed is summarised in Section 3.5.

The administration building and car park, and some ancillary equipment, such as the flare stack, will be constructed in an area where the peat will remain in-situ.

3.3.2 Enabling Works Phase

The main activities for the enabling works phase will be as follows:

- erection of site fencing around whole site using a stockproof type fence as close as possible to the red line boundary;
- erection of protective fencing for the trees to be retained,
- erection of construction area safety fence;
- improvements to the main site entrance;
- construction of the main site access road;
- augmentation of the existing site drainage;
- construction of new site drainage, temporary silt ponds and installation of dewatering wells; and
- installation of wheel wash facilities.

A number of these activities will be happening in parallel. At the same time the haul road to Srahmore will be made suitable for the peat haulage operation, before the main peat removal phase commences. Mayo County Council will undertake this work. A more detailed description of the enabling works is provided in Section 3.4.

3.3.3 Peat Excavation Phase

The main activities for the peat excavation phase will be as follows:

- construction of the truck parking area and initial construction facilities,
- construction of the temporary construction facilities,
- construction of a new access road from the R314 to the settlement pond area,
- initial excavation of peat in the north-eastern area of the terminal footprint,
- excavation of the settlement ponds,
- installation of site drainage
- main peat excavation, windrowing, stockpiling and removal from site,
- installation of the southern perimeter sheet piling and terminal permanent perimeter drainage;
- excavation of the mineral soils and rock for the cut and fill of terminal footprint.

A more detailed description of the enabling works is provided in Section 3.5.

3.3.4 Civil, Mechanical, Electrical and Instrumentation Construction Phase

After removing the peat and levelling and compacting the site the following activities, will take place:

- ground works (piling and civil);
- structural framework (pipe-racks and equipment supports);
- construction of main buildings;
- installation of major equipment items;
- piping fabrication and erection;
- installation of electrical and instrumentation systems;
- testing of equipment and systems;
- commissioning of the plant and process; and
- landscaping of the site including tree planting, compensation habitat development and environmental conservation of the surrounding areas.

The civil activities are expected to commence before the excavation and filling of the terminal platform has been completed.

A more detailed description of the civil, mechanical, electrical and instrumentation construction activities is given in Sections 3.6 to 3.15.

3.3.5 Overview of Schedule and Workforce

Construction Schedule

The construction and commissioning of the terminal is expected to take 27 months. The peat removal activity is expected to take 6 months and it will be weather dependent and may be suspended occasionally due to inclement weather. Therefore depending on the start date on site, and the weather experienced, it may be necessary to undertake the peat removal activity in two phases - suspending it for the winter.

Working Hours

Typical working hours during construction will be from 0700 to 1900 Monday – Friday and from 0700 to 1600 Saturday. Certain work activities may be undertaken at night and/or at weekends. Working outside normal hours may also be necessitated through considerations of safety or weather and sub-contractor availability. Exceptional construction activities will be carried out in consultation with EMG and Mayo County Council.

Construction Workforce

An estimation of the personnel profile for the construction phase of the terminal and associated upstream pipeline is shown in Table 3.2:

Table 3.1 Personnel Profile for Construction

Date	Works	No of Personnel
2004 Q3	Road Construction	100
2004 Q4	Peat Movement	100
2005 Q1	Civil Works	50
2005 Q2	Peat Movements And Civil Works	200
2005 Q3	Civil Works And MEI Works	200
2005 Q4	MEI Works	300
2006 Q1	MEI Works	300
2006 Q2	MEI Works	400
2006 Q3	MEI Works	500
2006 Q4	MEI And Commissioning	250

3.4 Initial Site Set-up and Site Preparation

3.4.1 Site Survey

The site will be set out and surveyed to confirm all existing survey data is correct.

3.4.2 Fencing of the Site Area

The boundaries of the site will be set out, marked and a stock proof perimeter fence erected.

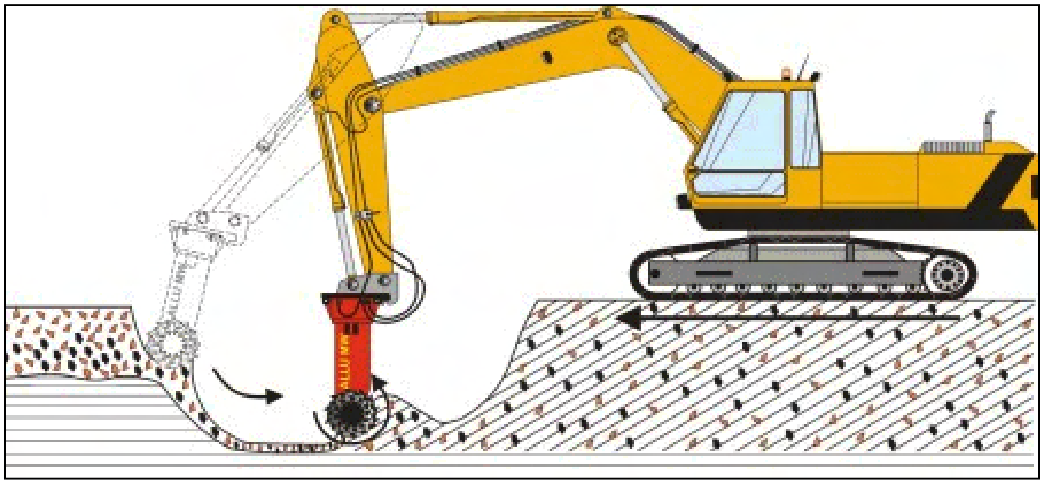
3.4.3 Site Clearance and Tree Protection

The existing trees and scrub in the Terminal field earthworks area will be cleared and placed in the field to the western boundary of the Terminal to form an environmental baffle to the windward side of new tree planting. In addition, certain groups of trees will be retained. These will be protected by fencing, which will be erected in the early stages of work on site.

3.4.4 Construction area safety fencing

The area to be excavated will be fenced off and appropriate signage erected in order to ensure that it is secure and to warn personnel of the presence of an open excavation and the presence of heavy plant.

Figure 3.1 Peat Improvement Technique



3.4.5 Site Access Roads

The main entrance to the site from the R314 will be improved to make it suitable for construction traffic. The existing approach to the entrance will be widened and modified to cater for the turning of long trailer and multi axle vehicles.

Signs warning of the site entrance will be installed on the side of the R314 road, to the east and west of the site entrance.

The principal access to the site will be via the R314. Site security will control and register the movement of all vehicles and people entering and leaving the site. A secondary / emergency access to the terminal will be via the entrance on the Pollatomish road at the north-western corner of the site. A third access point will be provided from the R314, to the west of the main entrance, to facilitate construction of the settlement ponds.

Once the entrance has been improved the permanent north-south terminal access road will be upgraded. The upgrading of this road will involve:

- the improvement of the in-situ peat (see note below) within the width of the upgraded road,
- the installation of sheet piles (see note below) along the edges of the road, and
- the importation of fill, which will be laid on a geotextile membrane on top of the improved peat.

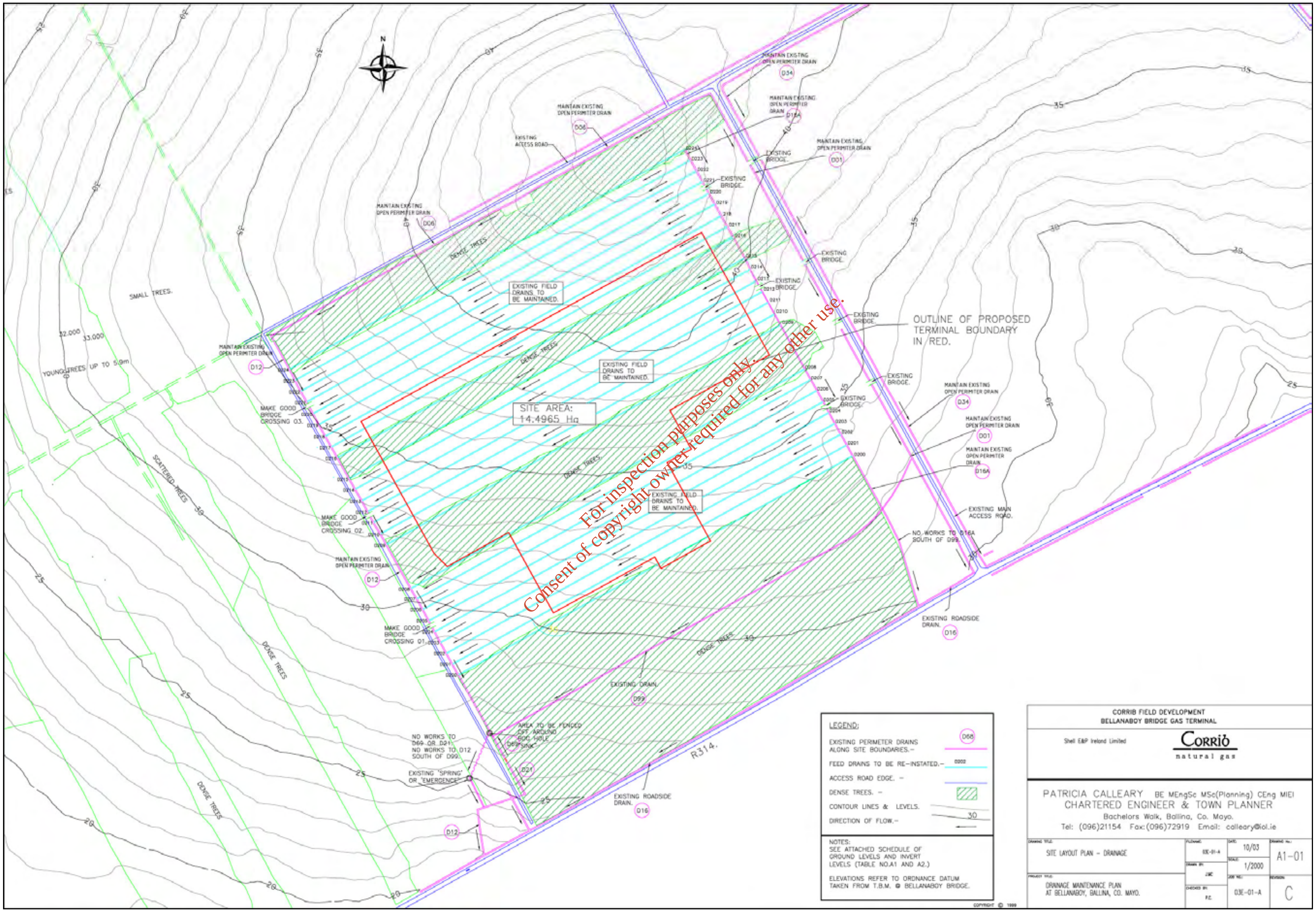
It is envisaged that the upgrading works will start at the entrance on the R314 and work northwards. This upgrading will allow heavy traffic onto the site. The wheel wash facility will be located near the site entrance.

The secondary / emergency access road will be upgraded, by peat improvement techniques, followed by placing fill and geotextile membrane, along the line of the existing forest track, which gives access from the Pollatomish Road.

Note: Peat/Soil improvement is a technique used to increase the strength of soft materials such as peat and silt. A binder such as lime or cement is mixed with the in-situ peat. When the binder sets, the resultant mixture has a far higher strength than the original peat. There are various techniques for introducing the binder to the peat. For the terminal, it is proposed to use ‘dry deep mixing’. In this technique an augur drills a hole, into which compressed air and dry cement is injected. Columns of strengthened material are created that overlap to form a cellular pattern. The treated area is surcharged immediately after treatment by placing of fill on it. Cement will be imported for this purpose. The impacts of this activity on the environment are considered in sections 6,7,8, and 11.

Sheet piles are corrugated steel plates, which are driven individually. Each pile interlocks with the pile on either side, to give a continuous steel wall in the ground. The sheet piles will extend below the peat into the firmer mineral soils and weathered rock. A pile-driving rig will install the sheet piles. It is estimated that approximately 26,000m^2 of sheet piles will be used.

Figure 3.2 Upgrading of Land Drains



3.4.6 Upgrading of Land Drains

The hydrology and hydrogeology of the site has been considered in some detail because it is anticipated that control of the surface and groundwater will facilitate the earthworks. Modifications will be made to the existing drainage and new drains will be installed to control rainfall runoff at each stage of the construction works.

An extensive system of forestry and agricultural drains and drainage ditches already exists in the site area. In parallel with the upgrading of the main access road, the existing drainage ditches in and adjacent to the terminal footprint area will be deepened. These drains discharge to a deep drain which runs north south to the east of the Terminal footprint. The drain will be upgraded and a series of weirs constructed in it, to control the rate of flow. An existing drainage ditch within the firebreak to the south of the terminal footprint, will also be upgraded. A silt pond will be constructed on this drain close to the south western corner of the Administration Building area. The firebreak drain discharges to the deep north south drain on the western side. Initially this drain will continue to discharge to the drainage ditch beside the R314. The deep north south drain and firebreak drains will act as catch drains for the early stages of construction. These drains are indicated on Figure 3.2. For details of the drainage proposals refer to the planning drawings.

All of the east west ditches in the terminal field will have small sediment capture ponds on the western end of the drains prior to joining the deep north south drain.

3.4.7 Settlement Ponds

A pair of settlement ponds will be constructed at an early stage in the excavation phase. The rainwater and runoff from the excavation will be collected and discharged to the settlement ponds.

The ponds will be securely fenced as a safety precaution.

Bord na Móna have been consulted on the design of the settlement ponds, which will be generally similar to the ponds at the Bord na Móna Oweninny Works.

Plate 3.2 below, shows a typical settlement pond at Bord na Móna Oweninny Works. The plate shows the outlet weir and the general design of the pond.

Drainage from the ponds will discharge, through a riprap outfall to the ground, from where it will drain to the existing drainage ditch along the R314. Refer to Sections 2, 9 and technical appendix Site Drainage Report for more detailed information on the settlement ponds.

Plate 3.2 Bord na Móna Oweninny Works showing silt pond viewed from N59 North West of the ESB Power Station. The weir is at downstream end of lagoon.

The discharge from the ponds will be monitored for suspended solids and phosphate, as described in Section 9.

The settlement ponds will be operated and maintained in accordance with procedures detailed in the Environmental Management Plan, which will be in place for the site, both during construction and operation.

During the construction period silt recovered during the maintenance of the settlement ponds, will be transported to the windrowing area of the site. It will remain there until it is in a suitable condition for transfer to the peat deposition site.

During the operation phase, it is predicted that very limited amounts of silt will be generated as there will be no un-vegetated or otherwise uncovered peat surfaces. This will be handled and disposed of in accordance with the terminal non hazardous waste management procedures.

3.4.8 Groundwater Control Wells

In order to remove water from the mineral soils and bedrock underlying the peat, as well as to promote under-drainage of the peat in the area to be excavated, it is proposed to install a series of groundwater control wells. Due to the relatively low permeability of the peat, mineral soil and bedrock vacuum assisted pumping wells, designed to suck water out of the ground, will be used.

Two lines of wells are proposed, as indicated in Figure 3.3. One line will capture the bedrock groundwater from the north eastern corner of the terminal footprint. The zone of bedrock groundwater with positive pressure will be intercepted by the second line of wells, some distance to the southwest of the first line of wells. The wells will be drilled down into the zone of more highly permeable fractured bedrock.

The volume of water from the wells will be very low and will be discharged to the upgraded land drain system.

3.5 Peat Excavation Phase

3.5.1 Truck Parking Area and Administration Building Access Road

In parallel with the latter stage of upgrading the main access road, the peat in an area to the west of the road will be strengthened. This area will be piled and then capped with a reinforced concrete slab.

During the initial site works period, before the temporary construction facilities have been prepared, this area will be used for site offices, the storage of excavation and haulage equipment and overnight parking for trucks. While basic maintenance and refuelling will also be carried out in this area, major maintenance to vehicles will be carried out at an offsite, dedicated yard.

After completing the truck parking area, the peat improvement and piling activities will continue in order to complete the full area of the permanent car park and administration buildings footprint.

A new road will be established from the main access road to this area. This road will also provide access to the south eastern corner of the terminal platform. This road will be constructed in the same way as the main access road, with peat improvement, sheet piling along both edges, geotextile membrane and fill.

3.5.2 Temporary Construction Facilities

Following on from preparation of the administration building footprint, the temporary construction facilities compound will be prepared. The peat in this area will be strengthened and sheet piles will be installed around the perimeter. Imported rock fill will be placed on a geotextile membrane on top of the improved peat.

3.5.3 Access Road to Settlement Ponds

A new entrance to the site will be opened from the R314 to gain access to the settlement pond location. This road will be constructed using the same technique as for the main site access road. The road construction will continue around the perimeter of the settlement ponds and along the strip separating the ponds. A small laydown/turning area will also be formed adjacent to the entrance from the R314, using the previously described road construction technique.

A sheet pile wall will be installed around the perimeter of each settlement pond.

3.5.4 Drains for Access Roads, Administration Building Area and Temporary Construction Facility

New drainage ditches will be excavated on either side of the main access road and the track to the west of the terminal footprint. A new drainage ditch will be constructed on the northern, eastern and southern sides of the temporary construction facilities and on the southern and eastern sides of the Administration Building area.

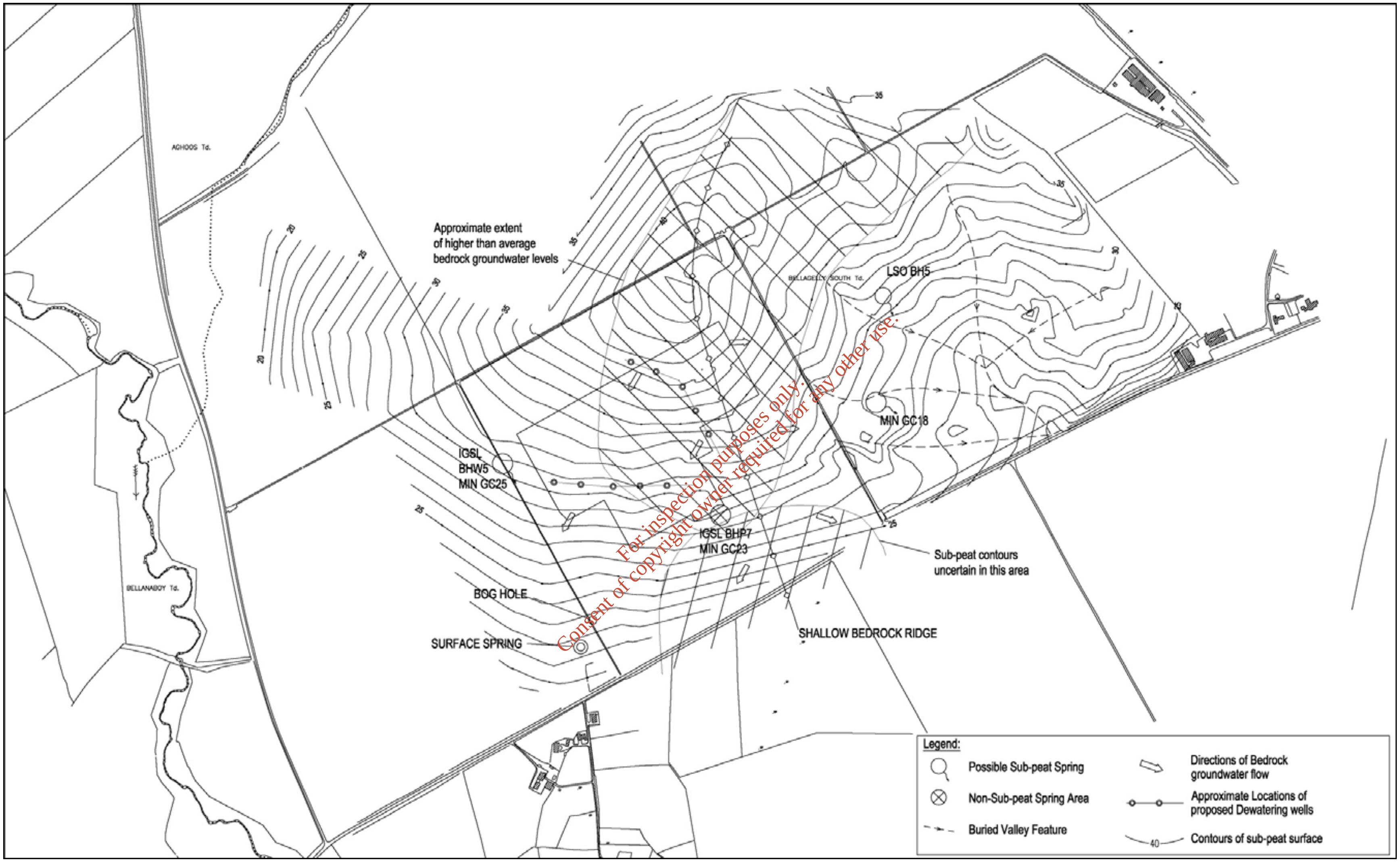
The drain serving the Administration Building area will discharge to the firebreak drain. The drain serving the temporary construction facilities will discharge to the drain on the eastern side of the main access road. The drains on either side of the main access road will discharge to the firebreak drain. The drains on either side of the main access road, down slope from the connection to the firebreak drain, will discharge, via silt ponds, to the existing drain beside the R314.

When the settlement ponds have been constructed, the drains on either side of the track, to the west of the terminal footprint, will be diverted into a culvert which will discharge to the settlement ponds. The existing land drains in the part of the site between the track and the settlement ponds drain from north to south. These drains will be reinstated once the culvert construction has been completed. The drains on either side of the track, downstream of the connections to the new culvert will continue to discharge to the existing drain beside the R314.

A new ditch will be constructed to intercept the land drains in the vicinity of the settlement ponds. This ditch will discharge to the existing drain beside the R314. The existing drains on either side of the secondary/emergency access road will be upgraded.

Detailed drainage calculations and drawings are provided in Technical Appendix: Site Drainage Report.

Figure 3.3 Groundwater Control Wells



3.5.5 Drainage of the Area of Excavation

Because of the presence of a shallow surface water table in the peat and the saturated (or near-saturated) condition of the underlying mineral soils and bedrock, groundwater can be expected to flow into any excavation that extends more than a few metres below the ground surface. Even though construction of the terminal will involve up to 10m of excavation below existing ground level, the volumes of groundwater are likely to be relatively small (given the low permeability of the materials).

Rainwater and groundwater, if it is not removed from the excavation area will tend to cause the materials to soften and consequently they will be more difficult to handle. A detailed drainage plan has been developed to deal with flows during excavation.

Most of the existing land drains drain away from the terminal footprint. When they are intercepted by the excavation of the terminal platform, they will continue to function. A number of new catch drains will be constructed to re-direct the water from the existing drains, via a silt pond, into the upgraded firebreak drain. Detailed drainage calculations and drawings are provided in Technical Appendix: Site Drainage Report.

3.5.6 Excavation of the Terminal Footprint

Peat Excavation Methodology

The peat excavation methodology has been devised in consultation with Bord na Móna.

Generally peat will be excavated by tracked excavators using large buckets to minimise the amount of cutting action on the peat fibre and existing root structures therein, it will be then loaded in to dumper trucks and transported to the windrowing area. The excavated peat will be windrowed prior to loading it into trucks for removal from the site. Windrowing consists of placing the excavated peat into linear stockpiles on a mineral soil foundation. The linear stockpiles, or windrows, will be up to 3.5m in height at the centre. When the peat has been windrowed for at least 8 days, the peat will then be transported off site. A Bord na Mona representative will monitor loading operations to ensure the suitability of the peat leaving the site.

The windrow area will have sufficient capacity to store the quantity of peat excavated over an eight day period. This is estimated to be about 28,000m^3. It is expected to transport approximately 4,000m3 per day to the Bord na Mona site.

The windrows will allow the free water to be shed from the peat. They will be orientated on approximately a north-south alignment so that drainage will occur between them, additional drains will be constructed to divert the water shed from the windrow areas away from the area in which excavation is underway. Free drainage from the windrows will be maintained at all times. Sumps will be dug down-slope from the excavation face. Water from the sumps will be pumped or drained to the land drain system.

Sequence of Peat Removal

At the initial stage there will not be an area of exposed mineral soils on which to windrow the peat. However, the peat located in the north eastern quadrant of the site is thinner and drier than much of the peat over the rest of the terminal footprint. It is planned to intensively drain this area at the initial stages of construction, following that, Bord na Móna have indicated that this peat will be dry enough to be loaded directly into the trucks for transfer to the Srahmore deposition site, without windrowing. This initial activity will expose the mineral soils and gradually create space for the windrows, and the truck loading bay. Temporary access to this initial area will be via an existing track in the northeast corner of the Terminal field that will be constructed in a similar manner to the other access roads on the site.

Gabions will retain the cut edge of the peat. Gabions are rock filled steel cages. These will be placed in a trench, excavated down to the mineral soil, around the part of the terminal footprint perimeter in which a cut edge of peat will be exposed on completion of the earthworks.

In parallel with the upgrading of the main access road, a further permanent access road to the eastern boundary of the terminal footprint will be constructed, working westward from the side of the main access road. Peat excavation will progress from the north-eastern corner of the terminal platform towards the west.

As soon as the windrowing area has been established, the peat from inside the sheet-piled settlement ponds will be excavated, transported to the terminal platform, mixed with peat from within the terminal area, and windrowed. The windrowing area will gradually move across the site (as will the truck loading bay) as the peat excavation front moves west and then south.

In the areas of the terminal platform, in which the removed peat will be replaced by fill, the cut edge of the peat will be retained with sheet piles. Figures 3.4 to 3.7 indicate various stages of the peat removal operation.

Figure 3.4 Peat Removal Initial Stage

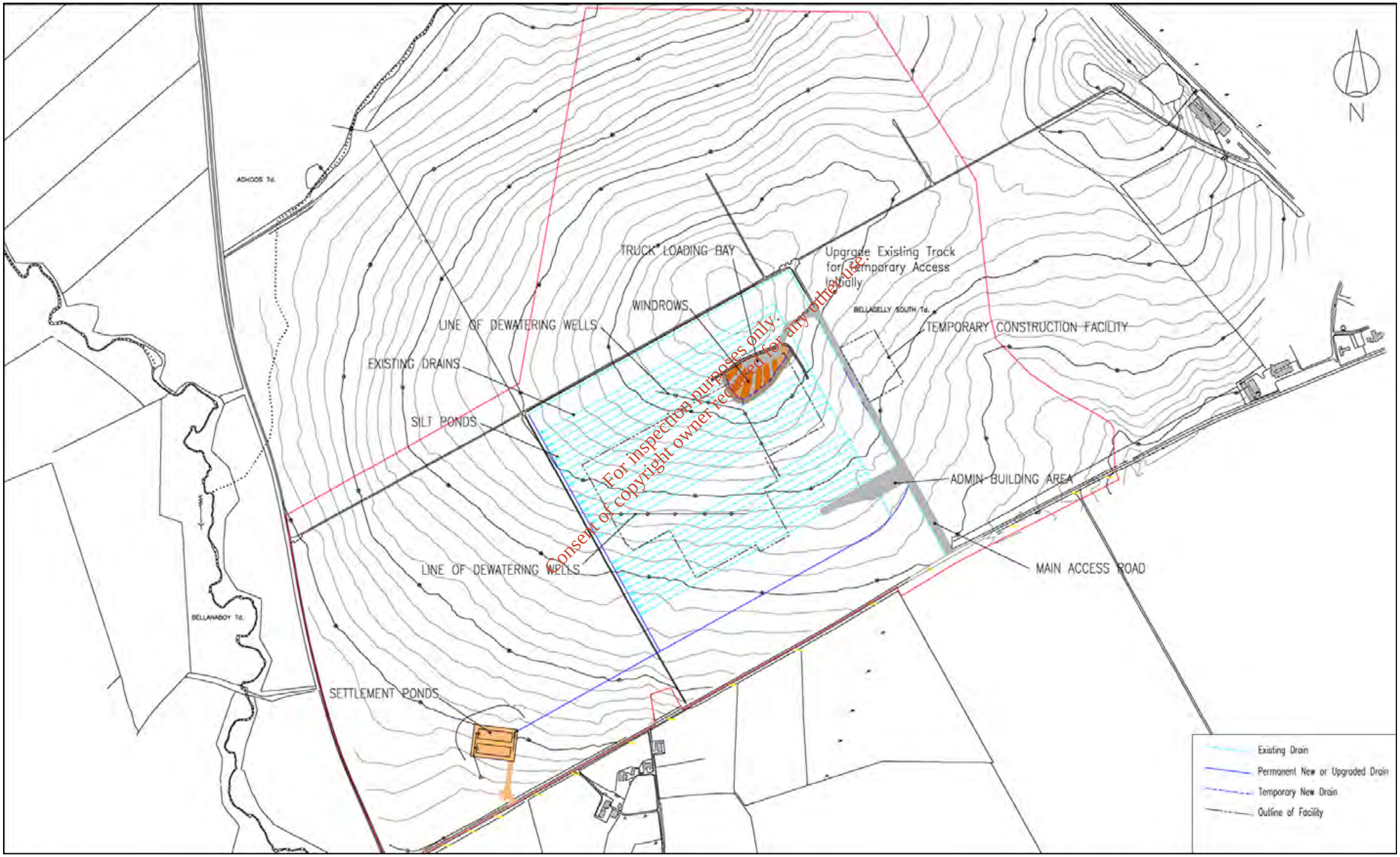


Figure 3.5 Peat Removal Intermediate Stage

Figure 3.6 Peat Removal Latter Stage

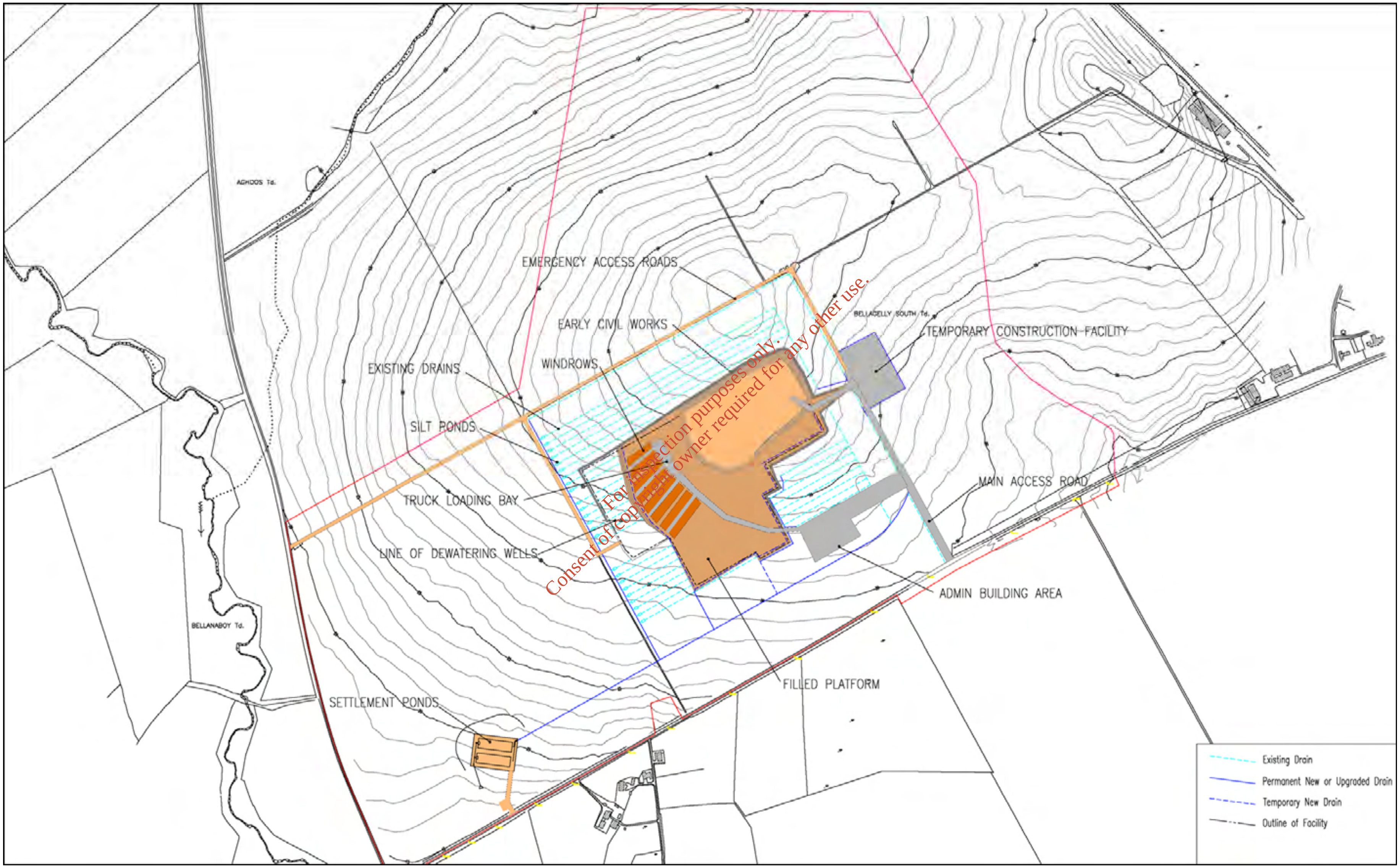
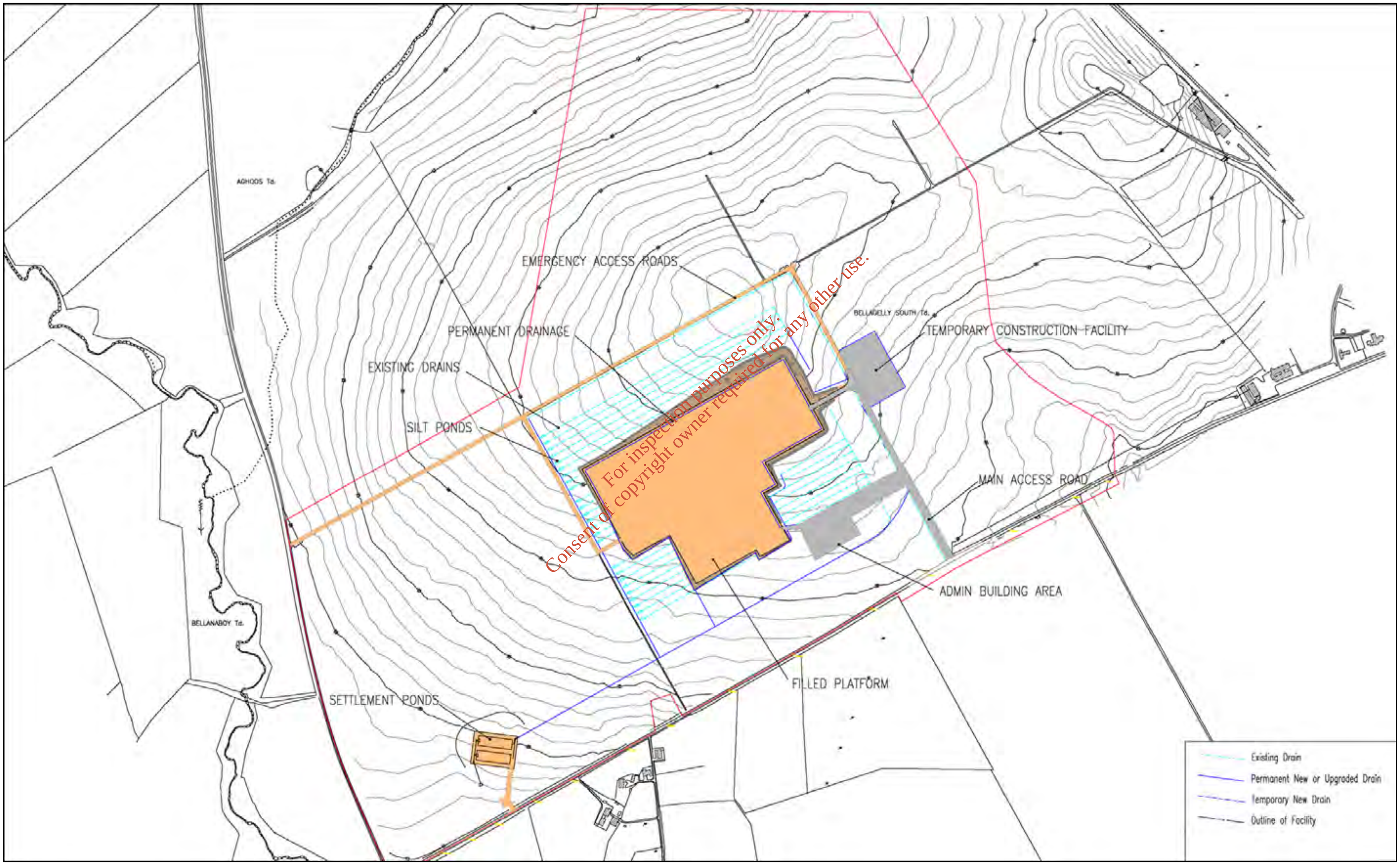


Figure 3.7 Peat Removal Completed Stage



Peat Excavation Schedule

The peat removal activities are expected to take up to six months to complete. As it will be weather dependent, it may not be possible to complete the excavation of all of the peat from the terminal footprint site in one season. This may result in a temporary suspension of the peat removal works during the wettest season, and recommencement the following spring When the peat excavation work is suspended for a period of time due to inclement weather, sufficient perimeter drainage of the earthworks will be provided to ensure adequate removal of surface water.

3.5.7 Construction Traffic Management during Peat Removal

A road Traffic Management Plan (TMP) for the operations along the R314, L1204 and crossing at the R313 has been prepared in consultation with Mayo County Council, the Garda, and local residents. The management principles proposed are outlined below.

Section 16 of this EIS discusses in detail the impacts that might be expected from the traffic movements associated with construction activities.

Safety

Particular safety aspects have been addressed in the TMP. The measures to be implemented include:

- Road signs: New road signs will be erected on the approaches to the Haul Route from Bangor, Pollatomish, Glenamoy and from Belmullet, at locations to be agreed with Mayo County Council, but typically 2- 3 km from any point of traffic control.
- Communication: Regular updates will be given to Midwest Radio and to Radio na Gaeltachta, with details of any significant activities anticipated over the coming week.
- Minibus: A minibus service will be established to transport local residents to towns in the local area;
- School bus runs: The timing and organisation of school bus runs will be discussed with the appropriate authorities in order to avoid conflict with haul route traffic.
- Driver training: All drivers will have site specific safety training.
- Speed controls; A maximum non-statutory speed limit of 40 mph will be imposed for contracted haulage vehicles on the Haul Route. A lesser maximum speed limit of 30 mph will locally apply on bends, marked by appropriate contract-specific signage, and will be implemented and enforced for all fleet vehicles.
- Tachographs; In order to ensure compliance with national regulations on maximum working hours and break intervals for drivers, vehicle tachographs and GPS position recorders will be fitted to all haulage vehicles. These will be recorded to archive and analysed for compliance with work duties, productivity limits and the like on a daily basis.
- Driver communication: Two way VHF radio communications will be provided between each vehicle and the Transport Operations Managers office. Each flagman and the weighbridge records office will also have access to this communications system, and will be trained in its use, and in the priorities and disciplined usage necessary for effective communication.
- Wheel washes and road sweepers: These will be used to minimise the transfer of mud onto the public roads.
- Flagmen at junctions: This activity will serve to minimise queuing at junctions and ensure safe passage for all traffic.

The cycle to be completed by each vehicle, several times per day, includes the following basic elements:

- filling of the Payload, followed by wheel wash;
- haulage of the Payload;
- weighbridge and electronic recording procedures;
- manoeuvre into tipping position, tipping, and truck deck lowering followed by wheel washing;
- return trip unladen; and
- manoeuvre into loading position.

Logistics of the Loading Area

Each evening, approximately half of the Truck Fleet will be parked at the Bord na Móna peat reception area (Srahmore), and approximately half will be parked at the Loading Area. This proportion may change slightly depending on operational conditions encountered. Those vehicles which are parked at the Loading Area, will be preloaded for the following morning before parking, and where practicable will be wheel-washed before being parked, so that they commence their first cycle ready to depart with a loaded payload.

All vehicles will have been fuelled and safety checked during overnight downtime at either the Loading or peat reception area sites, and the Loading Area excavators will commence to fill those trucks which have travelled empty from the Srahmore peat reception site, as they commence their cycle each day.

Any queues which develop will be accommodated on the access roads to the Terminal and Deposition

Area. The flagmen and vehicle spacing guidelines will otherwise ensure that the mean frequency of one truck passing in either direction every 90 seconds at a given point on the Haul Route is not persistently exceeded by unplanned formation of clusters of trucks in convoy.

Logistics at the Srahmore Peat Reception Area

Bord na Móna plan to operate similar working hours to the Terminal site moving material from the peat reception area into the Peatland placement vehicles.

For more information refer to Section 2 of the peat deposition volume of this EIS which describes the operations at the peat deposition area.

3.5.8 Excavation, of Mineral, Soils Site Levelling, Cut and Fill

Once a sufficient area of the terminal platform has been stripped of peat to allow the peat removal activities to proceed unhindered, the excavation of mineral soils will commence, starting from the north-eastern corner of the terminal platform. The excavated mineral soil will be used for levelling the terminal footprint as well as the upgrade internal access roads. It is expected that there will be a surplus of mineral soil, which will be removed from the site, (see Section 16). The cut face of the mineral soil will be graded to a one in three slope to ensure its stability.

Plate 3.3: Peat Overlying Micaschist Bedrock in NE Corner of Site

Excavation of Rock

It will be necessary to remove rock from the north-eastern part of the terminal footprint. The geotechnical site investigation has provided a considerable amount of data on the bedrock underlying the footprint. The state of the rock varies from being completely decomposed by weathering to intact, unweathered rock. Excavators, using standard buckets, will be used to remove the more weathered rock. It may be necessary to use rock breaking chisels, attached to the excavators, and bulldozers equipped with ripping tines, to remove the intact rock. Rock blasting will not be necessary. There may be a requirement to pre-split the more intact rock to aid ripping, this will be achieved by drilling the rock at a regular intervals and using an expanding chemical crack inducer.

The exposed face of the excavation in rock will be cut to approximately a one in one slope to ensure its stability.

Processing of Rock

It may be necessary to crush/screen the excavated rock to reduce it to a size suitable for compaction. In this case, a mobile crusher/screener would be used. The potential impacts of this plant would be noise and dust. Noise suppression would be achieved by positioning the crusher/screener within a bunded area, which would also provide the facility to dampen down the area with a water spray, in order to minimise dust.

Fill Operation

The excavated rock will be used as fill material in the southern and western parts of the terminal footprint. The edge of the fill will be reinforced with geotextiles, and, where it is above the level of the surrounding ground, the face will be graded to a one in three slope. If very wet weather conditions are encountered during the filling operation the filled area may be stabilised, using soil improvement techniques as described above.

The site will be capped where appropriate, with the best quality rock. It will also be necessary to import rock fill and stone for this purpose.

Mineral Soil and Rock Excavation Schedule

Prior to the cessation of works before the first winter season, it is expected that an area of approximately two to three hectares will have been excavated to the finished terminal level of 33.4m AOD Malin. It is expected the fill operation will not be completed until the second season. A portion of the rock will be stockpiled over the first winter period.

3.5.9 Monitoring Equipment

Before any earthwork activities take place on site, piezometers, inclinometers and extensiometers will be installed in the area of the works and in adjacent areas. These will be used for monitoring the levels of the water tables in the peat, mineral soils and rock, and for detection of movement in the peat.

Air, noise and vibration monitoring equipment will be deployed as and when required, which will be advised by the onsite environmental engineer and as part of the overall environmental management system.

3.5.10 Permanent Terminal Perimeter Drainage

The silt ponds for the terminal will be retained after the completion of construction. Once the site preparation phase has been completed and final site levels have been established for the terminal, the new permanent terminal perimeter drainage system will be constructed and connected to the settlement ponds. This drainage will comprise of a drain, at the toe of the slope, to intercept surface water runoff, and a deep drain, also at the toe of the slope, to intercept groundwater. Refer to the planning application drawings for details of these drains. Rainwater runoff from the clean surface water drains will also be directed to the settlement ponds.

3.5.11 Fencing

When the earthworks, have been completed, a 2.4m high security fence will be erected around the terminal footprint. A 3.4m steel fence, with an intruder alert detection system, will be attached to the security fence to make a double-skin fence for the operational phase.

3.5.12 Site Landscaping

Following completion of the peat excavation operations and formation of the terminal platform, the side slopes to the terminal site will be, where appropriate, topsoiled, seeded and planted with shrubs to encourage the growth of vegetation.

3.6 Piling and Civil Works

Foundations for the support of the terminal equipment, structures and buildings will be constructed using either spread pads laid directly on the underlying bedrock or by the use of piles.

It is anticipated that up to 2000 number piles will be used.

Piling, foundation and civil works will be phased to reflect the construction schedule. The civil engineering activities, including piling, may be undertaken in parallel with the later stages of the peat excavation operations.

3.7 Structural Steelwork

All activities relating to the fabrication, preparation and coating of structural steel will be carried out offsite. Activities on site will be limited to the erection of all steel work and any minor modifications required. Painting of the steel will also be undertaken offsite. This will reduce the potential for some environmental impacts on site that can arise from these activities. It is anticipated that minor touch up to painting will be required on site.

3.8 Buildings

The following buildings will be constructed on site:

- control building;
- administration complex, warehouse and workshop complex;
- power generation and electrical switchgear building;
- firewater pump house;
- gas export compression building;
- water treatment building; and
- minor equipment housings.

The Control Building and the Administration, Warehouse and Workshop complex will be constructed on piles the beginning of the civil and mechanical construction period.

It is anticipated that the Switchroom, Generator Building, Administration and Control Buildings are constructed first and made weatherproof. This is due to the large amount of fitting out required in these buildings. However should the peat excavation operation be suspended due to bad weather those buildings in the areas of the site which have been levelled will be given priority.
This is most likely to be in the north-eastern section of the terminal and include the compressor building. The Compressor building will be erected and substantially fitted out prior to delivery of the compressors.

3.9 Installation of Piping, Tanks and Equipment

Equipment will be prefabricated, pre-assembled and pre-finished, where possible, to minimise site work. However, the extent of this will be restricted by the limits on the size and weight of components, which can be transported to the site by road. There will be a small number of oversize loads. The transport routes for these items from the port of entry, will be under an approved permit, carefully planned, in liaison with the Local Authorities and Gardai along the route.

Tanks T4002A/B, T3001A/B, T3002 and T4001 A/B/C will be site erected from floor plates, sketch plates and shell plates prepared/rolled off-site. Erection will be by welding on site. Purpose designed scaffolding will be erected to ensure safe access.

Although the tanks are not particularly large, the amounts of water required to carry out the appropriate hydrostatic tests will be in excess of what can realistically be provided through the site potable water system. Therefore, water will be drawn from the firewater pond, the water in the firewater pond will be drawn over an agreed period of time from the newly constructed mains fed from the local authority water supply. Tank linings, where relevant, will be applied following hydrotest. Dehumidification and temperature control equipment will be utilised as necessary to dry the internal surface and prevent any weather-related delay to the lining activities.

3.10 Equipment Installation and Craneage

Equipment erection will be phased to reflect the construction schedule which will optimise the availability of heavy/specialised cranes on site and to release work faces for follow-on activities. Major equipment items will be erected directly from their transportation trailers on to their bases wherever possible. Rigging studies and method statements will be generated for major equipment items in order to ensure compliance with the site health, safety and environmental plan.

A number of equipment items, such as the air coolers that weigh approximately 65t each and sit on top of the pipe-rack, will be lifted as a complete unit using 400t capacity cranes. These cranes are needed to place the equipment at approximately 15m radius. During the visit of any heavylift crane to site, its utilisation will be maximised to give optimum benefit to the project schedule.

The building for the Sales Gas Compressors will be completed and partially fitted out prior to Compressor delivery. These units will be offloaded and then skidded into position using mechanical skates and pull lifts or similar. Final positioning will be by jacking.

The site layout permits good access for erection craneage. Careful sequential installation will be employed around the east west rack through the Process Area in order to allow craneage close enough to erect all the high level Air Coolers. For protection during the equipment, installation of scaffold shelters or tarpaulined habitats will be used to allow setting/alignment/hook-up activities to proceed through periods of inclement weather.

3.11 Pipe Fabrication and Erection

All pipe spools will wherever possible be shot blasted and primed prior to delivery to site thus reducing onsite work.

Pipe which is essentially straight run i.e. on racks or tracks will be shot blasted and primed prior to delivery to site. Any fabrication that can be carried out on these runs will wherever possible be carried out in the fabrication shop prior to delivery to site. All pipe spools will be supplied to the maximum dimension that can be readily and safely handled and transported.

Pipework erection will be phased to reflect the construction schedule.

Safe and practical access will be provided together with environmental and weather protection to allow work to proceed regardless of weather conditions.

On completion of the erection each piping system will be pressure tested to ensure its mechanical integrity. Once mechanical testing is complete any touch up painting will be carried out.

On completion of testing, pipework will be released for final painting to the required paint code on site.

3.12 Slugcatcher

The Slugcatcher will be erected using dedicated squads of specialist erectors, fitters and welders. Fingers and manifolds will be prefabricated offsite to the maximum dimension that can be readily and safely transported to site by road.

A number of options with regard to Site Assembly methodology are being investigated but the final method of erection is still to be decided.

3.13 Electrical and Instrumentation

Wherever possible work will be performed offsite by way of pre-fabrication and testing. Detailed pre-planning will clearly identify priority routings for the electrical and instrumentation cables. Ladder rack and tray installation will start on the pipe racks and in the process area with access being progressively granted across the plant, finishing in the Compressor House.

In order to obtain acceptable working conditions within the various buildings, lighting and small power systems will be installed first in order that these can be hooked up to temporary diesel generators ahead of energisation of the main power generation equipment.

Electrical equipment installation will commence with the installation of the main power transformers by crane followed by the skating/rolling in of switchgear, panels, boards, etc. progressively. A priority of the civil and structural steel sub-contractors will be to ensure that the various buildings are weathertight, and secure prior to installation of equipment. Electrical testing requiring equipment energisation prior to Mechanical Completion will be conducted using temporary diesel generators.

Prior to installation, instruments will be stored under conditions stipulated by the supplier in order to protect the integrity of the equipment. This will include, as appropriate, environmental protections i.e. air conditioning, heating, dehumidification, etc. Prior to installation, calibration of instrumentation will be carried out in a properly equipped and certified calibration workshop. After calibration, each instrument will be clearly labelled as having been calibrated with the date of testing.

When the control room and local equipment room are totally weatherproof, environmentally sound and physically secure, installation of the Distributed Control System (DCS) and Fire and Gas detection equipment will proceed.

3.14 Pressure Testing

To ensure the mechanical integrity of the piping systems and as part of the mechanical completion activities, all piping systems will be pressure tested prior to hand over for commissioning.

The majority of this testing will be carried out by hydrostatic tests, which requires the system to be filled with water, incrementally brought to the required pressure and held for a given time. A small number of pneumatic tests will be required where it will be essential that the piping remains completely dry. In this case air will be used rather than water.

It is anticipated that a significant quantity of water will be required to carry out this testing programme. In order to ensure that this water is available it is envisaged that use will be made of the firewater pond and storage tanks as reservoirs. The pressure test water is likely to be disposed of via the water treatment plant to the sea outfall.

Following pressure testing the system will be leak tested using an N_2/He gas mixture.

3.15 Commissioning

Commissioning of all systems will be carried out in a systematic and controlled manner to ensure that the plant is brought safely into service following completion of construction.

To ensure that the transfer from fully constructed, mechanically complete equipment to commissioning and operation, the equipment will be grouped into a number of packages called systems. Each system performs a particular function. Commissioning personnel will be involved early in the design to ensure that these systems are safely and correctly defined.

Systems will reach mechanical completion at different stages and each system will be individually commissioned following a documented commissioning procedure.

Commissioning will be carried out using a combined team of engineers from Shell, the contractor, and the equipment vendors' specialists as required. A commissioning plan will be prepared and the commissioning activities will be undertaken strictly in accordance with the defined procedures and protocols.

The transfer of systems from construction to commissioning will be controlled and documented using mechanical completion packages. These packages will contain traceable records of all material and calibration test certificates, and an agreed list of outstanding works to be completed prior to plant start-up. These documents form part of the quality control systems and will be combined with the commissioning documentation.

The order of commissioning systems will be detailed on the commissioning plan and this will follow the following basic categories:

- utility systems such as drains, water, instrument air etc.;
- safety systems such as emergency power, fire and gas detection, firewater, deluge etc.;
- plant control systems and main process units such as fuel gas, main power generation; and
- gas processing, compression and transport and measurement systems.

Once all systems have been commissioned, and handed over to the Terminal Manager, the plant will be prepared for the introduction of hydrocarbon gas. This activity will be co-ordinated with the offshore group. At, or just prior, to this time, the terminal will be placed under control of the "Permit to Work System". The permit to work system is standard practice on all process plants and is designed to ensure safe and co-ordinated working at all levels. The permit to work system places an increased level of discipline, formality and accountability on all activities to ensure safety is the first consideration. Prior to the introduction of hydrocarbon gas to the plant all required systems will be fully commissioned and handed over to the Terminal Manager. The final responsibility for introducing hydrocarbon gas to the terminal is with the Terminal Manager, who will be supported by a team of operators, the project team and by engineers and technicians from the EPC contractor.

Hydrocarbon gas will be introduced to permit post-commissioning start-up of the gas treatment and export facilities. During this time a co-ordinated series of checks will be carried out to monitor for gas leaks or any abnormal process deviations.

A performance verification run-in period will take place to verify that all systems are operating correctly and that gas of the required quality and quantity can be delivered into the gas grid.

3.16 Temporary Construction Facility

An initial temporary construction facility of approximately one hectare will be built to provide offices, car parking, canteen and washroom facilities for construction staff involved in the peat excavation phase. The temporary buildings used are expected to be of the 'Portakabin' type. This area will be to the east of the terminal footprint on the east side of the north-south access road.

For the civil, mechanical, electrical and instrumentation construction phase this initial temporary construction area as well as an area to the south of the terminal, adjacent to the administration buildings, will be used for further office and welfare facilities. Storage and lay-down areas for construction equipment, consumables and plant have been identified at various clear areas in the terminal. A dedicated area will also be set aside for the pipeline contractor to store his materials.

There will be a dedicated car parking area for up to 200 cars. At certain stages during the construction project the parking demand is expected to exceed this number. To ensure that construction workers do not cause obstruction by parking on the roads in the vicinity of the site. The contractors will be encourage to provide transport to the site for their workforce.

3.16.1 Construction Plant

Throughout the construction of the terminal the plant to be used for the various activities is listed below:

The site preparation phase (including peat removal) will require the following plant:

- excavators of various capacities;
- loading shovels;
- rock breakers;
- peat improvement rigs,
- piling rigs,
- dump trucks of various capacities;
- bulldozers;
- graders;
- road sweeping equipment;
- road spraying equipment;
- compactors; and
- mobile crushing/screening plant;
- rock drills;
- pumps and associated hoses;
- road tipper trucks; and
- generators and compressors.

For the Construction phase:

- standard construction equipment including, for example, welding equipment, generators, hand tools etc.,
- variety of cranes;
- special cranes for limited periods (as defined by lifting studies); and
- piling rigs.

A temporary ESB power supply will be installed including a sub station, transformers and switchgear to allow all temporary lighting to be installed prior to the provision of permanent power, which will be available as part of the commissioning programme. "Island mode" operation (the main operational status of the terminal where it will be self sufficient in terms of power) will not be possible until after the introduction of hydrocarbons.

Mayo County Council will install a water main from the local water treatment plant to the site entrance on the R314. A 100mm (4 inch) branch for the permanent supply will be provided to the terminal. This will be utilised during construction. A 250mm (10 inch) branch will also be provided to the fire water storage pond. In addition, water hydrants will be installed on the water main along the R314 parallel to the terminal site. Other than in emergencies this line will only be used by agreement with Mayo County Council.

3.16.2 Water Supply and Sewage Disposal from the Temporary Construction Facilities

Water will be tankered into the site to service the temporary construction facilities up until the permanent supply becomes available, the water will be sourced from the local authority water treatment facilities, which has adequate capacity.

A holding tank will be provided for the sewage from the temporary construction facilities. The tank will be emptied routinely and the contents disposed of by a licensed contractor in an appropriate manner.

3.17 Receiving Environment and Impacts

The aspects of the local environment, which may be affected during the construction phase, are described, and the impacts assessed, throughout this EIS, commencing with Section 5, Human Beings.

Most impacts during construction are temporary and are often very short term. Clearly the construction of any plant or building will change the local habitats immediately as a result of the presence of the new structure. The local area where the plant is to be built is a modified habitat as a result of forestry research operations. As described in Sections 6 and 7, there are no sensitive habitats that will be impacted by the construction process. There will be emissions to air and minor changes to the local drainage on site. There will be noise and there will be an increase in traffic especially during construction. The mitigation of these impacts is dealt with in the respective sections of this EIS. Apart from the loss of the habitat immediately beneath the terminal footprint, and the consumption of resources, there will be no long-term impacts arising from construction.

3.18 Mitigation Measures

During construction many of the impacts, which are not acceptable in an operation phase of a project are usually tolerated due to their short-term nature in the construction phase. However Shell is committed to ensuring that the impacts on the local environment during construction are kept as low as possible. The key impacts that will therefore be very carefully monitored and controlled are noise, dust, traffic, waste and social interactions. The environmental strategy during construction is discussed in Section 3.2.

Local liaison will ensure that the community are regularly consulted and informed of the elements of construction that will have most impact. These include the arrival of a heavy load or large piece of plant, the activities of rock breaking and piling and the occasional need to work at night, which would require light.

Shell recognises that Mayo County Council may apply conditions on the construction operation. In addition it is the wish of Shell to consult and liase closely with the local community via the EMG in order to clearly understand their concerns and mitigate as far as possible the impacts during construction.

Four

Alternatives

4 Alternatives

4.1 Need for the Scheme

With gas consumption increasing annually and predicted to rise sharply in the future, demand for energy has outstripped Ireland's domestic production. The two small new gas fields on the South Coast, Seven Heads and Green Sands, which are expected to be on stream by late 2003, will not make up the short fall. Consequently, Ireland requires significant additional supplies of gas.

From 2001 to 2003 Bord Gáis Éireann (BGE) undertook a major upgrade of the gas pipeline infrastructure, with the construction of a second pipeline connection between Scotland and Dublin, and a transmission pipeline from Dublin to Limerick via Galway. The new infrastructure allows more gas to be imported from the UK and continental Europe gas networks, but it does not provide an alternative source of indigenous gas. A very significant proportion of Europe's gas comes from Algeria, Siberia and a number of the former Soviet Republics in Central Asia. As can be seen from Figure 4.1, Ireland is at the very end of the gas supply line and is vulnerable to an interruption of supply anywhere along the system.

The development of Corrib will help to provide security of supply, as Corrib will be an indigenous source of gas. It will also stimulate expansion of the onshore transmission system to the north west of the country, which in turn will result in increased potential for growth in this region of Ireland, similar to that which occurred in the Cork region when the Kinsale Head gas field came onstream.

Ireland's recent high economic growth has driven the demand for power and energy. Gas is predicted to become a greater provider of energy in Ireland due to its reduced CO_2 emissions compared with other fossil fuels. This combined with the current liberalisation of the energy market will lead to increased gas consumption in Ireland. Infrastructure investments, of which the development of the Corrib field is a significant part, will cater for the predicted increased demand in gas, contributing to the long-term economic well-being of Ireland.

4.1.1 Energy Sources in Ireland

Ireland currently uses coal, oil, gas, wind, hydroelectric and peat as sources of energy. As the demand for energy increases, it is expected that gas will have increasing importance in power generation because of the significantly greater efficiency of combined cycle gas turbine generators, the lowest CO_2 emissions per thermal unit of fossil fuels and the resulting relatively benign environmental impact of the emissions.

Figure 4.1 European Gas Network

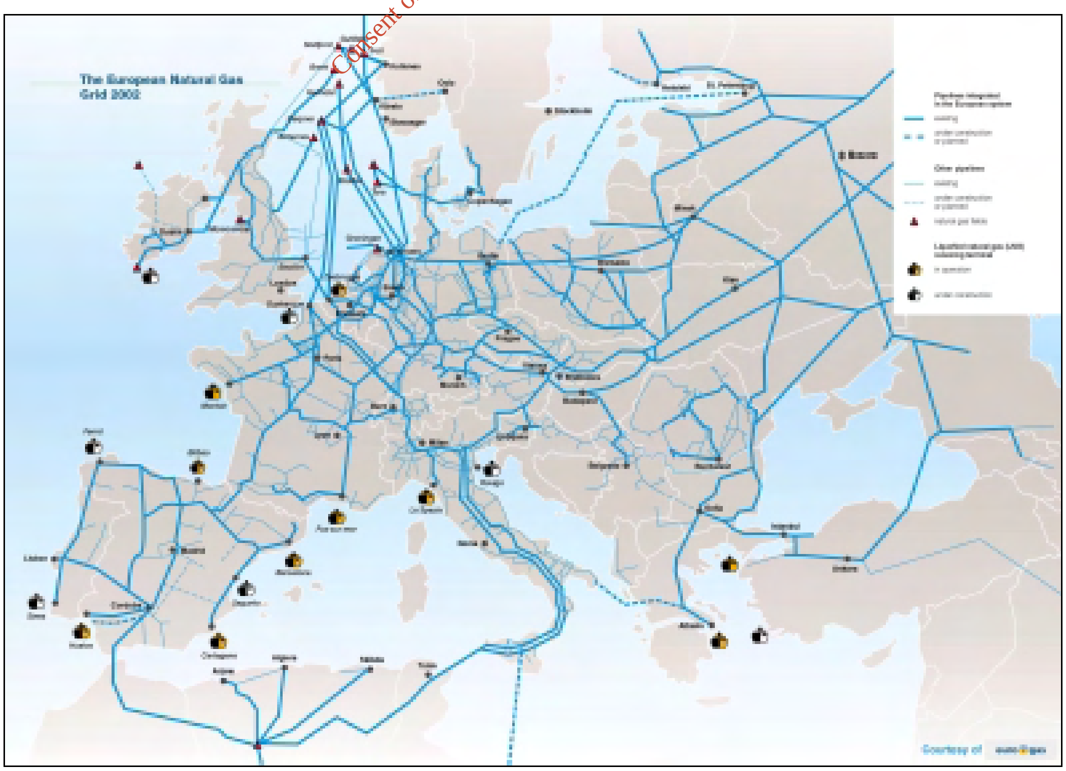


Figure 4.2: Location of Corrib

Substitution of other fossil fuels by natural gas in power generation has the potential to assist in achieving Ireland's targets for reduction of greenhouse gas emissions under the Kyoto protocol.

4.1.2 Need for the Terminal

The Corrib field is located in the Atlantic Ocean, some 65km off the west coast of Ireland shown in Figure 4.2 below. To supply consumers in Ireland the gas must be brought ashore from the offshore wells. The gas must be conditioned to meet BGE specifications before entering the national transmission system for subsequent use by domestic and industrial users. This conditioning can be carried out either offshore or onshore.

An onshore reception facility is required near the landfall regardless of whether the gas is processed offshore or onshore. However the size of the onshore terminal and activities to be undertaken in it will depend on where the gas is processed.

4.2 Development Concept Alternatives Considered

The selection of development options and technologies for the Corrib project followed the approach normally adopted for major projects. Initially a very wide range of options was considered at a high level. The range of options was narrowed and refined in a progression of engineering studies, each study going into considerably more detail than the proceeding one. The studies were:

- pre-feasibility;
- feasibility;
- front end engineering; and
- detailed engineering.

The process began in late 1998, when Enterprise Oil (now Shell E&P Ireland Limited) undertook a pre-feasibility study into the different options for the development of the Corrib field.

4.2.1 Development Concept Selection

In the pre-feasibility study a number of development concepts to exploit the gas in the Corrib Field were identified through a series of screening exercises in order to select and define the preferred development strategy.

Key considerations in the selection of the development concept were the characteristics of the Corrib field location. Compared with gas production facilities in other parts of the world, the Corrib Field lies in deep water, it has a harsh marine environment, there are no existing gas production facilities in or near Corrib, and there is an active fishery.

Conceptual assessments (of safety, operations and cost) concluded that due to these factors the most robust technical solution would be to carry out the gas conditioning onshore. The reasons for this are discussed in Section 4.2.2.

The principal development concepts considered were:

- construction and installation of a deepwater fixed steel jacket or compliant tower with processing, drilling and accommodation facilities together with the installation of an associated gas export pipeline to shore;
- construction and installation of a "shallow" water (<100m depth) fixed steel jacket, at a location between the Corrib Field and the shore, with minimum facilities together with the installation of associated subsea infrastructure (feeding gas from Corrib) and an export pipeline transporting gas to shore;
- construction and installation of a Tension Leg Platform (TLP), a buoyant "SPAR" platform, deep draft semi-submersible floating platform, or tanker-based floating production vessel;
- subsea development with a moored control buoy and telemetry link to an onshore control station and an onshore terminal; and
- subsea development with electro-hydraulic control via an umbilical and an onshore terminal.

The three former options would be provided with processing and accommodation facilities and the two latter options would be combined with subsea completions, subsea production infrastructure and a subsea gas pipeline transporting gas to shore. All options would require an onshore terminal for reception, methanol (Shallow water platform only) and condensate storage (for safety and environmental reasons), gas metering and odorisation facilities.

4.2.2 Reasons Why Alternative Concepts were Eliminated

Economic analyses determined that the very high capital and operating cost of each of the floating or fixed platform options, combined with the requirement for extensive gas transport infrastructure, could not be recovered due to the relatively moderate size of the predicted Corrib reserves and envisaged gas sale price, consequently the first four of the development options were eliminated. Safety, environmental and technical considerations supported this decision including:

- the water depth and hostile nature of the marine environment in the Corrib field area pose major engineering difficulties for a fixed steel jacket or compliant tower. The latter has only been used in the more benign environment of the Gulf of Mexico;
- the floating production concepts are similarly not suited to extended field life in the prevailing harsh environment, with large bore high pressure gas export risers presenting a particularly complex engineering problem;
- Floating production concepts are also mostly associated with oil production where storage volumes are important;
- Remote Control Buoy technology has not been developed for the extreme environmental conditions experienced in the Corrib field area. Development of an acceptable, reliable system could not be guaranteed within the proposed project time scale;
- for all of the offshore manned facilities there are significant safety implications, due to the need for regular and frequent offshore transfer of personnel by helicopter, the requirement for full time standby vessels at sea regardless of weather conditions, the very confined layout with personnel quarters in close proximity to hazardous operating equipment and the restricted escape options in the event of an emergency;
- the offshore facilities have greater environmental impacts due to increased consumption of resources and greater emissions during construction, installation and operation;
- the offshore facilities pose greater environmental risks during installation and operation as the hostile marine environment at the Corrib field would increase the risk of spills and make spill remediation more difficult;
- the offshore facilities pose greater safety risks to personnel in the decommissioning phase, due to the need to work offshore in such a harsh environment;
- the offshore facilities involve much greater environmental risks in the decommissioning phase as the hostile marine environment at the Corrib field would increase the risk of spills and make remediation more difficult; and
- the relatively dry nature of the Corrib gas (eliminating the need for processing close to the well field), the high reservoir productivity (minimising the number of wells) and high initial flowing pressures allow the use of simplified production facilities with high reliability. This permits the practical adoption of subsea production technology for Corrib.

4.2.3 Development Concept Selected

The development concept selected for the Corrib field is a long-range subsea tie-back to a terminal onshore with an export pipeline to connect to the gas transmission grid. Whilst during the construction phase, there will be local environmental impacts, this is the only development option which, from an economic perspective would make development feasible. It will have the lowest risks to the safety of the workforce and in total project terms have the lowest environmental impacts and risks.

Oil and Gas Industry Perspective on Subsea Developments

Non oil industry observers will be familiar with large scale North sea platforms and floating production systems and may perceive these as the "right" or "normal" method for developing offshore gas fields. Sub sea developments are by their nature less visible, have less environmental impact, use fewer inputs of materials, minimise offshore manpower and the resultant exposure to the hazards of offshore hydrocarbon production and as such represent the way forward for offshore gas production in water depths of 200 metres or greater.

The oil and gas industry has invested heavily in research and development of sub sea technology to ensure reliable long distance production of untreated gas streams tied back to either an existing platform or an onshore terminal.

Sub sea production in the North Sea commenced some 25 years ago and has now reached mature technology status. Sub sea technology development has enabled smaller gas fields such as Corrib to be developed safely and economically.

Currently there are two major gas field developments in Norway (Ormen Lange and Snovit) and one in Egypt (Scarab Saffron), which will be developed as sub sea tie backs to onshore terminals.

Thus the development concept for Corrib follows a very clear trend elsewhere in the oil and gas industry, a trend, which is driven by environmental, safety and economic factors.

4.2.4 Feasibility studies

Three feasibility studies were commenced in mid 1999 to examine and refine the main elements of the development concept. The feasibility studies considered:

- offshore field development options;
- landfall, terminal location and onshore pipeline routes; and
- layout options and terminal gas processing technology.

The feasibility studies were undertaken in parallel by independent consultants and, on completion, Shell Corrib combined the findings of the three studies to determine the best overall development concept.

4.3 Gas Field Development

4.3.1 Gas Field Development Feasibility Study

The field development feasibility study examined the development concept, identified in the pre-feasibility study, and addressed the engineering requirements and appropriate technologies. It was concluded that there should be about seven subsea wells, which would be tied back to a central, subsea collecting system known as the manifold. The manifold would be connected to a pipeline to shore. All of the subsea facilities would be operated remotely from a shore based terminal via an electro-hydraulic remote control system. Electrical power and signals, along with hydraulic control and chemical injection fluids would be carried in a composite underwater umbilical cable, laid in the seabed.

4.3.2 Constraints Imposed by the Development Concept

The field development feasibility study identified a number of constraints imposed by the characteristics and behaviour of the untreated gas flowing from the Corrib field to the terminal. These are discussed below.

Due to the pressure and temperature changes and the chemical composition of the gaseous well stream, the pipeline could be blocked by ice-like crystalline structures known as "hydrates". The length and routing of the pipeline, and the presence of water and hydrate inhibitor in the pipeline would cause slugging. These constraints require good engineering and operating practices to ensure safe and reliable operation of the offshore production system and the pipeline to shore. The distance between the wells and the terminal influences the operability of the system. This distance needs to be kept as short as possible to maximise the operability of the system and minimise the size and frequency of slugging.

The control umbilical would be a key component of the system. Construction joints in the umbilical would be a potential source of failure and should be eliminated or be kept to a minimum. Consequently the length of the umbilical should be kept as short as possible.

For these reasons the study determined that the distance between the wells and the terminal should be kept to a practical minimum.

4.3.3 Field Development Engineering Design

The engineering concepts developed in the feasibility study were further refined in the Front End

Engineering phase and the Detailed Engineering phase.

The facilities which will be incorporated into the subsea scheme can be summarised as follows:

- subsea 'Christmas trees', a series of isolation and control valves;
- subsea production chokes (pressure reduction and flow control);
- pressure and temperature sensors;
- well gas flow meters;
- manifold isolation valves; and
- an internal pipeline integrity gauge (PIG) launching connection (for possible future use).

4.4 Examination of Alternative Landfalls, Terminal Sites and Onshore Pipeline Routes

4.4.1 Landfall Pre-Feasibility Study

The Corrib field is located in the Atlantic Ocean, some 65km off the west coast of Ireland. The natural gas transmission pipelines, are in the midlands, east and south of the county. It was apparent that whichever field development concept would be adopted, the Corrib project would require a pipeline to shore and onwards to connect to the existing gas grid.

Consequently, in 1998, in parallel with the development concept pre-feasibility study, a study was undertaken to determine suitable locations to bring a pipeline ashore.

The coastal morphology of the West Coast of Ireland from the mouth of the Shannon to Sligo Bay was reviewed. The review used published data on environmental designations, public amenity areas, aquaculture licences, aerial photography, marine and land geological information, topographical mapping and site visits.

The review concluded that, along the West Coast of Ireland, there are extensive areas of seabed where rock outcrops occur and this severely limited the number of locations suitable for bringing a pipe ashore. Aquaculture licences are prevalent in Clew Bay and Connemara and there are extensive tracts of coast and associated hinterland that are subject to National Heritage Area, Special Area of Conservation (SAC) and Special Protection Area (SPA) environmental designations made pursuant to EU and Irish legislation on the protection of wildlife and habitats.

The review identified four main areas where a possible landfall location might be found that would not have significant environmental impact.

They were as follows:

- Killala Bay area, in Counties Mayo and Sligo;
- the eastern side of Broadhaven Bay and Blacksod Bay in Co. Mayo;
- the Emlagh point area, to the west of Westport in Co. Mayo; and
- Liscannor Bay and Doughmore Bay in the central part of Co. Clare.

The above locations were then subjected to a more detailed appraisal in terms of:

- environmental constraints and potential impacts;
- offshore pipeline routing;
- technical feasibility and costs;
- pipeline shore approach and landfall construction issues;
- possible onshore terminal locations; and
- onshore pipeline routing and construction considerations.

This appraisal refined the previous information and lead to the identification of four areas for a more detailed study. These locations were:

- north or south of the Sruwaddacon inlet, in Broadhaven Bay, Co. Mayo, with the reception terminal located inland at Bellanaboy Bridge;
- Bunatrahir Bay, Co. Mayo, with the reception terminal within 0.5km of the land fall;
- Ross Point on the south side of Killala Bay in Co. Mayo, with two possible reception terminal sites, one at the landfall and the other some distance inland adjacent to the former Asahi plant; and
- between Lenadoon Point and Rathlee Head, on the east side of Killala Bay, Co. Sligo, with the reception terminal at the landfall.

4.4.2 Onshore Pipeline, Landfall and Reception Terminal Siting Feasibility Study

In mid 1999, coincident with the feasibility studies for the field development and the onshore terminal, a feasibility study was commissioned to identify landfall locations, terminal sites and onshore pipeline routes. The study used the findings of the landfall pre-feasibility study as its starting point.

The four potential landfall areas were examined. Landfalls in each area were identified and a suitable terminal site (or sites) was identified for each landfall.

The main criteria against which the terminal sites were judged were:

- minimisation of distance from Corrib field to terminal;
- sufficient area of suitable land;
- sufficient distance from nearby housing;
- minimisation of impact to environmentally sensitive areas; and
- minimisation of visual impact and intrusion.

The conclusions of the study were as follows:

- Rathlee – primary constraint identified was the visual impact of the terminal. All locations would be highly visible and would have been difficult to screen.
- Killala – several landfall locations were considered around the bay. The most suitable landfall location was a designated Special Area of Conservation and Natural Heritage Area; another was a recreational beach area. The areas to the west of the bay, which were the best landfall locations, were designated as being of Special Scenic Importance. No suitable terminal location could be identified within a short distance of the landfall. The option of locating the terminal adjacent to the former Asahi site was considered but later discounted on the basis of its distance from the Corrib field, see Section 4.4.3.
- Bunatrahir – the beach area was designated as an area of special recreational importance. Also, it was considered that the sandstone bedrock in the area could cause problems for landfall construction. The nearby beach at Portnahally was considered. One of the main disadvantages was the visibility of the potential terminal sites. The land is very flat and exposed and the sites were particularly visible from the R314 road into Ballycastle.
- Broadhaven Bay – The ground conditions of the foreshore and approach are predominantly sand and were considered ideal for landfall construction, allowing rapid natural regeneration. The area around the landfall was designated as an Area of Special Scenic Importance and the road along the coast and estuary was designated as a Scenic Route. The land, close to the landfall, was gently undulating with no existing screening. It was considered that any potential terminal sites within a short distance of the landfall would have a major visual impact and would not be easy to screen. A location within commercial forestry, which provided existing natural screening for visual impact, was considered. Although the bay is a candidate for SAC status, the terminal development would not be in an area covered by the proposed SAC.

The feasibility study also considered routes for a pipeline from each reception terminal to connecting points to the gas transmission grid.

4.4.3 Selection of Broadhaven Landfall

As explained in Section 4.2.4 above, on completion of the three feasibility studies, Shell combined the findings.

The field development feasibility study had determined that the distance from the field to the reception terminal should be minimised. Locating the landfall and terminal in the Broadhaven area would give the shortest distance from wells to terminal. An alternative considered at this stage was to separate the umbilical from the pipeline. The umbilical would be brought ashore at Broadhaven and the pipeline would be brought ashore at one of the other landfalls. This alternative was discounted on the basis of practicality, safety, security and cost. Moreover, because the longer pipeline distances involved would result in excessive pressure loss in the pipeline and in the hydrate inhibitor line(s), the terminal would require a larger slugcatcher, additional power for gas compression and inhibitor pumping thereby increasing the size of the facilities and associated environmental emissions onshore.

The Killala and Bunatrahir options would involve considerably greater distance between field and terminal, which would require an umbilical which would be longer than current industrial experience.

Consequently the Broadhaven landfall was chosen.

4.4.4 Selection of Bellanaboy site

The feasibility study had identified a potential terminal site in an area of forestry close to Aghoos, to the north of the Bellanaboy site. When the Front End Engineering Phase and preparation of the EIS for the reception terminal commenced terminal sites were considered in detail.

A terminal location near the landfall was considered. This site was located to the south-west of Pollatomish, at the bottom of the hill inland from Brandy Point. Whilst the location cannot be seen from the south-west, it is not considered possible to screen it effectively from the road or from some residential properties. It would be completely open to views from the bay. Given the scenic nature of the area, and the conservation status of the bay, this location was discounted as it was considered that the terminal would be intrusive.

Site visits determined that the terminal at any potential location between Ross Port and the forestry near Aghoos would be very intrusive and would have a major visual impact on this scenic area. The Bellanaboy Bridge site was selected as it gave better immediate screening to the terminal than the site nearer Aghoos, identified in the feasibility study.

The route for the pipeline from the landfall to the terminal was determined on the basis of environmental and technical feasibility criteria. These were described in detail in the Offshore (field to terminal) EIS, which accompanied the application for pipeline consent made pursuant to the Gas Act and granted April 2002.

4.4.5 Examination of Alternative Locations Within the Bellanaboy Site

Various options were considered to minimise the overall environmental impact of the terminal. The first of these was to select a location on the Bellanaboy land where existing screening is present. The terminal layout and design were optimised to minimise visual impact. Alternatives that did not offer a reduction in visual or other impacts were discounted.

In particular a design that provided low initial visual impact was progressed on a site in the southwest corner of the Bellanaboy land. This area is the lowest lying in the land acquired by Shell and has established tree screening to the west and to a certain extent to the south. The site design was based upon three terraces in order to further minimise visual impact and permit, by cut and fill, the creation of flat site levels clear of the wet ground that characterise this location.

Further studies indicated that a better site would be on the land adjacent and to the east of the original location. A number of issues influenced this, the key ones being visual impact, peat thickness and groundwater issues.

Whilst this land is higher in elevation, detailed analysis showed that the immediate visual impact is reduced even more than that of the original site due to the presence of taller established forestry combined with cutting the terminal site into the hillside. The cut and fill levels will be designed to minimise the import and export of material to the site.
The buildings and onsite structures have been designed to be multiple low level rather than multi-story. The buildings will be designed in sympathy with the local surroundings using local materials and colour schemes.

There are seven items of equipment whose design means that from some view points they will protrude higher than the tree line. Two of these are the HP and LP flare stacks, combined in a single structure. Alternatives using ground flares rather than elevated flare stacks were considered but were discounted as only suitable for use in routine maintenance flaring and not for full capacity flare use. A ground flare will be used for maintenance.

4.5 Examination of Alternative Construction Methods

The ground works will be one of the principal elements of the construction project. It is estimated that up to 450,000m^3 of peat and up to 50,000m^3 of mineral soils will be removed from the site in order to create a suitable platform for the terminal plant and equipment, at an elevation that will ensure that the existing forestry screens the site.

The main issues considered in order to determine the best solution for site preparation and the alternatives, including why they have been discounted or selected are discussed in this section. It also takes into account the grounds for refusal by An Bord Pleanála of permission for the previous scheme, which included the proposal to store the peat onsite.

4.5.1 Required Characteristics of Terminal Platform

The proposed terminal site is at a slight incline, of approximately one in forty, and is underlain by a layer of peat, of varying thickness, which in turn overlies mineral soil.

In considering the development of the site, Shell had the following options:

- build the terminal on the slight slope, or
- re-grade the site to create one or more flat terraces.

A flat site is proposed for the following reasons:

- for ease of construction and maintenance access to areas of plant should be from level roads;
- hard standings to facilitate fire fighting around storage tanks should be at the same level as the tanks being served;
- ease of operations, maintenance and emergency access and egress, stairs and access routes should be simple;
- embankments (possibly with retaining walls) would have to be introduced in a split level site, thus increasing the area required; and
- equipment design, operation and maintenance would be far more complicated if there were differences in relative elevations on a sloping or split level site.

In considering the foundations for terminal structures, and equipment, the options were:

- found the terminal on the peat and/or the mineral soils;

- treat the peat and/or the mineral soils in order to increase their strength; and
- found the terminal on bedrock.

It was concluded that minimal differential settlement of the ground in different areas of the terminal would be essential because:

- for safety and operability, particularly for equipment operating under high pressure, piping and equipment require very tight tolerances on differential settlement;
- piperacks, piping and equipment design and installation would be very complex in a plant subject to differential settlement, as flexible connections would be required throughout; and
- excessive settlement would create operability difficulties for equipment such as pumps, turbines and compressors.

4.5.2 Foundation Options in Peat and Mineral Soil

In determining how a flat site, with minimal differential settlement could be achieved, consideration was given to the question: Can the peat and mineral soil be utilised to support foundations?

The geotechnical site investigation work concluded that the peat would have very low load bearing capacities and would give rise to excessive, variable and difficult to predict settlements, if subject to foundation loads. It was determined that it would not be feasible to achieve the necessary foundation criteria in the peat, without improving its engineering properties.

Of equal importance was the suitability of the peat as a platform from which to construct the terminal buildings and erect the terminal structures. It was concluded that the peat, without improving its engineering properties, would not provide a suitable surface, and would not be a stable platform from which to undertake construction works.

The engineering properties of the mineral soils vary. However, most of it has sufficient strength to provide suitable foundations for terminal structures and equipment. The mineral soil would also provide a stable construction platform, provided rainfall runoff was carefully controlled to avoid water collecting, as ponding would soften the mineral soil.

4.5.3 Peat Improvement Techniques

Various methods were considered for improving the engineering properties of the peat and mineral soil. The techniques and the advantages and disadvantages associated with each are outlined below.

Ground Improvement by Either Vibro Stone Columns or Vibro Concrete Columns

This technique would require the placement of columns on a regular grid covering the complete area of the proposed works followed by a geogrid reinforced granular mattress. This would create a sound-working platform for the construction of the works.

This method was discounted due to the need for in excess of 10,000 columns. The equipment to install the columns would also require stable working platforms, necessitating the import of additional fill because the peat would not provide a stable platform. This method would result in the terminal being built at a higher elevation creating a more significant visual impact and the traffic movements related to material import would also be high.

Surcharging the Peat

This option was reviewed but was discounted. If the peat and mineral soil were surcharged with sufficient load, for a sufficient duration, they would be consolidated and compacted. This would increase their strength and, by causing settlement to occur in advance, would result in reduced settlement when loaded by the terminal equipment and structures.

Surcharging of the peat and mineral soil would require a considerable thickness of fill to be laid on the peat. The thickness could then be reduced after design settlement had been achieved. This solution would result in the terminal being built at a higher elevation creating a significant visual impact. The long-term settlement would be an issue over the life of the plant because, although the peat would have been compressed, its engineering characteristics would continue to be uncertain and hence lead to uncertainty in determining future differential settlement. The surcharge would have to be left in place for a significant length of time to maximise the strength gain and the consolidation of the peat. This would delay the overall schedule. This Option also had high associated traffic volumes.

Treatment of the Peat

There are methods by which soft soils such as peat can be treated. The addition of either lime or cement can greatly improve the strength properties. In recent years peat improvement techniques have proved successful for road and rail construction and for enabling works but have yet to be proven for building and equipment foundations.

4.5.4 Foundations on Bedrock with Peat Retained

It was considered that the peat could not be improved sufficiently to provide an adequate founding medium for the terminal buildings and structures. Consideration was then given to the following techniques, which would allow the peat to remain in place, yet provide a stable construction platform, with foundations supported on piles on the bedrock.

Creation of Fully Piled Concrete Raft

A piled concrete raft would be constructed on top of the peat over the terminal footprint area, on which to support the equipment, structures and/or buildings. The raft would offer the advantage that it would act as a single foundation for all the works both temporary and permanent. However, it would require a significant volume of imported fill to create a level platform. Furthermore, the raft itself would be a major construction project. It would require a considerable number of piles and a considerable volume of reinforced concrete. This option would result in a much higher terminal elevation creating a significant visual impact. There would also be schedule implications as the raft would have to be constructed before the main terminal works could commence. The import of this fill and ready mixed concrete would generate significant environmental impacts related to vehicle movements.

Addition of a Graded Fill Blanket

The principle of this alternative is to leave the peat in place and to introduce a complete blanket coverage of a graded rock fill over the entire area of the site. The rock fill blanket would provide a construction platform. The main structures and equipment would be supported on piles on the bedrock, through the rock blanket. Site roads and hard standings would be support on the rock fill blanket.

Settlement of the peat would generate maintenance issues during the life of the terminal because the un-piled areas would consolidate over time. This alternative would also result in a much higher terminal elevation creating a significant visual impact. This option would require an enormous volume of rock fill, which would be difficult to source locally and would have major traffic implications.

As all of the techniques for improving the strength characteristics of the peat and retaining the peat on site had considerable disadvantages, the assessment then considered firstly partial and then total removal of the peat.

4.5.5 Partial Peat Removal

In this option the peat would be removed from the parts of terminal footprint in which the main structures and equipment would be located. The main issues arising from this option can be summarised as follows.

A significant volume of imported fill would still be required to provide a construction blanket and pile head restraint. A significant volume of peat would have to be removed which would also require the initial construction of temporary haul roads. This option would result in the terminal being built at a higher elevation, causing greater visibility and therefore a more significant visual impact. The import of fill would also generate a significant amount of vehicle movements. Settlement of the remaining peat would generate maintenance issues during the life of the terminal because all the unpiled areas would consolidate over time. Measures to minimise the effects of settlement on underground drainage systems would also have to be implemented.

4.5.6 Total Peat Removal

Total peat removal was considered. The plan would involve the excavation of the peat and underlying soil and rock to create a level platform. This would ensure a stable working platform for the construction of the terminal and eliminate the maintenance and operability problems associated with differential settlement. The terminal elevation could be chosen to ensure that the visual impact was minimised.

However, very large quantities of peat and some mineral soils would be generated for which a use or disposal site would be required.

It was concluded that if an environmentally appropriate reuse or disposal option could be identified for the excess peat and mineral soils, total peat removal would present the best practical option for the terminal, both for its construction and operation.

4.5.7 Peat and Mineral Soil Re-use

The reuse of the peat and mineral soil was considered.

The excavated peat would not be suitable as an engineering fill material. It cannot be laid down and compacted to meet engineering criteria. The characteristics of the mineral soils are quite variable. Some of this material would be reusable as fill but not all of it.

4.5.8 Alternative Uses of Peat

Investigations were undertaken to identify and assess alternative means of utilising the excavated peat. These are described below:

Fuel in Power Stations

The use of the excavated peat as a fuel in power stations has been investigated in discussions with Bord na Móna. It was determined that the peat would be too wet to be used directly as fuel and a complex and time consuming procedure of drying the large volumes would be required. In addition, there would be the issue of haulage from the site to the power stations (it is understood that the local peat burning power station at Bellacorrick will cease operation by the end of 2004). These issues determined that it would not be feasible to use the peat as a fuel.

Gardens / Horticulture

The type of peat used for horticultural purposes is termed Younger Sphagnum Moss Peat. The peat present on the terminal site is Blanket Bog Peat, which has been humified too much and its structure broken down. It is therefore not suitable as a horticultural material.

There is the possibility that the peat could be used to improve soil texture in agricultural land. However, the very large quantities of peat to be excavated make this alternative impracticable due to the infinite variety of potential locations and the uncertainty over the timescales in which the peat could be removed.

Fuel for Domestic Use

Market demand was deemed too small relative to the quantities of peat involved. Use as domestic fuel would also entail a lengthy process of drying, need land to dry out material to a depth of 0.1m as well as the difficulty of distributing the peat as discussed above.

4.5.9 Peat Storage Proposal

Since any offsite reuse or disposal option would involve significant traffic movements and consequent impact, on-site peat storage was investigated.

A method was identified to store this peat on a site adjacent to the terminal in an engineered repository. This solution had the advantage of a short haul distance within the construction site, thus avoiding the use of public roads. It also offered the possibility of utilising the storage area for future planting or forestry. To avoid importing substantial quantities of fill, and thereby minimise the traffic impacts, the repository would have been founded on the in-situ peat.

Shell's previous Planning Application to Mayo County Council incorporated the peat repository. While Mayo County Council granted permission, the repository was the reason for refusal of planning permission by An Bord Pleanála, which had concerns over the drainage and the long-term stability of the stored peat.

Offsite Removal

Transportation of the peat offsite by various means was considered depending upon the location of the deposition site or end use. Export of the peat away from the area by barge was considered but discounted for the following reasons:

- the Sruwaddacon Estuary would have to be crossed. This would increase the time and costs for installing the pipeline;
- building a new pipeline in a short timeframe may not be possible;
- there is no adequate mooring point for a barge, therefore barges would have to be moored more than 2km offshore from Glengad and a pipeline laid out to the barge;
- the distance to pump would be almost the same as to Srahmore area, 9km pipeline length and 1-2km offshore;
- this would be a large volume for any barge system to collect and then deposit in another place; and
- acquisition of the necessary wayleaves would potentially impact on the project schedule.

4.6 Current Proposal – Peat Removal

Following the An Bord Pleanála refusal, all options were reviewed, including the alternatives for retaining the peat in situ and treating it, which had been investigated prior to the previous Planning Application.

The review determined that total peat removal was the preferred method of dealing with the peat on the footprint.

Given that the option to retain the peat in a repository on site was rejected by An Bord Pleanála, and the difficulties with other options referred to above it was necessary to consider the potential for depositing the peat off site.

A number of sites were considered and the methods whereby the peat would be removed and subsequently deposited were also assessed.

4.6.1 Peat Removal Options and Sites Considered

An assessment was made of potential deposition locations, in the Erris area which would be acceptable from a planning and environmental point of view. The criteria used to identify potential sites were:

- Landownership: ease with which site could be made available for development;
- Gradient; a flat site with no evidence of stability problems;
- Drainage: well drained site that would not have any potential impacts on adjacent water courses;
- Access by road: good road access from Bellanaboy site to minimise impacts on local road users;
- Worked bog: preference for an already worked bog to avoid sterilisation of peat reserves; and
- South of Carrowmore lake or in Glenamoy catchment to avoid any potential risks to Carrowmore lake.

The various sites considered are presented in Table 4.1.

Table 4.1 Potential Sites for Peat deposition

Potential Site Locations
Coillte land to south of R314
Site north and east of terminal site
Site at Barnatra
Site at Glenturk
Eight sites belonging to Bord na Mona
Local landfills
Retain 50% on site in old peat repository

On the basis of the assessment the favoured site is a Bord na Móna cut over peatland, at Srahmore, to the north west of Bangor Erris.

This site, approximately 11km away from the proposed terminal site, is one from which the peat has been harvested for a local power station. The peat from the terminal could be deposited at this site, which is nearly flat (basin shaped) and has been drained.

Having identified a deposition location, consideration was given to the method of transporting the peat from the terminal site.

4.6.2 Assessment of Transport Methods

A number of possible peat transport methods were considered by Shell and its consultants, including, experienced earthworks contractors. The methods are summarised below:

4.6.3 Alternative Peat Transport Options

The possibility of transporting the peat from the Bellanaboy Bridge Site by rail was considered. Issues which were identified included:

Transport the Peat by Rail

- installing a temporary rail link would take a considerable amount of time given the many stream and small river crossings required. It would be a major construction project in itself;
- wayleave agreements with landholders would be required;
- there would be severance of farms;
- train drivers may require special licences as there would be several roads to cross as well as many private driveways;
- loading and unloading facilities would be considerably more complicated for trains than for trucks or for a pipeline; and
- there would be no residual benefit to the community of either a train system which would have to be removed after use.

Pump the Peat

Pumping the peat in a pipeline to Srahmore was considered.

Following are some characteristics and problems associated with pumping, in general:

- two types of pumping are possible, either as a paste with 0-1 times water added or as a more liquid waste with 5-6 times water added. As liquid waste, the volume would be 6-10 times as large as a paste (2-4 million cubic metres);
- it is possible to pump the peat;
- this quantity, distance and timeframe has never been done before;
- to progress the proposal some investigation and sampling of the peat would be required to determine rheology and settlement patterns;
- to ensure a reliable, working system, extensive testing and trials would be required. There are also potential environmental problems with the risk of run-off of the liquid waste into rivers.
- pumping paste would require a much higher pressure than pumping as a liquid and therefore would require a steel pipe;
- pumping paste may require intervention during operation to clean the system or provide additional pumping. This may pose a serious risk for a pipeline crossing watercourses.

- pumping liquid waste would require large amounts of water for mixing; and
- wayleave agreements may also be required for a temporary pipeline but it might be possible to lay the pipeline along the road with minimum disruption.

Pumping to Srahmore raised a number of issues:

- a temporary pipeline should be buried alongside road to avoid disruption to road users;
- there would be concern at the receiving end with handling liquid peat. Bord na Móna would consider taking and depositing peat delivered by truck as they consider that receiving the peat in solid form is the most feasible and environmentally the safest option; and
- there is uncertainty about the characteristics of the peat in 5 or 10 years time, if the peat would be stable and if vegetation would colonise the deposit.

During consideration of these factors it was concluded that there were constraints on the pumping option based upon:

- uncertainty about pumping a paste type substance over 10km distance (several intermediate pumps may be required, additional water injection, etc.);
- the handling difficulties to be dealt with at the deposition location if the peat is pumped in liquid waste form (containment, bunds, drainage, etc.);
- the pipeline difficulties to be resolved including temporary wayleaves;
- the extensive testing regime, which would be required to prove the feasibility of pumping and the time required to undertake this (characteristics of the peat, preliminary pump trials, more extensive scale trials, etc.); and
- environmental risks to watercourses caused by the disaggregated nature of pumped peat. .

It was therefore decided on environmental and logistical grounds that further study of this option would not be beneficial.

Peat Transport by Truck

The use of trucks travelling on the public roads to transport the peat would be simple, practical and a proven method. The roads are already there. There would be no new severance and new wayleaves would not be required. The transport operation would be expected to take up to six months. It would be necessary to upgrade the roads between the terminal site and Srahmore and to take other measures to minimise disruption to other road users.

The upgraded road network would be a residual benefit to the local community.

Bord na Mona have for many years transported significant quantities of peat in the Bangor Erris region by truck.

Having considered alternative peat transport methods, it was decided that the peat would be transported by truck on the public road.

4.6.4 Modification to Total Peat Removal Option

Following the decision to remove the peat from the site and to transport it using the public road network, construction methods were reviewed in order to reduce, to the practical minimum, the quantities of peat and mineral soil which would have to be removed from the terminal footprint.

Thus, as described in Section 4.5, a combination of different techniques are proposed to create stable construction platforms. In the process area of the terminal footprint the peat will be removed. The peat will be left in place in the access roads, the administration building area and the temporary construction facilities. Peat stabilisation will be used in these areas to increase the strength of the peat, in order to create a working platform. In the truck parking area, part of which will be used in the long term, as the terminal car park, a piled concrete raft will be constructed on top of the peat, the foundation loads being transferred to the underlying mineral soil and rock.

4.6.5 Peat Deposition Methods

Alternative methods of deposition of the peat are covered in the volume of this EIS dealing with the peat deposition site.

4.7 Terminal Technology Options

4.7.1 Introduction

The terminal feasibility study considered a range of technology options for the terminal. These technologies were refined in the subsequent Front End Engineering and Detailed Engineering Design phases.

The terminal will comprise:

- slug catching and separation facilities;
- gas conditioning facilities;
- sales gas compression;
- fiscal metering and odorising;
- condensate stabilisation and storage;

- hydrate and corrosion inhibitor storage and pumping system;
- hydrate inhibitor (methanol) recovery system;
- water treatment facilities; and
- supporting utilities including power generation and fire fighting systems.

The main technological options considered for the terminal are outlined below. The various options were evaluated in terms of technical feasibility. The reasons for choosing the selected option are given.

The options for the following materials/processes are described:

- Gas Conditioning;
- Hydrate Inhibitor;
- Produced Water Treatment; and
- Mercury removal.

4.7.2 Gas Conditioning

When a wellhead gas is treated to meet a sales gas quality specification such as heating value (calorific value) and water and hydrocarbon dewpoints, the treatment is referred to as gas conditioning. This conditioning enables condensate and water present to be separated out. As the gas is produced, the reservoir pressure falls and as a consequence the inlet pressure to the terminal falls. Gas compression will be required for all gas conditioning alternatives.

Initially, the following gas conditioning technologies were studied for their suitability for use at the Bellanaboy Bridge Terminal:

- Joule-Thompson (J-T);
- silica gel adsorption;
- activated carbon;
- molecular sieve;
- mechanical refrigeration;
- turbo-expansion; and
- lean oil adsorption.

Preliminary evaluation concluded that all but the Joule-Thompson and the silica gel adsorption schemes were technically, environmentally and economically less attractive.

Activated carbon and molecular sieves are solid desiccants, which remove mainly water and condensate by adsorption. The molecular sieve method was rejected because its condensate adsorption rate is too low for the composition of the gas. Activated carbon was rejected because its water adsorption rate is very low. Compared to the Joule-Thompson alternatives, turbo-expansion requires an increased amount of rotating equipment and hence, results in reduced reliability. The turbo-expansion option is also economically less attractive than the other alternatives.

Lean oil adsorption will not be effective at the higher operating pressures envisaged for Corrib and hence has been discounted. As sufficient pressure will be available for utilising the J-T option, mechanical refrigeration is not required in the early years of operation. Mechanical refrigeration for cooling the gas will be used when the terminal inlet pressure decreases around year 9.

Silica Gel Adsorption

Silica gel is used to remove water and condensate from the gas stream to meet the prescribed dewpoint specifications. The gas is passed through silica gel desiccant beds, which are contained in vertical vessels, where the water and condensate are adsorbed. The adsorbed components are removed from the bed by recycling hot gas through the adsorbent bed. The adsorbed components are then cooled and separated in a vessel, and the water and condensate routed to the produced water and condensate stabilisation systems respectively.

Joule-Thompson Expansion (J-T valve)

The gas pressure is let down to a level sufficient to enable water and condensate liquids to condense out of the gas phase from where they would be separated in a downstream cold separator. As the inlet pressure to the J-T valve falls, a gas/gas exchanger would be used to pre-cool the gas, thus helping the J-T effect and improving separation. As the inlet pressure drops further (around year 9), a mechanical refrigeration based gas chiller is introduced between the gas/gas exchanger and the J-T valve to achieve the required water and hydrocarbon dewpoints.

Comparison of Silica Gel Adsorption and J-T Valve

Further studies were then conducted on J-T and silica gel technologies using a predicted set of criteria for the gas and dewpoint requirements.

The J-T option has been chosen over the silica gel option as no guarantee of operational performance could be obtained from the silica gel manufacturers with the predicted pressures and possible variations in the composition of the gas. The silica gel option would also have resulted in the periodic replacement of the silica gel beds due to reduced efficiency. The silica gel would have been classed as hazardous waste. The silica gel option would also require a regeneration compressor.

The J-T option requires gas compression from start-up, resulting in an installed thermal input of approximately 50 MW. This installed energy requirement would necessitate an IPPC Licence from the EPA.

4.7.3 Hydrate Inhibitor

Hydrate is a solid ice-like material formed from gas and water at specific temperatures and pressures. Hydrate inhibition options were assessed to identify the best inhibitor to protect the subsea facilities and the terminal from hydrates formation during normal operation, shutdown and start up conditions. The selected inhibitor will not adversely affect water quality, or significantly increase atmospheric emissions, at the terminal and it allows for the minimisation of the environmental impact of the terminal in areas of waste generation and toxicity of the process systems.

The hydrate inhibitors investigated were:

- methanol;
- Glycols - Mono Ethylene Glycol (MEG); and
- Threshold Hydrate Inhibitors (THIs).

Methanol

Methanol is a very effective and commonly used hydrate inhibitor requiring relatively low concentrations in the gas stream. In addition to its ability to inhibit the formation of hydrates, it can dissolve hydrates which have already formed. Methanol vaporises along with other low volatility components leaving the waste water relatively free of hydrocarbons, thereby reducing the impact on the water treatment plant. In environmental terms this is important. The cost of methanol and methanol regeneration facilities is significantly lower than that of glycol.

Glycol

Glycol is another commonly used inhibitor. The use of glycol was rejected for a number of reasons. Glycol cannot dissolve hydrates, once they have formed. Glycol is required in higher concentrations than methanol to achieve the same degree of hydrate suppression. The glycol option would require a 3” pipeline in parallel to the subsea pipeline due to the higher volumes required and higher fluid viscosity. This would result in significant additional investment and also cause the release of aromatic volatile organic compounds known as BTEXs (Benzene, Toluene, Ethylene and Xylene) to the waste phase. Due to the environmental and occupational health risks associated with BTEX, equipment would be required to remove them from the waste water.

A glycol recovery system produces high volumes of solids that require disposal offsite as a waste, thus increasing the environmental impact. The predicted extent and cost of this disposal will make any glycol scheme less attractive. Furthermore, at current prices, fresh glycol costs are 2.5 times higher than methanol.

Threshold Hydrate Inhibitor

Of the two types of Threshold Hydrate Inhibitors (THIs) available, the Anti Agglomerate (AA) inhibitors were ruled out due to the Corrib Field’s very low condensate volumes which preclude the formation of a stable water and condensate emulsion.

The other type of THIs, Kinetic Hydrate Inhibitors (KHIs), could not be used on their own for the first 8 years of the project due to their poor effectiveness in higher (above 70 barg) operating pressures. KHIs also have to be used in conjunction with a carrier fluid such as methanol. There is also a general lack of experience of working facilities using KHIs. The environmental effects of KHI use were also uncertain, especially regarding the water treatment aspects.

Conclusion

The use of methanol was therefore selected as the hydrate inhibitor of choice, as methanol provides the most cost effective method of preventing hydrates over the life of the field. It also provides significant environmental benefits in minimising effluent production volumes and does not produce significant levels of solids.

4.7.4 Mercury Removal

Gas

Well tests in the Corrib Field have shown the presence of trace amounts of mercury in the wellstream, which is not unusual for natural gas fields.

In order to establish whether the associated emissions from using the Corrib gas as fuel within the terminal would fall within acceptable limits, exhaust concentrations of mercury were calculated for normal terminal fuel gas usage of 3 mmscfd. The calculations indicated that mercury levels were well within recognised limits. The range of concentrations measured were found to be below 10 micrograms(µg)/m^3, an order of magnitude below the level recommended by EPA in the IPC BATNEEC ‘Guidance Notes for the Chemical Sector’. However in line with industry practice the gas will be passed through a mercury removal bed which will remove the mercury to below measurable levels.

Condensate

Mercury levels in the condensate are predicted to be in the range of 1ppm or less. On this basis the mercury concentrations in the heating medium heaters, where the condensate will be used as fuel, were calculated and shown to exceed current EPA guidance level. To ensure that mercury levels within the condensate will be within EPA guidance levels, mercury removal equipment will be installed. This equipment will be detailed in Shell's application for an IPPC Licence.

4.7.5 Produced Water Treatment and Disposal

Produced water treatment is discussed in detail in Section 2 and its disposal in Section 10. Disposal options considered for the treated waste water were:

- onshore injection;
- local drainage;
- coastal discharge, no mixing;
- estuarine discharge, no mixing;
- coastal discharge, limited heavy metal removal;
- water treatment and coastal discharge mixing;
- estuarine mixing; and
- reinjection into the Corrib reservoir

The onshore injection and local drainage options were ruled out due to the possible salty nature of the waste water. Local drainage discharge to Sruwaddacon Bay was ruled out due to the shallow and tidal nature of the bay.

To re-inject water into the reservoir, it would require much larger onshore facilities for pumping, creating associated environmental emissions onshore. The laying of a second high pressure pipeline back to the field to re-inject the produced water into the reservoir would also have required a trench in the seabed. A water disposal well would be required with the consequent additional offshore environmental impacts of drilling a well to a depth of approximately 4,000m.

The chosen disposal option is water treatment, to environmental quality standard levels and coastal mixing. Discharge and dispersion modelling studies have been carried out, and are discussed further in Section 10.0.

Waste Water Treatments Considered

With the decision to treat the water to EQS discharge levels, a number of the technical options were discounted during early design phase.

Evaporation

Evaporative treatment of effluent can apply to effluents from a methanol or KHI based inhibitor system. A glycol based system effectively includes total evaporation in regenerating the glycol.

Evaporative treatment systems were discounted as they generate very significant quantities of salts for disposal.

Primary Treatment

The separation of insoluble gross oil and settleable solids content using API separators and plate interceptors (tilted or corrugated) were considered to reduce waste mass loading and protect downstream equipment.

Separate API separators would be required for the surface water runoff from the process and utility areas of the facilities. It is proposed to use corrugated plate interceptors as primary treatment.

Secondary Treatments

Flocculation, air flotation (dissolved or induced), sedimentation and filtration (gravity or pressure), hydrocyclones and absorption were considered to further lower oil in water concentrations and particulates. They are also used to enhance metals precipitation / separation.

Flocculation and precipitation by pH adjustment and sedimentation were also considered for heavy metals removal.

Pressure filtration systems were considered to reduce the volume of solids. This was selected as the preferred method of secondary treatment due to the performance characteristics.

Tertiary Treatment

Residual treatment of dissolved pollutants and metal ions using biological processes, aeration, micro, ultra or nano filtration, final polishing by ion exchange / granulated activated carbon [GAC] or a combination were considered.

Biological processes were discounted due to the high dissolved solids feeds, particularly the brine type fluids that will come from a methanol based hydrate inhibitor system. The effluent would require dilution to approximately 1/3 of seawater chloride concentrations for biotreatment to work. The only source of such water would be from potable water.

High pressure membrane filtration, is preferable in these circumstances and was selected.

Selected Waste Water Treatment Methods

The following has been adopted as the most effective method of achieving the required discharge limits. This philosophy has been determined as Best Available Techniques (BAT).

The two streams identified for treatment are:

- Surface water
- Produced Water

Surface Water Treatment Package

The process comprises of:

- Corrugated Plate Interceptor (CPI) for removing the bulk of separable oil.
- Multimedia Filters for the removal of particulate suspended solids
- Ultra Filtration (UF) for the removal of residual free and emulsified oil

The proposed treatment route will comprise the following:

- Corrugated Plate Interceptor (CPI) for the removal of suspended solids and free oil.
- Ultra filtration (UF) for the removal of emulsified oil and certain organics
- Nano filtration (NF) for the removal of the majority of heavy metals.
- Ion exchange to remove remaining traces of metal.
- Activated Carbon (GAC) for removal of trace residual hydrocarbons.

As discussed above a detailed description of the selected option is given in Section 2.

Five

Human Beings

5 Human Beings

5.1 Introduction

Tom Phillips & Associates have prepared this section of the EIS. The section discusses the key issues effecting human beings, and the potential impacts of the proposed terminal on them. The issues discussed include population, language and culture, employment and economic climate, tourism and health and safety.

5.2 Study Methodology

An integral part of the assessment on human beings involved quantitative, qualitative and documentary research. The quantitative research involved the examination and assessment of information supplied by the Central Statistics Office.

The Qualitative research was informed through public consultation and attendance at the oral hearing for a previous application for the proposed development. Allied to this, further qualitative information has gathered by Shell E&P Ireland Limited staff based in a community information office in Bangor. The County Enterprise Board and Udaras Na Gaeltachta were also consulted and provided some baseline information.

Government, local and County publications were consulted. These include the "Border, Midlands and Western Region Development Strategy 2000-2006" prepared for the regional authorities in 1999 and the "Mayo Sustainable Tourism in the Coastal Zone" published by An Taisce and Mayo County Council.

5.3 Receiving Environment

5.3.1 Population

While Ireland as a whole has recently experienced significant economic growth, this has not had as great an impact on the West of the country. Generally, County Mayo and the west of Ireland is characterised as a rural area with a weak urban base and poor infrastructure relative to the rest of the State. The area has suffered from continual economic decline stretching back to the early 1800's.

The 1991-1996 period was the first period of growth in County Mayo since the beginning of census records and halted a decline that has seen the population of the county fall to 111,524 in 1996 from almost 390,000 in 1841 and almost 200,000 in 1901. In more recent times, the population of County Mayo has increased by 0.7% between 1991 and 1996 and by 5.3% between 1996 and 2002. However, most of the rural areas, particularly in Mayo, are continuing to decline with the urban centres accounting for recent population growth.

As shown in Table 5.1 and Figure 5.1, the populations at National and county level decreased between 1986 and 1991, but subsequently increased between 1991 and 2002. Over the same period, the populations of the Belmullet Rural District and at a more local level, the DEDs of Knocknalower and Glenamoy, have continually declined between 1986 and 2002. This decrease is quite pronounced, which would tend to indicate that there is a migration from rural areas to urban centres in the county.

The number of residences living close the to the terminal is limited. Within 2 km of the centre of the site there are only 14 households. This population density would be typical for rural areas in the Erris region outside on the main settlements. As a consequence of existing and likely proposed planning policies restricting rural housing, it is not expected that this number will increase significantly in the medium to long term.

5.3.2 Age Profile

The age profile for the local area surrounding the proposed gas terminal at Bellanaboy Bridge has been determined from Small Area Population Statistics (SAPS) records provided by the Central Statistics Office. This analysis is carried out using the 1986, 1991, 1996 and 2002 SAPS. The proposed site is mainly located within the District Electoral Division of Glenamoy. However, given that the proposed site is located adjacent to the boundary of the Knocknalower DED, the figures presented below in relation to the local community include the 2 DEDs.

In 2002, the local population of the two DEDs represented 13.8% of the population of the greater Belmullet Rural District, and 0.9% of the population of County Mayo.

Table 5.2 shows the age profile of the State, County Mayo, Belmullet Rural District and the DEDs of Glenamoy and Knocknalower in 2002. According to Table 5.2, the local area surrounding the proposed gas terminal has a higher proportion of young people aged 0-15 years (23.2%) than the State (21.1%), county (21.5%) or wider rural district (22.1%). However, the local area has a lower proportion of 25-44 year olds (24.1%) than the State (30.1%) and county (26.4%), recorded in the 2002 Census. The proportion of over 65 year olds in the local area (18.1%) is notably higher than the State (11.1%), county (14.7%) and rural district (16.8%).

Table 5.1 Population Change 1986 – 2002 (Source: CSO)

Year ►	Population				% Population Change		
Area ▼	**1986**	**1991**	**1996**	**2002**	**1986-1991**	**1991-1996**	**1996-2002**
Ireland	3,540,643	3,525,719	3,626,087	3,917,203	-0.4	2.8	8.0
County Mayo	115,184	110,713	111,524	117,446	-3.9	0.7	5.3
Belmullet Rural District	9,160	8,467	8,339	7,927	-7.6	-1.5	-5.1
Knocknalower & Glenamoy	1,321	1,142	1,137	1,095	-13.6	-0.4	-3.7

(Source: Census of Population, 1986-1996)

Figure 5.1 Population Change 1986 – 2002 (Source: CSO)

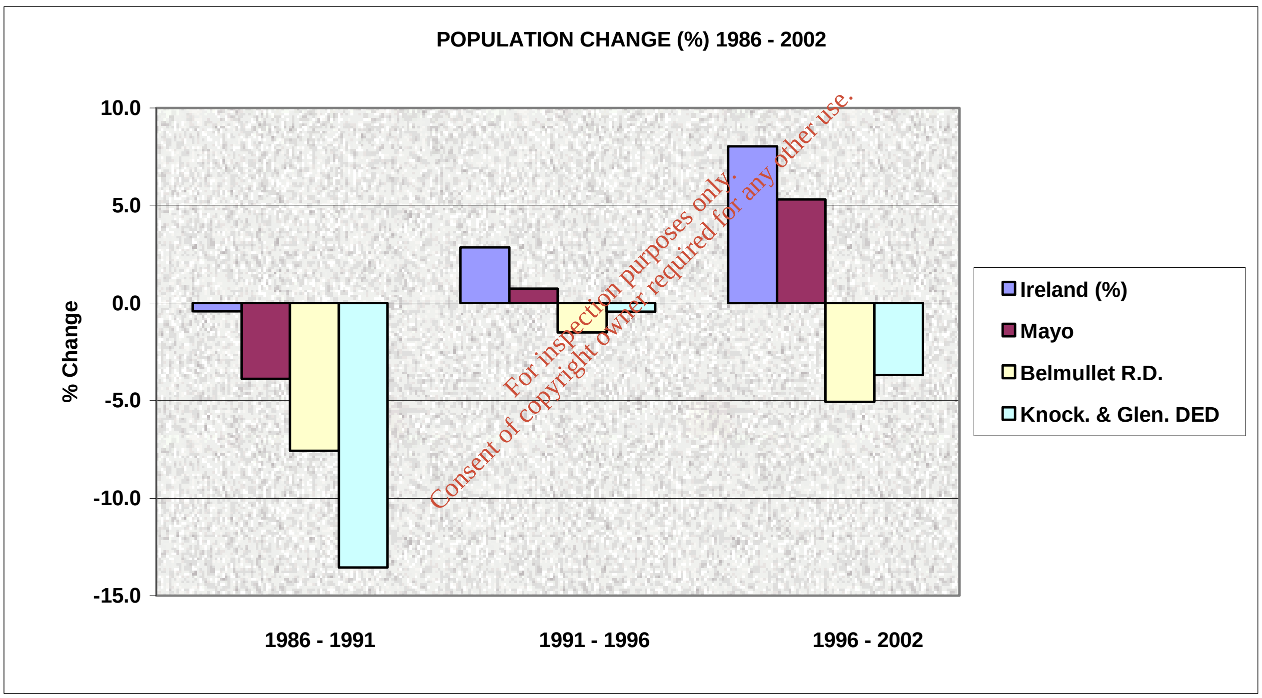


Table 5.2 Age Profile of the State, County Mayo, Belmullet Rural District & Glenamoy & Knocknalower DEDs, 2002 (%). (Source: CSO)

Area ► Age Groups ▼	State	County Mayo	Belmullet Rural District	Glenamoy & Knocknalower
Less than 15	21.1%	21.5%	22.1%	23.2%
15-24	16.4%	14.2%	14.2%	14.4%
25-44	30.1%	26.4%	23.4%	24.1%
45-64	21.3%	23.2%	23.5%	20.2%
65+	11.1%	14.7%	16.8%	18.1%
Total	100%	100%	100%	100%
Dependency Ratio	32.2%	36.2%	38.9%	41.3%

(Source: Census of Population, 2002)

The proportion of the population classified as "Dependent" relates to the age groups of 0-14 year olds and over 65 year olds. The dependency rate in Knocknalower and Glenamoy in 2002 was 41.3%, higher than the comparable rates for the wider rural district (38.9%), County Mayo (36.2%) and the State (32.2%).

Figure 5.2 shows the age profile of the local community in Knocknalower and Glenamoy, analysed over the last 3 intercensal periods. This graph indicates a high proportion of young people in the local area, with a peak of 136 no. 10-14 year olds in the 1996 Census. This peak has followed through from a corresponding peak in the 0-4 age cohort, recorded in the 1986 Census. However, the number of children in the 0-4 age cohort has halved from 135 to 67 over the same 10 year period, indicating a decreased birth rate in the area. The graph shows a sharp drop in population in the 15-19 year and 20-24 year age cohorts, suggesting a high migration rate at around school leaving age, as young people leave to attend third level education or to take up employment in urban areas. A combination of in-migration and people returning to the area has resulted in a noticeable peak in the 35-39 age cohort in the 1996 Census, with a subsequent peak in the 40-44 age cohort recorded in the 2002 Census. The remaining cohorts have been relatively constant over the four Census periods.

This trend fits with the findings of the Border, Midlands and Western Region Development Strategy 2000-2006 which notes that this region as a whole 'suffers from a major "braindrain"', with school leavers leaving the area to study in third level institutions and not returning.

Figure 5.3 shows the age profile of the wider community in the Belmullet Rural District, over the last three intercensal periods. The overall graph is quite similar to Figure 5.2, with a high proportion of young people in the area. A peak of 983 no. 10-14 year olds was recorded in the 1996 Census, following corresponding peaks in the first two age cohorts in 1986 and 1991. This pattern represents the logical progression of people from one age cohort to the next. The 15-19 year and 20-24 year age cohorts have recorded a constant population decline, again indicating a "braindrain" in the wider rural district. From the 1996 and 2002 Census, the population of 35-49 year olds appears to have increased, indicating a level of in-migration to the area.

5.3.3 Household Numbers & Size

Census of Population trends indicate that the average household size in Ireland experienced a gradual decline over time. Between 1986 and 2002, the national average household size fell from 3.53 to 2.94 persons per household. The Economic and Social Research Institute (ESRI) estimate that by the year 2011, the average household size will be in the region of 1.98 persons.

The average household size for the State in 2002 was 2.94 persons, with a slightly lower figure of 2.87 persons per household in County Mayo. As indicated in Table 5.3, the average household size in the Belmullet Rural District in 2002 was 2.99 persons per household, with 3.12 persons per household in the DEDs of Glenamoy and Knocknalower.

As shown in Table 5.3, the number of households in the DEDs of Glenamoy and Knocknalower has increased by 7% in the 2002 Census, following a constant decline over the period 1986 to 1996. The number of households in the Belmullet Rural District has increased by 6.5% over the period 1991 to 2002. In both instances, this is despite continued population decline.

5.3.4 Economic Performance

The most appropriate measure for gauging differences in the level of economic development across a Country or a Region is GVA (Gross Value Added). GVA is a measure of output per capita for an area, equivalent to GDP at market prices.

Table 5.4 below shows that per capita output for the West amounted to only 73% of the national average. County Mayo as well as Donegal, Leitrim and Roscommon are particularly weak in this regard.

The data on GVA per capita outlined in Table 5.4 are supported by the Composite Deprivation Score, (1996) for Ireland as a whole. This measure also shows that most of County Mayo is classified as "Most Disadvantaged".

Relative Deprivation

The Haase Index of Relative Affluence and Deprivation provides a single measurement of the overall Deprivation of the area. Based on the 1996 Census, the index takes into consideration the social class composition, the level of education, the level of unemployment and long-term unemployment, the proportion of lone parents, the extent of small farming and the age dependency rate. The index ranks each DED on a scale of 1 to 10. A rank factor score of 1 indicates that an area is amongst the most affluent 10% of areas, whilst a rank factor score of 10 indicates that an area is amongst the most disadvantaged 10%.

Figure 5.2 Age Profile of Knocknalower & Glenamoy (Source: CSO)

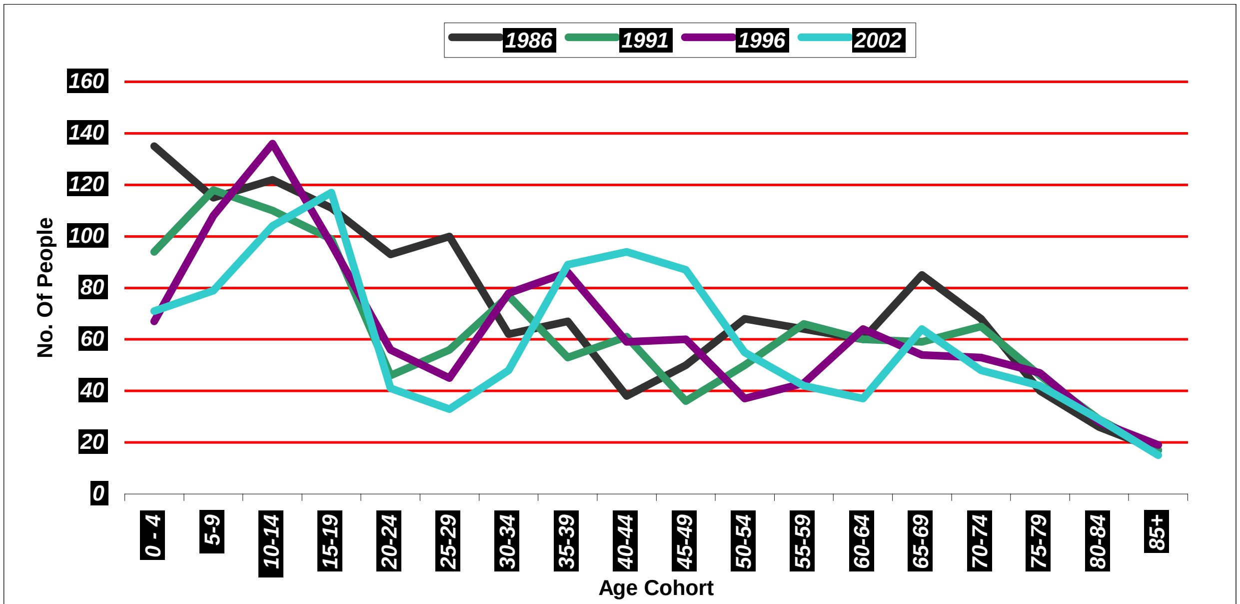


Figure 5.3 Age Profile of Belmullet Rural District (Source: CSO)

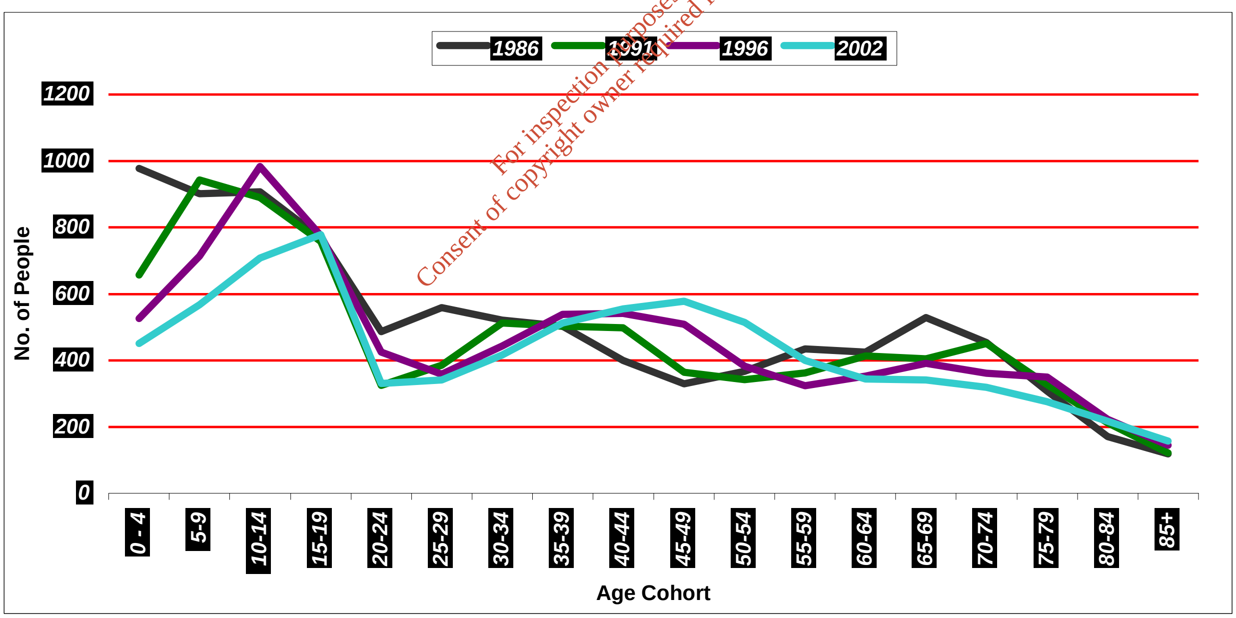


Table 5.3 Household Numbers & Size (Source: CSO)

	1986		1991		1996		2002	
Households	No.	Avg. Size (persons)	No.	Avg. Size (persons)	No.	Avg. Size (persons)	No.	Avg. Size (persons)
Glenamoy & Knocknalower	354	3.92	341	3.47	340	3.45	364	3.12
Belmullet Rural District	2419	3.74	2401	3.48	2476	3.33	2557	2.99

(Source: Small Area Population Statistics, 1986-2002)

Table 5.4 Indicative Estimates for GVA per Capita (Source: CSO)

County / Region	Total GVA per Capita £	Index State = 100	Index EU = 100
Mayo	6,800	67.3	61.9
Galway	8,100	80.2	73.7
Donegal	6,100	60.4	55.5
Sligo	7,700	76.2	70.1
Leitrim	5,200	51.5	47.3
Roscommon	5,600	54.4	50.1
Clare	9,600	95	87.4
Total "West"	7,348	72.7	66.9
Ireland	10,106	100	100

In 1991 and 1996, the deprivation score for both Knocknalower and Glenamoy was 10, while in the Belmullet Rural District, all 14 DEDs had a score of 10 in 1996. This leaves the entire Rural District in the top 10% most deprived areas in the country, well above the national mean of 4.6. In 1991, 2 of the 14 DEDs, Baroosky and Belmullet, had a deprivation score of 9. This indicates a slight increase in the level of deprivation in the area since 1991.

5.3.5 Employment

Poor employment growth is a feature of lagging economic development and there is a correlation between this measure and the state of the region's infrastructure, low labour force participation rates and higher rates of outward migration.

The level and growth in employment in the Western Counties (i.e. those west of the Shannon) is shown in Table 5.5 and gives a context within which to view the employment performance of County Mayo. Between 1991 and 1996, while the region experienced employment growth of 11.8%, the level of growth in Counties Mayo, Roscommon and Leitrim, in particular, was considerably below the national average of 13.8%. In the 1996 to 2002 period, employment growth across the country has dramatically increased, with the national average growth being 25.6%. The corresponding figures for the West Region and County Mayo are 22.8% and 22.4% respectively. This rate of employment growth in Mayo, while slightly below the regional average, is higher than the rates of growth in Counties Donegal, Sligo, Leitrim and Roscommon.

As mentioned in Section 5.3.2 The Border, Midland and Western Region Development Strategy 2000-2006 (BMW Report) prepared for the regional authorities in 1999, states that the overall Region suffers from a "braindrain". In this case, participation in third level education is relatively high and young people generally leave the region to study and do not return. Nationally, in 1999, only 13% of all new graduates finding employment in Ireland did so in the Border Midland and Western region.

In addition, the BMW Report notes that the Region's economy is still more reliant on agriculture than is the national economy, and that this agriculture is relatively weak. The Region's industry is more traditional in nature than that of Ireland as a whole, particularly outside the larger urban centres.

The BMW Report notes that there is a good availability of human resources in the Region, but that this availability is being reduced by declining unemployment. The Region has not yet experienced labour shortages as pronounced as those in the Eastern and Southern Regions, nevertheless, it does have difficulties in relation to highly skilled personnel in many instances.

The Region as a whole scores relatively lowly in terms of research, technology and innovation in comparison to other areas of the country. The number of high R & D performing companies is limited and is heavily concentrated in a few specific locations.

The employment trends in the local area are slightly more difficult to gauge. However, an examination has been carried out of the recent Live Register figures for the Belmullet area, which is representative of the population in the vicinity of the proposed terminal. These figures show a decrease in the number of persons claiming unemployment benefit over the eight year period 1996 to 2003 (See Table 5.6).

While this trend would seem to reflect the current economic situation of the country as a whole, as referenced in the BMW report, the decrease in unemployment will affect the availability of labour in the local area.

Table 5.5 Employment Growth in the West (Source: CSO)

County/Region	1991	1996	2002	% Change 1991-1996	% Change 1996 - 2002
Mayo	33,664	36,583	44,764	8.7	22.4
Galway	58,816	67,497	85,210	14.8	26.2
Donegal	35,134	39,811	48,379	13.3	21.5
Sligo	17,992	20,204	23,927	12.3	18.4
Leitrim	8,012	8,518	9,990	6.3	17.3
Roscommon	17,493	18,559	21,270	6.1	14.6
Clare	30,735	34,572	43,679	12.5	26.3
Total "West"	201,846	225,744	277,219	11.8	22.8
Ireland	1,149,080	1,307,236	1,641,587	13.8	25.6
Leinster	620,666	715,137	916,027	15.2	28.1

Table 5.6: Average Number of Persons on the Live Register in Belmullet (Source: CSO)

Year	1996	1997	1998	1999	2000	2001	2002	2003 (To Sept)
Average No. of Persons	1244	1234	1103	1036	935	822	778	708

Table 5.7: Persons aged 15 years and over in the State, County Mayo, Belmullet Rural District, Glenamoy and Knocknalower DEDs, classified by principal economic status, 2002 (Source: CSO)

Area ► Principal Economic Status ▼	State	County Mayo	Belmullet Rural District	Glenamoy & Knocknalower
At work	53.1%	48.6%	33.9%	24.7%
1st Job Seeker	0.7%	0.8%	1.8%	3.1%
Unemployed	4.5%	5.0%	9.8%	12.0%
Student	11.4%	10.8%	12.0%	13.2%
Home Duties	14.2%	15.3%	19.7%	23.9%
Retired	10.8%	13.0%	12.5%	12.0%
Unable to Work	4.2%	5.4%	8.8%	9.9%
Other	1.1%	1.1%	1.5%	1.2%
Total	100%	100%	100%	100%

(Source: Census of Population, 2002)

Table 5.8: Employment Status of Those Aged 15 Years and Over , Knocknalower & Glenamoy (Source: CSO)

Employment Status	1986		1991		1996		2002	
	No. of Persons	%	No. of Persons	%	No. of Persons	%	No. of Persons	%
At work	238	25.1	237	28.9	237	28.7	208	24.7
1st Job Seeker	57	6.0	32	3.9	38	4.6	26	3.1
Unemployed	163	17.2	94	11.5	108	13.1	101	12.0
Student	60	6.3	55	6.7	83	10.0	111	13.2
Home Duties	251	26.4	234	28.5	231	28.0	201	23.9
Retired	131	13.8	120	14.6	93	11.3	101	12.0
Unable to Work	49	5.2	48	5.9	36	4.4	83	9.9
Other	0	0.0	0	0.0	0	0.0	10	1.2
Total	949	100.0	820	100.0	826	100.0	841	100

(Source: Census of Population, 1986 - 2002)

Employment Status

The principal economic status of persons aged 15 years and over, recorded at national, county, rural district and local levels in 2002, are given in Table 5.7. The local DEDs have a population of people "at work" (24.7%) of less than half the State level (53.1%), and notably lower than the populations "at work" in County Mayo (48.6%) and in the Belmullet Rural District (33.9%). The proportion of unemployed people is notably higher at the local level (12%), than the comparable proportions at State (4.5%), county (5%) or rural district level (9.8%). It is interesting to note that the local DEDs have a higher proportion of students (13.2%), than the State (11.4%), county (10.8%) and rural district (12.0%).

The labour force in the area adjacent to the proposed terminal can be gauged from the employment status of persons aged 15 and over in the local DEDs of Knocknalower and Glenamoy. Table 5.8 presents these figures for the 1986, 1991, 1996 and 2002 Census, with Figure 5.4 showing the employment status of the local community graphically.

As can be seen from the Table 5.8 and Figure 5.4, in 1986, 1991, 1996 and 2002, the two most common categories were people in employment and people engaged in home duties. The level of employment was virtually constant at approximately 28% from 1986 to 1996, but dropped to 24.7% in 2002. Unemployment dropped from 17.2% in 1986 to 11.5% in 1991, before rising slightly to 13.1% in 1996, and falling again to 12% in 2002. However, in the recently published Principal Socio-Economic results from the 2002 Census, the DED of Knocknalower is listed as one of five unemployment blackspots in County Mayo, having an unemployment rate of 40.1% in April 2002.

In the most recent Census, only 3.1% of the population were first time job seekers, while 13.2% were students. The proportion of the local population engaged in home duties has constantly declined from 1986 (26.4%) to 2002 (23.9%).

As shown in Figure 5.5, in the wider Belmullet Rural District, the employment status of persons aged 15 years and over is quite similar to that of the local DEDs. The most frequent categories are people in employment and people engaged in home duties. Unemployment levels in 2002 were 9.8%, slightly lower than the 12% unemployment rate at the local level.

Employment by Industry

The number of persons aged 15 and over, categorised by the industry in which they work in the local DED's of Knocknalower and Glenamoy, in 1986, 1991, 1996 and 2002 is outlined in Table 5.9. From this data, it is obvious that the number of persons engaged in agriculture has dramatically declined over the last Census period from 50.2% in 1996 to 18.3% in 2002. This represents a decrease of 31.9% in the proportion working in the agricultural sector. From 1986 to 1996, the manufacturing industry represented the second largest employment sector, although the proportion of local people employed in this area was in decline from 27% in 1986 to 22% in 1996. However, in 2002, only 14% of the local population were engaged in the manufacturing industry. The trends at local level have seen employment in the building and construction sector increase from 5% to 21% between 1996 and 2002. Commerce is the third largest sector, employing approximately 17.8% of the population in 2002.

Table 5.10 below shows the number of persons aged 15 and over, categorised by industry, in the wider Belmullet Rural District. This data also shows an obvious decrease in the proportion of people employed in the agricultural sector, falling from 44.4% in 1991 to 19.9% in 2002. The commercial sector is now the second largest employer, with 16.6% of the population engaged in commercial activities in 2002. The proportion employed in professional services has increased steadily from 10% in 1986 to 16.4% in 2002. Similar to the situation at the local level, the reliance on the manufacturing industry has dropped from 19.5% in 1991 to 12% in 2002.

Employment in the services and commercial sectors is mainly in and around Belmullet, the main service centre for the area. Among the most important public service activities in the town are primary and secondary schools, a district hospital, a welfare home for the elderly, a public health clinic, a library, a Garda station and industrial training and promotion agencies.

Figure 5.4 Employment Status of Those Aged 15 Years and Over, Knocknalower & Glenamoy (Source: CSO)

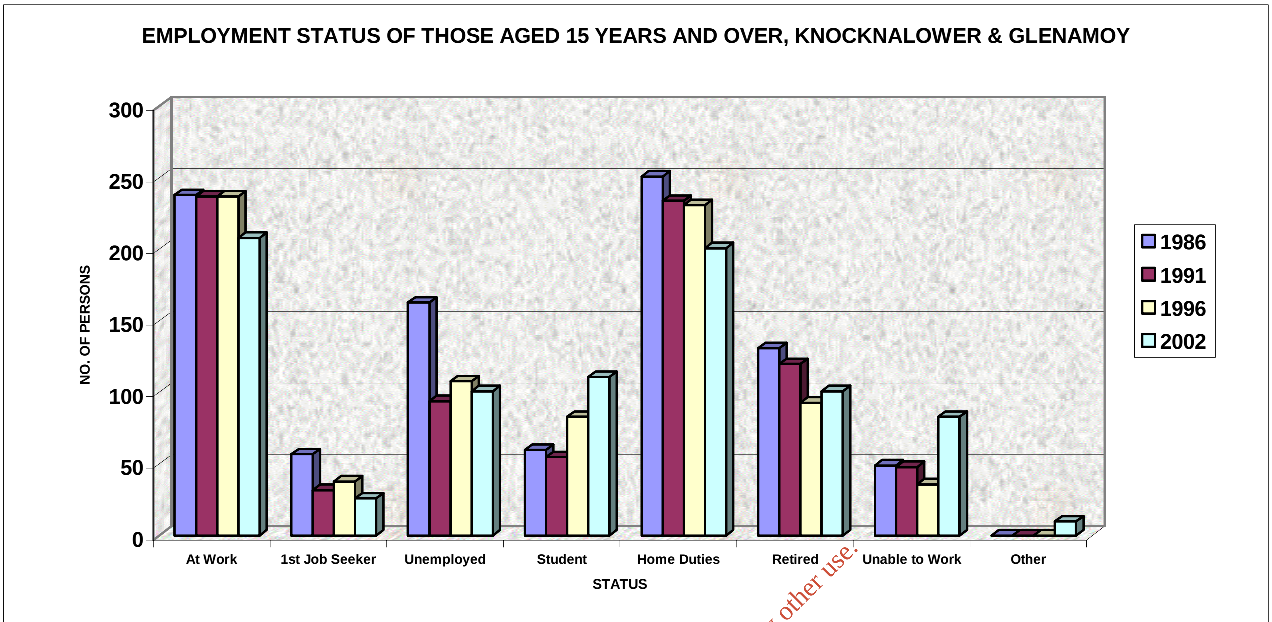


Figure 5.5 Employment Status of Those Aged 15 Years and Over, Belmullet Rural District (Source: CSO)

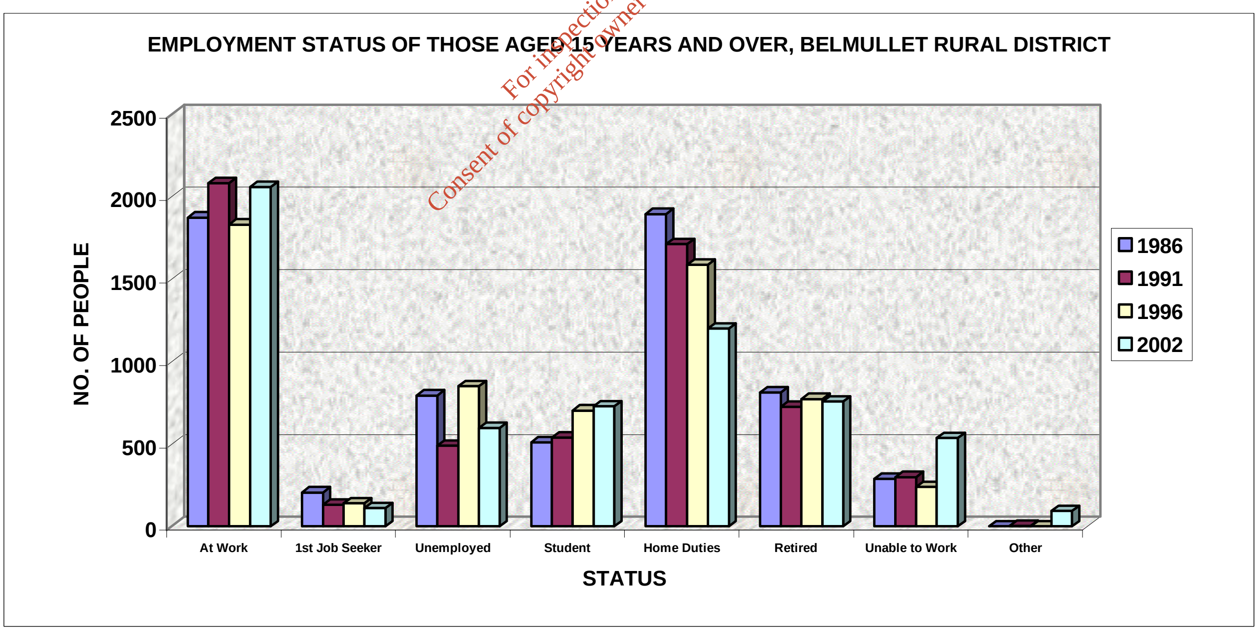


Table 5.9 Persons Aged 15 and Over, Categorised by Industry in Which they Work, Knocknalower & Glenamoy (Source: CSO)

At Work by Industry	1986		1991		1996		2002	
	No. of Persons	%	No. of Persons	%	No. of Persons	%	No. of Persons	%
Agriculture	119	50.0	118	49.8	119	50.2	38	18.3
Building and Construction	11	4.6	9	3.8	12	5.1	44	21.2
Manufacturing Industry	65	27.3	71	29.9	54	22.7	29	14.0
Commerce	19	8.0	15	6.3	22	9.3	37	17.8
Transport	9	3.8	5	2.1	4	1.7	11	5.3
Public Administration	4	1.7	3	1.3	4	1.7	8	3.8
Professional Services	7	2.9	9	3.8	16	6.8	21	10.1
Other	4	1.7	7	3.0	6	2.5	20	9.5
Total	238	100.0	237	100.0	237	100	208	100

Table 5.10 Persons Aged 15 and Over, Categorised by Industry in Which they Work, Belmullet Rural District (Source: CSO)

At Work by Industry	1986		1991		1996		2002	
	No. of Persons	%	No. of Persons	%	No. of Persons	%	No. of Persons	%
Agriculture	808	43.1	919	44.4	594	32.5	409	19.9
Building and Construction	97	5.2	99	4.8	104	5.7	297	14.4
Manufacturing Industry	363	19.4	404	19.5	343	18.7	247	12.0
Commerce	210	11.2	227	11.0	252	13.8	341	16.6
Transport	67	3.6	62	3.0	70	3.8	90	4.4
Public Administration	57	3.0	59	2.8	77	4.2	103	5.0
Professional Services	189	10.1	215	10.4	271	14.8	338	16.4
Other	82	4.4	86	4.2	119	6.5	232	11.3
Total	1873	100.0	2071	100.0	1830	100.0	2057	100

Employment by Occupation

Considering the occupation of people aged 15 and over in the local area, the majority of the working population in 2002 were labourers and unskilled workers (23.3%). This proportion has increased steadily from 8% in 1986. The proportion of farmers in the local area has halved from 33% in 1996 to 16.5% in 2002. From Figure 5.6, the drop in the number of producers/manufacturers in the area over the last three intercensal periods has been remarkable, from approximately 35% in 1986 to 12.6% in 2002.

The comparable situation in the Belmullet Rural District (Figure 5.7) shows the majority of persons aged 15 and over in 2002 are also classified as labourers and unskilled workers (16.9%), although this level is somewhat lower than that of the local DED level of 23.3%. The second most frequent occupation are farmers, although this proportion has also dramatically declined from 32.1% in 1991 to 16.3% in 2002. The commercial sector is the third largest occupation, engaging 14% of the population. Producers/manufacturers in the Belmullet area have declined constantly from 21.3% in 1986 to 11.4% in 2002

Agriculture, Forestry and Fishing

Low intensity sheep and livestock faming typify agricultural activity in the area immediately surrounding the proposed development. There is also a limited amount of silage production, dairy faming and organic farming.

The Forestry in the Bellanaboy area is primarily controlled by Coilte however there are pockets of private plantations. The majority of the plantations are coniferous.

Figure 5.6 Persons Aged 15 and Over, Categorised by Occupation, Knocknalower & Glenamoy (Source, CSO)

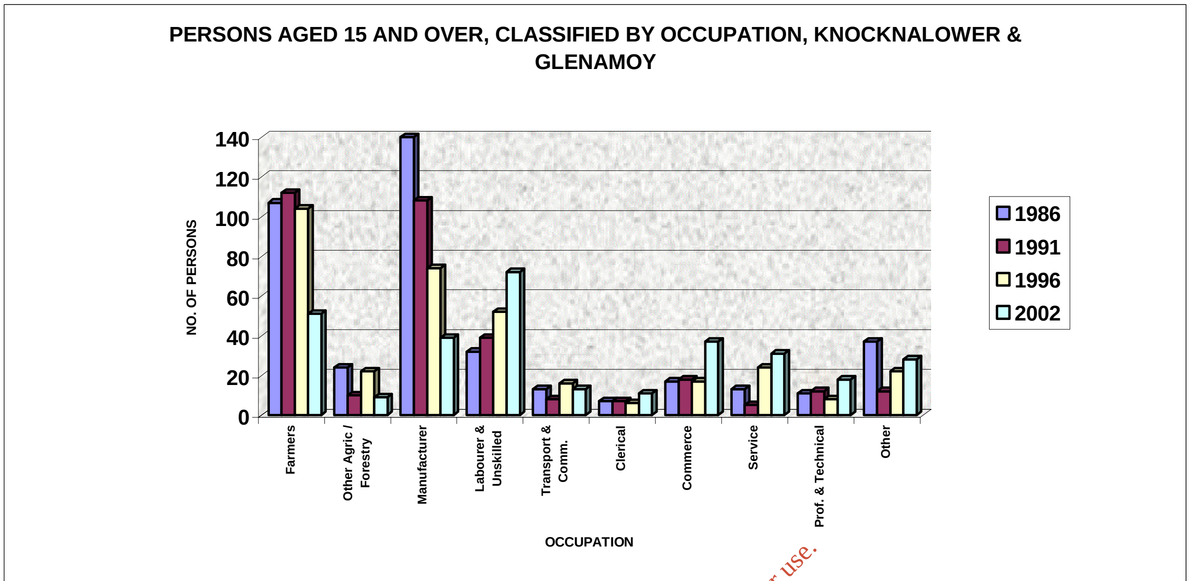
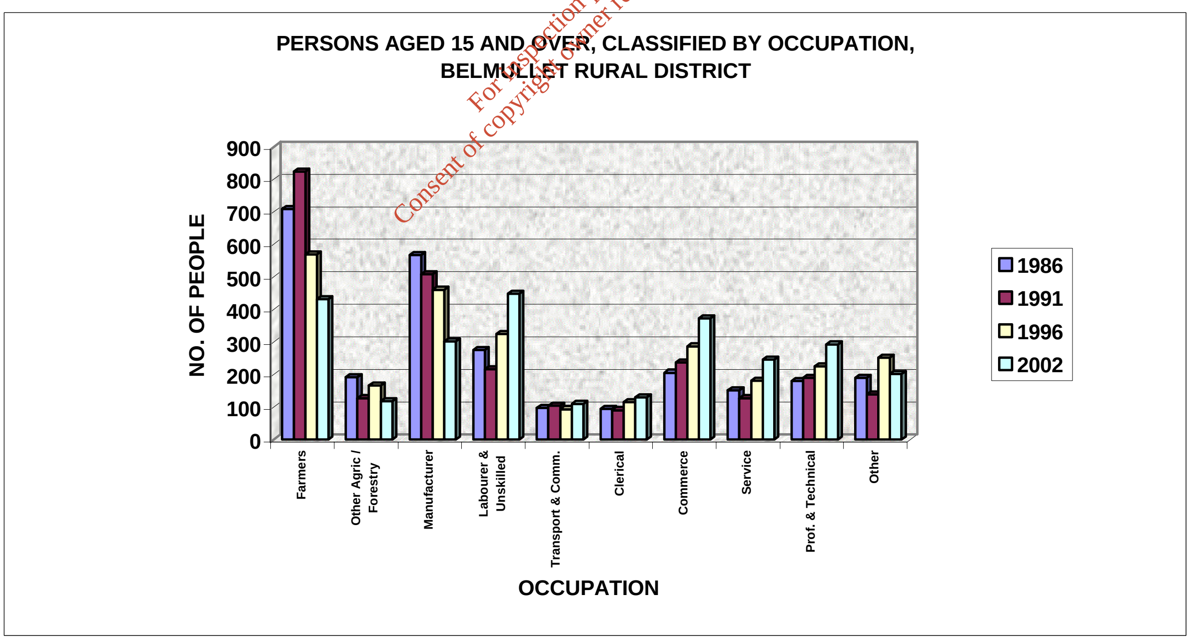


Figure 5.7 Persons Aged 15 and Over, Categorised by Occupation, Belmullet Rural District (Source: CSO)



There are five main fishing ports on the coastline closest to the proposed development these area at Portulin, Ballyglass, Rinnroe, French Port and tidally at Belmullet. These ports are used as bases for fishing trawlers and smaller fishing boats. There is also a crab factory at Portulin as well as an oyster farm in Sruwaddacon Bay. There is also an natural oyster fishery in Blacksod Bay.

Social Class Structure

Social class, as defined by the Central Statistics Office is based on an ordinal scale, with '1' being the highest social class. As shown in Table 5.11, proportionally, social classes 5 and 6 (semi-skilled and unskilled workers) are well represented in the local area, with almost 37% of the population aged 15 and over classified in these two social groups. This figure is more than double the proportion of people in social classes 5 and 6 at national level (16.5%). Social class 7, 'others gainfully employed', comprises 26.2% of the local population, in comparison to only 18.2% of the State, 17.7% of the county and 19.9% of the Belmullet area populations.

Overall, professional, managerial and technical workers (social classes 1 and 2) are not well represented in Glenamoy and Knocknalower, with only 11.4% of the population aged 15 and over falling into these categories, as opposed to 31.6% at national level, 26.7% in County Mayo and 17.6% in the Belmullet area.

5.3.6 Education

The Barony of Erris comprises the Belmullet Rural District, and the DEDs of Ballycroy North and South. There are 19 primary and three post-primary schools in the Erris area. Many of the primary schools are very small, with several having an enrolment of less than 30 pupils. The nearest primary schools to the proposed terminal are located at Pollatomish, Glenamoy, Rossport, Inver and Carrowteige. Two of the post-primary schools are located in Belmullet and the third is in Rossport. Post-primary students in the southern part of Erris go to secondary schools in Achill. The nearest form of third level education is the Galway Mayo Institute of Technology (GMIT), located in Castlebar.

According to the Census, persons aged 15 years and over whose full-time education has ceased are classified by the highest level of education completed. A strong link exists between educational attainment and earnings capacity. Thus the level of educational disadvantage in an area may be an indication of or a controlling factor to social and economic deprivation.

In 2002, 53.4% of people aged 15 years and over had no formal education or primary education only in the DEDs of Glenamoy and Knocknalower, in comparison to 44.8% of the population in the Belmullet area, 24.6% of County Mayo and 18% of the State. Only 5% of the local area population had received third level education in 2002. This figure is notably lower than the national level of 21%, the county level of 16% and the Belmullet area (10%). In the local area, almost 53% of the population aged 15 years and over ceased their education at or before the age of 15 years. This level is more than double the comparable rate at national level (17.6%), and at county level (22.6%).

5.3.7 Tourism

County Mayo

County Mayo is a largely rural area with rich scenic resources and a distinctive culture. The economy is heavily dependent on agriculture and fishing. Large proportions of County Mayo are designated as proposed National Heritage Areas (NHAs) and Special Areas of Conservation (SACs). In addition, the area is rich in cultural resources through language, history, literature, archaeology and vernacular building traditions. Visitors are attracted to the region for its tranquillity, unspoilt landscape and traditional community structure. Tourism has become an engine for growth in the county in recent times.

County Mayo is also well known for its museums and visitor attractions and has an abundance of festivals throughout the year, mostly during the summer months. Summer schools to learn or improve Irish language skills and schools to study English are hosted throughout the county. In this regard, a major element of the tourism industry in the Gaeltacht areas relates to Irish language schools for school children, students and others.

In recent years, tourism has become an important part of the local economy of west and northwest Mayo, but there is still potential to develop this resource further. However, the rapid growth of tourism (6 million tourists visited Ireland in 1999, projected to 8 million in 2005) and its impact on vulnerable environments has brought about concern. In order to address these concerns, County Mayo aims to promote sustainable tourism to:

- support the social and economic prosperity of the resident communities; and
- protect their cultural and natural environments.

A new co-ordinating tourism marketing company, Margaíocht Turasóireacht Iar Thuaisceart Mhaigh Eo, is currently being formed in north-west Mayo to implement the above policies.

Table 5.11 Percentage Distribution by Social Class, 2002 (Source: CSO)

Categories ► / Area ▼	1 and 2	3 and 4	5 and 6	7	Total
State	31.6%	33.7%	16.5%	18.2%	100%
County Mayo	26.7%	35.4%	20.2%	17.7%	100%
Belmullet Rural District	17.6%	30.2%	32.3%	19.9%	100%
Glenamoy & Knocknalower	11.4%	25.9%	36.5%	26.2%	100%

(Source: Census of Population, 2002)

Social Class Categories:

Social Class 1: Professional Workers
Social Class 2: Managerial & Technical
Social Class 3: Non-Manual
Social Class 4: Skilled Manual
Social Class 5: Semi-Skilled
Social Class 6: Unskilled
Social Class 7: Others gainfully employed

Table 5.12 Educational Attainment, 2002 (Source: CSO)

	Population (%)					
Area	Primary Education Only	Lower Secondary Education	Upper Secondary Education	3rd Level Education	Age Education Ceased (< or= 15)	Age Education Ceased (> or =15)
State	17.9	18.3	23.4	20.9	17.6	54.6
County	24.6	18.7	23.8	15.9	22.6	53.3
Belmullet Rural District	44.8	24.0	15.4	9.9	44.5	51.1
Glenamoy & Knocknalower	53.4	24.9	11.8	4.9	52.5	42.6

Tourist Survey of County Mayo

Mayo County Council published a tourism brochure entitled "Mayo – Sustainable Tourism in the Coastal Zone, published by An Taisce and Mayo County Council, 2000". Within this publication, a visitor survey was carried out during July, August and September of 1999 to determine the profile of current visitors to Mayo. During the survey, some five hundred and eighty three interviews were carried out across the following locations in Mayo: Achill; Mulranny; Erris; Westport and the Ceide Fields Visitor Centre.

It was found that the most popular type of accommodation in the region is bed and breakfast, followed by rented self-catering accommodation, hotels, and caravan and camping.

New accommodation is being developed at the moment with a hotel proposed for Mulranny and another due to be constructed near Carne. However, in other areas like Erris, the range of accommodation and other facilities are less developed.

Of the people surveyed, walking was the most popular leisure activity, followed closely by water-based activities, general sight seeing and relaxing. Fishing was also popular with those visitors staying in Westport and Erris.

A high proportion of visitors who come to Mayo have family connections in the nearby area, with 25% of the total sample from the An Taisce/Mayo County Council survey having family connections with Mayo.

Of the people surveyed, the largest single percentage of overseas visitors came from the UK, with Germany the second highest. The majority of these people were on their main holiday with 58% staying a week or longer.

Fifty-four per cent of visitors obtained information about Mayo from friends and relatives; 16% from guidebooks; and only 8% from a tourism office or Bórd Fáilte.

The most popular reasons for visiting Mayo were quoted as being for the scenery including its wild and unspoiled nature, the beaches and the quiet, uncrowded and non commercial character of the area.

Negative aspects of the holiday were quoted as being too much development (especially in Achill), a general lack of facilities (particularly no indoor leisure facilities to cater for wet weather conditions) and a need for improved roads and signage.

The Barony of Erris

The site of the proposed terminal is located in the Barony of Erris, with Broadhaven Bay to the north and the Atlantic to the west. Parts of Erris are classified as Gaeltacht, where Irish is the primary language. The Barony of Erris stretches from the village of Belderg and the Céide Fields in the North East to the villages of Ballycroy and Castlehill in the South, and includes Blacksod Bay, The Mullet Peninsula and Broadhaven Bay.

The Céide Fields, situated on the R314 coastal road from Ballina, 8km west of Ballycastle, is the site of a 5,000-year-old Neolithic farm site discovered beneath the blanket bog. These fields are the oldest known field systems in the world. The Céide Fields visitor centre explains the stone-age landscape of the North Mayo coast.

Another feature of the landscape is the North Mayo Sculpture Trail (Tir Saile), which begins in Ballina, and follows the coastal route through Killala, Ballycastle, Belderg, Belmullet and down to Blacksod. This unique trail of 15 site-specific sculptures encompasses miles of rugged coastline. Seven of these sculptures are to be found in the Barony of Erris.

Carrowmore Lake is the largest lake in Erris, covering an area of approximately 8km^2. It is home to a variety of birdlife, especially during winter months when Teal, Mallard, Chelduck, Widgeon and Brent goose are among the species to be spotted.

Tourism in the Area Local to the Proposed Terminal

The area immediately adjacent to the proposed terminal site has a limited number of tourist attractions. The R314 is a route used by tourists travelling from Ballina, to visit the Céide Fields and beyond into the Mullet Peninsula. Tourist activity in this area mainly focuses on, hill walking, fishing, horse riding and the North Mayo Sculpture Trail. The main centres for tourism nearest the site are Glenamoy, Bangor, Pollatomish, Rossport, Belderg, Belmullet, Glencad and Inbher.

Fly-fishing and spinning are the main attractions of the Bellanaboy local area. Salmon and sea trout may be caught here between early February and late September. There are three small rivers in the vicinity: Muingnabo, Bellanaboy and Glencullin. The Muingnabo is 14.5km long and flows into the Glenamoy Estuary 3km west of Glenamoy village. The Bellanaboy river flows into Carrowmore Lake from the north and has the best fishing opportunity at its last bridge closest to the lake. The Glencullin River flows west into the Carrowmore Lake.

One of the sculptures on the North Mayo Sculpture Trail is located on the Glenamoy/Belmullet Road at Bellanaboy Bridge. More precisely, it is on the west side of the road to Bangor. The sculpture was carved by Niall O'Neill from a mixture of sandstone and granite. It is called "Stratified Sheep" and aims to reflect the land structure and express the rural culture which formed it over millennia.

Plate 5.1 Stratified Sheep Sculpture

The local tourism group, Iorras Domhnann Rural Tourism Co-Op. Ltd., has developed a series of walks 'Siuloidi Iorrais' in the Barony of Erris. There are a variety of recommended walks to suit all age groups and abilities, ranging in distance from 3 to 21km, and graded from easy to moderate. All are circular walks with the exception of the Belderg to Glenamoy walk, which is linear. Each of the walks are way-marked using yellow arrows on naturally occurring features such as boulders etc. The self-guided walks closest to Bellanaboy Bridge include routes in Carrowteige and Rossport, as well as the Glencullen Loop.

The village of Pollatomish is located approximately 4.5km north west of Bellanaboy Bridge. There are 3 youth hostels in Pollatomish, each accommodating travellers interested in diving, watersports, hill walking, sea angling, salmon and trout fishing and Irish-speaking classes.

Tourist Accommodation

Shell has funded the development of a local tourist accommodation database. The database was developed by Atlantek Computers in Rossport for Iorrais Domhnan, a local tourism Co-op. The database shows that there are a total of 567 tourist accommodation beds within 40 Km of the proposed terminal site. Of these beds, 181 are within 10km, 304 are within 20 Km and 427 are within 30 Km.

Recreation and Sport

A large variety of recreation and sporting activities are available in the wider area surrounding the terminal site. There are Gaelic Athletics Association (GAA) Clubs in Glenamoy, Rossport, Bangor, Belmullet and Drum. Bangor also has a soccer club. Other past time and sports which are actively pursued in the area include:

- swimming;
- watersports;
- golf;
- cycling;
- hill walking;
- fishing;
- snooker;
- darts;
- tug-o-war;
- bingo; and
- drama and musical groups.

5.3.8 Language and Culture

The proposed site and surrounding area is located in a Gaeltacht area. The term "Gaeltacht" describes those areas where the Irish language is the primary language. Údarás Na Gaeltachta is the Regional Development Agency in Ireland with responsibility for the economic, social and cultural development of the Gaeltacht regions, ensuring the continuation of the Irish language as the spoken language of the community in these regions.

The Irish language is one of the oldest written languages in Europe and has a strong and rich literary tradition. The oral tradition has played a major role in the survival of Irish as a living language.

The Gaeltacht areas were established to encourage an unbroken link with a past that saw Irish as the main language in Ireland. They are seen as a vital lynch-pin for the transmission of Irish as a community language to the next generation.

5.4 Description Of The Proposed Development

5.4.1 Introduction

The proposed terminal at Bellanaboy Bridge is for a gas reception and treatment facility. It will be owned and operated by Shell and their partners. A combination of gas and liquid will be treated at the terminal to provide the required quality of gas to meet the Bord Gáis Éireann transmission system specification and for onward transportation. The Corrib gas field will be controlled, operated and managed from the terminal site at Bellanaboy Bridge.

5.4.2 Recruitment Philosophy of Shell Relating to the Proposed Gas Terminal

Shell will ensure that all recruitment is undertaken within the relevant legislative framework and the selection procedure used by the Company aims to result in the appointment of candidates with the appropriate qualifications and experience. The selection process will be based on the job description and the objective requirements of the job with reference to the Company's Equality Policy and the Policy on the Employment of People with Disabilities.

5.4.3 Manning Philosophy of The New Plant.

The proposed terminal will be a 24 hour manned operation utilising a four shift system. It is envisaged that most of the terminal operation including maintenance, service activities and administration will be carried out during the day shift period and that night shift work will primarily be of a process supervisory nature with some additional minor maintenance tasks being undertaken.

It is currently estimated that the total terminal staff will be in the region of 50 people. This will comprise terminal management, administration, operations and maintenance staffs.

5.4.4 Strategy for Implementing the Manning Philosophy

Initial recruitment will take place during the construction of the terminal to allow operations/maintenance staff to be trained up in time for them to be integrated into the commissioning and start-up teams.

This process will open up job opportunities to candidates who do not have prior hydrocarbon production experience, thereby providing greater opportunities for local candidates to apply for employment.

While previous hydrocarbon processing experience is advantageous, it is not essential, as full training will be given for the production operations posts. A number of experienced hydrocarbon operatives will be needed during the detailed design and start-up phase. They will assist in the selection of trainee personnel and facilitate knowledge exchange

Operations Department

The Operations Team will be responsible for the safe and efficient operation of all terminal process facilities, safety systems and utilities. A production shift supervisor will be responsible for the control and management of terminal and sub-sea control systems, being assisted in this task by a team of production operators.

Maintenance Department

In the maintenance department, the maintenance team will be responsible for ensuring that work programmes and plans are effected safely, and efficiently, to provide system reliability and equipment integrity. The team will comprise of a supervisor supported by a team of technicians covering mechanical, electrical and instrumentation/ control functions.

Support Services

There will be personnel providing support services in the areas of administration and health, safety and environment. Services will also be sub-contracted. In areas such as security, ground maintenance, landscaping, engineering modifications and catering etc.

For operational and safety reasons, it is important that terminal staff reside within close proximity to the plant. This will provide a positive contribution to the local community, and should help to ensure that the development provides a socio-economic benefit to the local area.

Training and Career Development

A Training Strategy document will be created to ensure that all staff have individual comprehensive training plans which includes major emphasis on safety and environmental issues thus contributing to the safe and efficient operation of the terminal and sub-sea facilities. This will also ensure that staff are assessed to be capable of performing their given function by satisfying training objectives and demonstrating their competence in the workplace.

Part of this strategy will also be to provide ongoing training, following commencement of operations, to ensure that safety awareness and competence are maintained, while at the same time broadening the knowledge and enhancing the capabilities of personnel.

5.4.5 Health and Safety

Under the Seveso II Directive, the Operator has a general duty to take all measures necessary to prevent major accidents and limit their consequences to persons and the environment. On the basis of the levels of inventory of hazardous substances in the plant, it has been designated a lower-tier site which requires the operator to prepare a Major Accident Prevention Policy document (MAPP). The MAPP will be made available to the Competent Authority, the Health and Safety Authority, when required. The MAPP document sets out the manner in which major accidents are to be prevented. The status of the Seveso II Directive is discussed in section 2.

5.4.6 Environmental Emissions

The environmental emissions from the proposed development which have the potential to negatively impact on humans include air, noise, water, visual impact, traffic and light emissions. The nature and extent of the environmental emission during construction and operation are discussed in detail in the relevant chapters of this EIS.

5.5 Impacts Of The Proposed Development

5.5.1 During Construction Impacts

Population, Language and Culture

The construction of the proposed terminal will impact on the local population, language and culture by the influx of new personnel. The population of the immediate area will increase, although workers will also commute from areas further away from the proposed site.

As well as employment opportunities during construction for the local community, there is also likely to be an inward migration of people who may not be familiar with the Irish language and the culture of the area. However, it is not expected that this will have a significant impact on the local culture and language. It should also be noted that any impact will be temporary in nature given the duration of the construction process.

Architectural Heritage

With reference to the Mayo County Development Plan, there are no protected structures that will be affected by the construction of the terminal site. There will be no effect on the architectural heritage of the area from the construction of the terminal plant site.

Employment and Economic Impacts

The net impact of the proposed terminal is expected to be positive in terms of increased income, especially in the out-of-season tourism months.
The construction of the proposed terminal will be a significant undertaking and will involve a workforce

of approximately 500 people over the course of the construction period (approximately 2 years). While some of these workers may be brought in from outside the area, local direct and indirect employment will be created through the hiring of local workers and the use of local sub-contractors.

During the construction period there will be a positive impact on the local economy with enhanced opportunities for local service providers. These will include increased trade in local shops, pubs, restaurants, and service providers. Local villages and towns and their rural hinterlands likely to be affected include Bellanaboy, Glengad, Inver, Barnatra, Bunahowen, Gweesala, Doohoma, Glenamoy, Pollatomish, Rossport, Belmullet, Bangor, and Ballycastle.

Construction site workers coming from outside the area will use local accommodation. As noted previously in Section 5.3.6, there are 567 tourist accommodation beds available within a 40 km radius of the proposed development. With a peak number of construction workers of approximately 400 this quantity may be absorbed without difficulty into the current accommodation stock. It should be noted that the Coca Cola plant at Ballina had over 1000 employees at peak construction without serious impacts on the local accommodation stock. The effect of the influx of workers will be positive, as it will help to level the annual seasonal peaks and troughs in the tourism sector and increase the level of disposable income spent in the area.

It is expected that local retailers and service providers will benefit significantly from during the construction period. To date the spend on local goods and services as a result of the Corrib project is estimated to in the region of €1,000,000. This figure is expected to be significantly increased if the project proceeds.

Some works have already been carried out to the landfall for the pipeline at Dooncarton. Based on research undertaken by Shell into the personal expenditure by construction worker in the local community, it is estimated that approximately €200,000 will be spent every 6 months per 50 construction workers employed. In this regard, there is likely to be a significant benefit accruing to local retailers as a result of the construction of the Corrib project.

Agriculture Forestry and Fishing

Any significant impacts on agriculture, forestry or fishing during the construction stage will be mitigated against through the measures proposed in the other sections of this EIS. In this regard, it is not expected that there would be any negative impact on agriculture, forestry or fishing during construction.

Tourism

A number of tourism centres have been identified in the county. However, most major attractions are sufficiently remote from the terminal site for their associated visitors to be unaffected by the terminal construction. During the construction period, visitors to the local area who have to pass by the terminal site will notice site activity. There will be some disturbance in terms of noise, visual impact, and increased traffic levels upon the local population.

Increased noise levels will be experienced in the localised area of the proposed terminal during construction and along 10km of the L1204 during a perio9d of the peat transfer operation. The noise increase will affect only a small localised area and will not impact on any of the local tourism centres.

There will be increased traffic movements on local roads during the construction period with site traffic volumes varying (see Section 16). These increased traffic levels should not impact significantly on local tourism.

The Mayo sculpture trail exhibition "Stratified Sheep" in Bellanaboy, shown in plate 5.1, is the nearest local attraction to the site. This will not be physically disturbed during construction. The local fishing industry and angling attractions will remain undisturbed by construction by ensuring that environmental mitigation measures are implemented appropriately on site. (see also Section 5.8 below.)

Local temporary accommodation will be used to accommodate construction site workers who are not local to the area. As stated in Section 5.5.1.3 this influx will take up less than 5% of the accommodation available in County Mayo. Thus the use of local accommodation is not expected to have a significant impact.

The proposed terminal site does not affect any known recreational routes. The site will, however, be visible from local roads and tracks used in the area. Terminal construction will be visible from footpaths and bridleways close by.

Recreation and Sport

Given the proposed mitigation measures outlined in this EIS it is not expected that there will be any significant negative impact on local recreation or sporting activities or facilities.

Health and Safety

Impacts on health and safety during construction will be mitigated with the implementation of a Safety Plan in accordance with Safety, Health and Welfare at Work (Construction) Regulations.

Environmental Emissions

The impact of the environmental emissions from the proposed terminal are discussed in each of the relevant sections of this EIS. Each section discusses the likely impacts during the construction phase of emissions on humans, flora and fauna and the environment, and reference to cumulative impacts, where these are relevant.

5.5.2 Impact of the Proposed Development during Operation

Population, Language and Culture

The proposed terminal is located in an area in which the indigenous population has continuously declined for the past 150 years. The underlying factors for this lie in the decline of agriculture and the lack of a viable economic alternative in the area. The increasing attraction of economic activity, education and employment into urban areas, particularly the larger towns and cities, has also drained rural areas of the West of Ireland of its population.

The introduction of the proposed terminal will help to reduce the outflow of the indigenous population from the local areas within the vicinity of the proposed terminal. It is expected that non-locally based contract specialists recruited for the start-up phase, will be leaving within 12 months of producing sales gas. This will give opportunities of employment to the people living in the immediate area as well as encouraging those who might have migrated away from the area to return. In this regard, it is expected that the proposed terminal will have a significant positive impact on the population levels, local language and culture of the local area.

Employment and Economic Impacts

The introduction of the proposed terminal will help to contribute to the regional development of the West of Ireland and County Mayo, in particular. The provision of natural gas in County Mayo will act as a catalyst to economic development and encourage investment in industry and commerce in the main urban centres. A similar impact on regional development was observed in the Cork area following the commencement of natural gas production from the only other indigenous development currently producing in Ireland, the Kinsale Head Gas Field in 1978.

Despite the scale of the terminal proposal, the operation of the gas terminal is not labour intensive and the number of jobs arising from the operation will be in the region of 50 full-time jobs. The effects on the local economy in terms of absolute income and employment numbers will be relatively small. However, due to the low density of population in the area and the existing economic base, the jobs and income accruing from the proposed terminal will have a disproportionately positive effect on the area. These direct jobs will in turn sustain other indirect local jobs through the multiplier effect given that there will be more disposable income spent in local retail and leisure facilities. Allied to this, the opportunity exists for other service providers in the area to benefit from providing services to the terminal site.

At a macro level, there will be considerable socio-economic benefits to the County of Mayo and the west of Ireland in general. The current electricity supply to western Ireland is unreliable and there is no gas distribution system to the west or north west of Ireland. The proposed terminal will provide a major and reliable alternative gas supply, increasing Ireland's overall security of supply. It will support the construction of a major gas pipeline in the west of Ireland. It will also allow for the provision of gas to both Sligo and Castlebar. The project has already resulted in the proposed development of the gas fired Rolls Royce power station at Bellacorrick and may result in the development of further regional power station projects and the development of an improved electricity supply system. Through increasing the attractiveness of the area for inward investment, in particular the urban centres, the terminal will help reduce the outflow of population from rural areas and help to consolidate and strengthen the existing urban areas. Increased economic activity and productivity will also help increase the general affluence of the area and contribute to regional development.

Agriculture Forestry and Fishing

Any significant impacts on agriculture, forestry or fishing during the operation of the proposed terminal will be mitigated against through the measures proposed in the other chapters of this EIS. In this regard, it is not expected that there would be any negative impact on agriculture, forestry or fishing during operation of the terminal.

Tourism

With the appropriate mitigation measures employed as detailed in the other sections of the EIS, there will be no impact on fisheries or the natural resources of the area as a result of emissions. In this regard, the important local tourist resources of fishing, hill walking and horse riding will not be negatively impacted.

The proposed terminal development can be assessed as having a moderate impact on the landscape character and visual amenity of the local area. In particular the stacks will be most visible at close distance from a small number of residential properties located to the north and the south-west, and a public highway adjacent to the west of the proposed site. There are no significant tourist attractions that will be visually impacted upon directly.

It is therefore anticipated that the long term impacts on tourism and recreation as a result of terminal operation will be negligible in terms of their magnitude.

Recreation and Sport

There will be a positive impact as the workforce and their families will support local sports clubs and recreational activities.

Health and Safety

Impacts on health and safety during operation will be mitigated with the adoption of the MAPP document as outlined in section 5.6.4. Moreover, a safety statement will be produced in accordance with section 12 of the Safety, Health and Welfare at Work Act 1989. The safety statement will detail the manner in which the safety, health and welfare of persons employed at the terminal shall be secured. The safety statement will be based on an identification of the hazards in the workplace, the assessment of the risk these hazards present to the workers' health and safety and the safeguards which will be put into place to address the risks.

A Quantitative Risk Assessment (QRA) has been undertaken and submitted to the HSA. It has concluded that there will be no significant risk to the local population from the operation of the terminal.

5.5.3 Environmental Emissions

The impact of the environmental emissions from the proposed terminal are discussed in each of the relevant sections of this EIS. Each individual section discusses the likely impacts during the operation phase of emissions on humans, flora and fauna and the environment, including reference to cumulative impacts, where relevant.

5.6 Mitigation Measures

5.6.1 Population, Language and Culture

The objective of Shell in developing the proposed terminal in this culturally sensitive area is to consolidate the development into the existing native environment. The cultural sensitivity of the area will be addressed by liaisons with Údarás na Gaeltachta, part of whose aim is to incorporate the Irish language into the work environment.

In conjunction with guidelines from Údarás na Gaeltachta's latest publication "Gno le Gaeilge", businesses local to the area are taught the process of developing a Language Plan through a supportive and thoughtful approach by their management team. Such a plan will be produced for the proposed terminal once construction has commenced.

Topics addressed in a language plan will include: written communication; outdoor and indoor signage; advertising and marketing; spoken communication; and recruitment and training. In this regard, Shell is considering the following specific measures:

- where appropriate, indoor and outdoor signage etc. to be bilingual;
- a pro-active company policy which promotes the use of the Irish Language where possible and facilitates staff members in availing of personal skills development including learning the language.

5.6.2 Employment and Economic Impacts

In order to maximise the economic benefit to the local community of both the construction and operation of the terminal, Shell have developed a local employment and services database. The database continues to compile information relating to persons interested and available for employment as well as companies in the Erris region that have services to offer during both the construction and operation of the terminal. The database will also be a resource for Shell's contractors on the terminal and the offshore projects with the aim that all of the available employment and service industries have the maximum opportunity to benefit from the project.

5.6.3 Tourism

The terminal will increase economic activity and productivity in Mayo and will thereby help to increase the general affluence of the area, contributing to regional development. This may in turn have a positive effect on tourism in the area with increased investment and recognition. As noted earlier, Shell has paid for the development of a local accommodation database to assist local accommodation providers and enhance sustainable tourism in the region. This database will also be used as a tool to maximum the benefits and minimise any potential negative impact to local accommodation providers during the construction period.

5.6.4 Health and Safety

A Major Accident Prevention Policy (MAPP) document and Safety Statement will be prepared prior to the commencement of production operations.

A training strategy document will also be created to train permanent and temporary employees to enable safe and efficient operation of the terminal and sub-sea facilities.

Site safety measures will be enforced to protect the local environment during construction.

5.7 Monitoring

Close liaisons with government bodies, Údarás Na Gaeltachta, Mayo County Council and representatives from the community will be developed to implement the above mitigation measures and deal with new issues as they arise. In this regard, a community liaison office has been established in Bangor since September 2001, employing two people, and a terminal Manager/Mayo Area Manager has already been appointed and been involved in this process.

5.7.1 Environmental Monitoring

The Minister for Communications, Marine and Natural Resources has placed conditions on the Corrib Field Development as follows:

> '*The Minister, in consultation with Mayo County Council, will establish an Environmental Monitoring Group (EMG) charged with monitoring development during all stages of construction and development and with ensuring adherence to the approved EMP.'*

The EMG will include representatives of the Department of the Marine and Natural Resources, Mayo County Council, EEI, Duchas, NWRFB, Local fishing interests and local residents.

The EMG was established in July 2002, when the initial construction activities associated with the landfall at Glengad commenced. It is intended that the liaison is continued through the already existing Environmental Monitoring Group (EMG) with membership expanded to include members of the community local to the development. The purpose of the Group is to ensure that interested parties, including local residents are kept informed of the activities to be carried out on site. The Group will also be a forum at which local residents will be able to raise environmental concerns relating to the construction project can be raised and resolved. The Group will meet on a regular basis for the duration of the construction period.

Allied to the above, an Environmental Management Plan will be prepared as described in Section 20 of this EIS. This will be a statutory requirement under the IPPC licence.

5.8 Do Nothing Scenario

If the proposed terminal did not proceed, the potential benefits and disadvantages of the proposal would not accrue to the local community.

5.9 Reinstatement And Residual Impacts

No reinstatement having regard to human beings is required as a result of this proposed terminal.

5.10 External Associated Impacts

The proposed terminal is part of an overall plan to exploit the Corrib Natural Gas field discovered by Shell and its partners. In this regard, it is proposed to install a pipeline and a control line umbilical conduit from the terminal to the Corrib Gas field located approximately 80 km off the north west coast of County Mayo. In addition, in the same trench, it is proposed to construct an outfall pipe to bring treated water from the terminal out to the outer reaches of Broadhaven Bay for disposal. The impacts of the offshore pipeline have already been considered by the Department of the Marine and Natural Resources. The Department approved the plan of Development for the Corrib gas field and granted a petroleum lease in 2001.

As part of the proposal to develop the terminal, the applicant is also applying for planning permission to develop a peat deposition site on lands owned by Bord na Mona at Srahmore, Bangor, Co. Mayo. The impact of this development is discussed in detail in the peat deposition site EIS and any cumulative impacts are discussed under the relevant sections of this EIS.

Six

Terrestrial Flora and Fauna

6 Terrestrial Flora and Fauna

6.1 Introduction

This chapter assesses the likely impacts of the proposed development on the ecology of the site in terms of the habitats present and their constituent plant and vertebrate species. The approach and methodology has been undertaken with due regard to the revised EPA Advice Notes on Current Practice, (2002); and in accordance with the Institute of Ecology and Environmental Management's Guidelines for Ecological Evaluation and Impact Assessment ("In Practice" IEEM - Regini, 2000; and Regini, 2002).

The study was undertaken by Ecological Advisory and Consultancy Services (EACS) and associates.

The habitats present are described along with their current status and an evaluation of their conservation value. Vegetation and faunal surveys were carried out in order to establish if any sensitive or protected species were present. Potential impacts on adjoining areas and nearby designated conservation sites are also evaluated. Appropriate mitigation or remedial measures will be implemented in the context of likely impacts on species and habitats. The study work was undertaken between June 2000 and October 2003.

The location of the proposed terminal development is not subject to any conservation designation, proposed, candidate or otherwise, under current legislation by the statutory authority (National Parks and Wildlife, Department of the Environment, Heritage and Local Government - NPW). Neither is there any designated conservation area immediately adjacent to the site. Details of designated areas in the wider locality are given below.

The terminal site is located on part of the former An Foras Taluntais Peatland Experimental Station, Glenamoy. The study area is more or less rectangular in outline and slopes gently in parts. For convenience of description, it may be considered as consisting of blocks, divided or bordered by tracks and roads.

The proposed terminal will be located on the central southern block. The overlying peat will be removed and taken from the site to an area of Bord na Mona cut-away bog at Srahmore near Bangor Erris. A temporary construction facility (lay down area) will be located immediately to the east of the proposed terminal footprint.

6.2 Study Methodology

The aims of the study and surveys were:

- to identify habitats and/or species, on or close to the proposed terminal site, which are likely to be of scientific interest and/or conservation value; and
- to investigate the presence of, or potential for, protected species of plants and animals.

These findings have been used to identify mitigating measures to reduce the impacts during construction and operation.

The methodology used was discussed with NPW personnel early in the consultation process and follows the standard approach for ecological evaluation and impact assessment. The level of detail to which the survey was carried out generally exceeded the basic requirements for impact assessment.

Information has been collated from statutory (NPW) and non-statutory consultees (BirdWatch Ireland and the Irish Peatland Conservation Council - IPCC). This included the assimilation of information on nearby designated wildlife sites, watercourses and protected species. This information helped define the development and ensure that the design and construction of the proposed development avoids, or minimises, adverse impacts.

Habitat mapping was based primarily on field survey with the assistance of aerial video (GeoFilm™) and high resolution colour aerial photography at scales of 1:5,000 and 1:3,000. Field surveys were carried out as follows:

Vegetation and habitats:
- June 2000;
- June 2001; and
- September 2003

Fauna:
- July 2000 (incl. birds);
- March 2001 (incl. birds);
- April 2003; and
- October 2003.

Specialist bird surveys:
- June 2001;
- November 2001;
- January 2002; and
- September to October 2003.

The faunal survey of March 2001 was carried out during the Foot and Mouth Disease alert with the permission of Department of Agriculture veterinary personnel and followed the precautionary guidelines set out by the Department, Coillte Teo and Enterprise Energy Ireland Ltd (company name prior to acquisition by Shell) at that time.

A desk study was also undertaken as follows:

- detailed Phase I Habitat mapping at 1:10,000;
- collection of data on presence of, and/or potential habitats for, protected plant species;
- collection of data on the presence of, and/or potential habitats for, protected species of fauna; and
- data on the presence of birds, particularly breeding and migratory species was also collected.

6.3 Receiving Environment

6.3.1 Introduction and Past Management of the Site

The site for the proposed gas terminal (Grid Ref. 86540, 333000) is located in the townland of Bellagelly South that lies 2km north-east of Carrowmore Lake and 3km west of Glenamoy village, in the north-western corner of County Mayo. Land adjoining the site is dominated by coniferous forestry with modified blanket bog, scattered farmsteads and small areas of improved grassland. In the wider locality there are extensive areas of intact Atlantic blanket bog, much of which is designated for nature conservation under current wildlife legislation.

The site itself covers an area of approximately 160 hectares, of which the proposed terminal will occupy approximately 13 hectares. The site lies at an altitude of between 20m and 45m O.D. and the terrain is for the most part gently sloping. Throughout the site the main soil type is a damp peat, which generally exceeds 1m in depth. The two main habitat types present within the site are immature conifer plantation and rank, wet, rushy grassland dominated by the Soft Rush - *Juncus effusus*.

Access to the site is from the R314 by a north-south track to the west of the proposed terminal footprint; several internal tracks enable access to the various sections of the site. These components are laid out in fairly regular blocks. The main "grassland" areas are divided by 'rides' of remnant, felled shelter belt plantation, spontaneous re-growth, new planting and rough tracks. There is relatively little semi-natural scrub on site, and many of the boundaries alongside the roads and tracks are of Rhododendron. Cattle occasionally lightly graze the area.

Drainage from the site is via a network of drains, which feed into Sruwaddacon Bay SPA (part of the Glenamoy Bog Complex cSAC (cSAC 500)) to the north, or at the south, ultimately into Carrowmore Lake SPA (part of cSAC 476). The west-east track within the site is in more or less the position of the watershed, essentially separating the area into the two local catchments.

Habitats and Land-use Around the Site

Much of the area is under coniferous plantation of varying ages, with a large proportion comprising relatively recent planting. Substantial areas of bog to the west of the site and adjacent to the nearby Bellanaboy River have also been planted with conifers. To the south of the site, and south of the R314, is extensive partially modified blanket bog, with active cut peat faces. Some has been fully reclaimed and is now improved pasture. There is also a very small field of improved pasture located just north of the R314 to the south-west of the proposed terminal location.

Past Land-Use and Management

The proposed terminal site is on part of the former Peatland Experimental Station, Glenamoy, which was established by the Department of Agriculture in 1955 with the following objectives:

- "to find suitable methods of reclaiming and fertilising blanket bog for agricultural and forestry"; and
- "to develop suitable animal and crop husbandry systems for peatland".

It was administered by the Soils Division of An Foras Taluntais from 1959 for many years and was wound down in the late 1970s/early 1980s. During that time, a research programme was developed aimed at determining "the best and cheapest methods of reclaiming western blanket peat" (Glenamoy Review Group Report, 1978). A number of issues were investigated at the research station including: drainage, soil fertility and grassland, arable crops, shelterbelts, horticultural and industrial crops etc. Of these, the most relevant to this study are:

- drainage;
- fertiliser applications; and
- shelterbelt planting.

Drainage

According to the Glenamoy Review Group Report (1978) various types of drain were tried in the study area, which included:

- open drains – about 1m deep and at different spacings from 2.5m to 30m. These were considered dangerous to livestock and wasteful of land;
- clay pipes or similar "field drains";
- sod drains (a traditional method);
- slotted plastic pipes; and
- gravel drains (tunnel drains using "tunnel" plough technology. Non-calcareous gravel was laid onto plastic sheeting as the base of the "tunnel").

Soil Fertility and Grassland

The Review Group Report (1978) lists two methods including "liming and fertilising the native vegetation" and these are detailed in the Review Group Report. The application of lime alone increased the growth of the Black Bog Rush (*Schoenus nigricans*) while phosphorus alone or with nitrogen encouraged dominance of the Purple Moor Grass (*Molinia caerulea*). Both methods were applied to the site during the operation of the experimental station.

Shelterbelts

Approximately one fifth of the experimental station's land area was planted as shelterbelt (from 1956 to 1958). These shelterbelts were mostly 30m wide. The main species was Lodgepole Pine (*Pinus contorta*), with Sitka Spruce (*Picea sitchensis*), some Japanese Larch and a little Alder. Heavy applications of fertiliser were necessary to counteract the "checking" effect of chlorosis (yellowing of the leaves).

Horticultural and Industrial Crops

New Zealand Flax (*Phormium tenax*) was first planted as a shelterbelt species then trials showed that (as in its native New Zealand) its fibres were a realistic commercial alternative to jute. However, with the arrival of polyester fibres, this aspect of the research was not developed further.

The blocks of land in which the proposed terminal site will be located are part of an area formerly used for grass productivity trials, which has been subject to drainage and substantial applications of fertiliser. The dominant vegetation types, conifer plantations and shelterbelt species present today reflect past management practices. The site is currently under the management of Coillte Teo.

6.3.2 Flora and Habitats

Survey Methodology

The site was surveyed on three occasions - in June 2000, June 2001 and September 2003.

The plant species present were noted for each of the main vegetation types within the survey area. The relative abundance of individual plant species in each vegetation type within the site was estimated using the DAFOR scale. This is a subjective scale in which the cover of plant species is assessed as:

D = Dominant
A = Abundant
F = Frequent
O = Occasional
R = Rare

It should be emphasised that this assessment of occurrence refers to the site itself, and does not reflect the status of the species in a national context (see Appendix 6.1).

Unknown plant specimens were identified using the keys contained in Smith (1978) for bryophytes and Stace (1991) for higher plants. For the most part, plant nomenclature in this section follows these authorities unless stated otherwise. A list of species recorded and their DAFOR cover estimates is given in Appendix 6.1.

Uniformity of species composition was found within the main vegetation/habitat types in all three surveys. This was confirmed by sample quadrats of the main vegetation types, which were taken during the June 2001 survey. These quadrats were described in order to provide a clearer picture of the composition and structure of these vegetation types. Vegetation was sampled according to the Zurich-Montpellier approach (Mueller-Dombois and Ellenberg, 1974). The cover abundance of plants present within quadrats was estimated according to the Domin scale of cover/abundance outlined in Table 6.1.

Table 6.1 The Domin Scale of Cover/Abundance

1 = <4%, few individuals
2 = <4%, several individuals
3 = <4%, many individuals
4 = Cover between 4 and 10%
5 = Cover between 11 and 25%
6 = Cover between 26 and 33%
7 = Cover between 34 and 50%
8 = Cover between 51 and 75%
9 = Cover between 76 and 90%
10 = Cover between 91 and 100%

In addition to species presence and cover, other parameters were noted for each quadrat, including:

- percentage cover of the vegetation, bare soil, water and rock;
- percentage cover and height of the different vegetation layers, i.e. herb and bryophyte;
- slope and aspect; and
- additional details such as the composition of the surrounding vegetation, degree of grazing and disturbance.

Vegetation of the Site

The main habitats occurring within the site area are:

- stoney forest tracks;
- remnant blanket bog;
- species-poor wet grassland dominated by Soft Rush (*Juncus effusus*);
- species-rich wet rushy grassland dominated by Soft Rush;
- wet drains supporting marsh vegetation;
- low deciduous scrub along track and plantation margins;
- immature conifer plantation; and
- mature conifer plantation.

Of these, the dominant habitat types are wet rushy grassland and conifer plantations. The distribution of the habitats is shown in Figure 6.1. Appendix 6.2 describes the main or dominant habitat types in terms of their phytosociology and habitat classification affinities. Habitat classifications and associations are also indicated below as appropriate.

In addition to these, there are areas of scrub, particularly along the margins, tracks and boundaries. These are primarily comprised of Willow, Rhododendron and, in places, New Zealand Flax (*Phormium tenax*). It should be noted that many of the vegetation types, for example the areas of scrub, are quite fragmented and it is not possible to show all pockets of any particular vegetation type on Figure 6.1 at that scale of mapping.

Plant species recorded within the study area are listed in Appendix 6.1.

Stoney Forest Tracks

A large number of gravelled forestry tracks traverse the site. The vegetation of such tracks is generally low-growing and sparse, however a large number of plant species occur, especially along the damper and less disturbed margins where there may be seasonal pooling of surface water. Most of the constituent plant species are typical of disturbed grassland or wet marsh habitats. Some of the most frequently encountered species include *Prunella vulgaris, Anthoxanthum odoratum, Ranunculus repens, Agrostis stolonifera, Poa annua, Plantago major, Plantago lanceolata, Poa trivialis, Juncus articulatus, Isolepis setacea*, *Sagina procumbens* and *Juncus bufonius*.

Remnant Blanket Bog

In places a few narrow strips of blanket bog, usually less than 5m in width, are to be found between the tracks and areas of forestry. At present most of these areas are in a desiccated condition due to drainage effects, however occasional waterlogged areas occur where drainage has been impeded. The vegetation of these areas is dominated by a typical array of blanket bog species of which *Calluna vulgaris, Molinia caerulea, Schoenus nigricans, Narthecium ossifragum, Trichophorum cespitosum, Polygala serpyllifolia, Cladonia portentosa* and *Sphagnum capillifolium* are generally the most conspicuous. One of the more unusual bog species recorded is the insectivorous Pale Butterwort, *Pinguicula lusitancia*, which is generally less common in Ireland than the larger *Pinguicula vulgaris*.

Note: Habitat and vegetation classifications and associations refer to intact blanket bog which occurs nearby – there is no intact blanket bog on the site itself, only small modified remnants of blanket bog. However the remnant bog can be broadly aligned with these vegetation types:

- Equivalent Phase 1 survey habitat classification for intact areas: Blanket bog (E1.6.1);
- Equivalent Phase 1 survey habitat classification for cutaway or overgrazed areas: Wet modified bog (E1.7);
- Equivalent Phase 1 survey habitat classification for industrially cutaway areas: Bare peat (E4);
- Phytosociological synonymy: Pleurzio purpureae – Ericetum tetralicis *Braun-Blanquet et Tüxen 1952;*
- Equivalent N.V.C. community: *Scirpus cespitosus – Eriophorum vaginatum* blanket mire (M17); and
- Fossitt: (PB3) Lowland Blanket Bog.

Wet Grassland Dominated by Soft Rush

Wet, soft rush grassland and partially cleared conifer plantation dominate the site, the former covering a greater area. This wet grassland vegetation typically attains a height of 1m or more. The high cover of this species is such that other plant species are generally infrequent. It falls into two subdivisions, species-poor and species-rich.

Habitat/vegetation classification and associations for wet rushy grassland are:

- Equivalent Phase 1 survey habitat classification: Neutral grassland (B2) and Marsh/marshy grassland (B5);
- Phytosociological synonymy: Holco-Juncetum effusi *Page 1980;*
- Equivalent N.V.C. community: *Holcus lanatus-Juncus effusus* rush pasture (MG10); and
- Fossitt: Wet grassland (GS4).

Plate 6.1: Rushy Grassland Dominates the Terminal Footprint

Species-Poor Wet Grassland Dominated by *Juncus effusus*

In the centre and west of the site there are large areas of species-poor wet grassland dominated by *Juncus effusus*. This vegetation has developed as a result of blanket bog reclamation and fertilisation experiments which were initiated in the 1950s and subsequently abandoned. The vegetation often attains a height in excess of 1m and in places the cover of *Juncus effusus* exceeds 90%. Apart from *Juncus effusus,* the only other species to occur with a relatively high frequency are *Anthoxanthum odoratum, Rumex acetosa, Holcus lanatus, Epilobium palustre, Agrostis stolonifera, Cirsium palustre* and the moss *Calliergon cuspidatum*. It must be noted however that the cover of these species is low.

Species-Rich Wet Grassland Dominated by *Juncus effusus*

A slightly more open and species-rich wet grassland, though still dominated by *Juncus effusus* occurs in a small part of the site. Here the vegetation is not so high and is, as a result, relatively more herb rich. In addition to *Juncus effusus*, conspicuous plant species in the vegetation include *Ranunculus acris, Anthoxanthum odoratum, Trifolium repens, Prunella vulgaris, Cirsium palustre* and the mosses *Calliergon cuspidatum* and *Rhytidiadelphus squarrosus*. Of note is the presence of three species of orchid: *Dactylorhiza incarnata, Dactylorhiza maculata* and *Platanthera bifolia*. This area of grassland contains a number of old drains, which are colonised by plant species typical of freshwater marsh/poor fen (see following habitat description).

Species-rich wet grassland falls into the same habitat/vegetation types and classifications as species-poor wet grassland above.

Wet Drains Supporting Marsh Vegetation

Within the area of wet grassland there are a number of long linear drains colonised by freshwater marsh vegetation. These drains are generally less than 50cm in width, however in places small areas of quaking marsh vegetation up to 2m wide has developed. The vegetation is generally species-rich with the most conspicuous species including *Galium palustre, Carex echinata, Carex nigra, Ranunculus acris, Anthoxanthum odoratum, Cirsium palustre, Trifolium repens, Juncus effusus*, *Prunella vulgaris, Poa trivialis*, *Leontodon autumnalis, Holcus lanatus* and the wetland moss *Calliergon cuspidatum*. A noteworthy feature of the vegetation is the high cover of wetland mosses and liverworts. In addition to the drains in the areas of wet, rushy grassland, numerous north-south ditches drain the area. Many of these support similar vegetation types.

Habitat types/vegetation classification for the wet drains found on the site are:

- Equivalent Phase 1 survey habitat classification: Swamp, marginal and inundation (F2); and
- Fossitt: Drainage ditches (FW4).

Scrub and Hedgerow

There is relatively little scrub within the study area. Scrub species, such as bramble, *Rhododendron ponticum* and Eared Willow (*Salix aurita*) are frequent along the ride verges and often spread into adjoining grassland areas. Many of the larger drains and tracks have an associated narrow verge of scrub composed mainly of willow and young Rhododendron. Gorse (*Ulex europaeu*s) is also present but not common.

Low Deciduous Scrub Along Track and Plantation Margins

Deciduous scrub vegetation between 2 and 5 m tall occurs infrequently along the margins of tracks and plantations within the site. The main shrub species are the Willows (*Salix cinerea* subsp. *oleifolia* and *Salix aurita)* with Gorse (*Ulex europaeus)*, Bramble (*Rubus fruticosus)* and the invasive, introduced shrub *Rhododendron ponticum* occurring less frequently. Of note is the presence of the two introduced species from the southern hemisphere, *Olearia macrodonta* and *Phormium tenax*, in this habitat. Both of these species were deliberately planted for experimental purposes. This habitat is important for birds which utilise the site.

Habitat types/vegetation classification for the scrub found on the site are:

- Equivalent Phase 1 survey habitat classification: Dense/continuous scrub (A2.1) and Scattered scrub (A2.2); and
- Fossitt: Scrub (WS1) Phase 1.

Plate 6.2 Willow-Bordered Track

Exotics

Rhododendron scrub forms linear boundaries along some tracks and is the principal "hedgerow" species along the R314, forming a tall scrub boundary to the east.

Part of the eastern boundary of the terminal footprint is dominated by large New Zealand Flax (*Phormium tenax*), formerly planted as a shelterbelt species and also for experimental purposes. Another New Zealand species, *Olearia* (Daisy Bush) is also present here.

Plate 6.3 Scrubby Area Dominated by Exotic Plant Species.

Conifer plantations

Immature conifer plantation

Areas of young conifer plantation which are generally less than 15 years old dominate much of the east and north-east of the site. The trees are generally less than 6 m in height and the main species is Sitka Spruce (*Picea sitchensis)* with lesser amounts of Lodgepole Pine (*Pinus contorta)*. In areas where the trees are less than 2 m and / or less close together there still remains a species-poor associated ground vegetation in which *Juncus effusus* is dominant, accompanied by *Rubus fruticosus*. This suggests that the forestry was recently planted on areas of wet grassland dominated by *Juncus effusus*.

Plate 6.4 Track Through Immature Plantation

Mature Conifer Plantation

There are only a few relatively small areas of mature conifer plantation within the site. The oldest (semi-mature) plantations are located at the extreme west and south of the study area, adjoining the local road to Pollatomish, and at that part of the site adjacent to the R314. Ground cover is sparse or absent. Small areas of mature conifer plantation have been felled recently and many of these areas now support opportunistic plant species such as *Rhododenron ponticum* and *Epilobium angustifolium*.

Remnant Coniferous Plantation

Partially cleared, remnant coniferous plantation is a prominent feature of the site. Generally this habitat occurs as relatively narrow strips of patchy woodland that divide the grassland areas – ie. former shelter belts. Lodgepole Pine (*Pinus contorta*) and Sitka Spruce (*Picea sitchensis*) are the main species. Some areas appear to be recently re-planted (10 years or less) or may be spontaneous regrowth. These rides have largely been clear-felled and replanted, with strips of remnant older planting on either side. These afforested rides are generally dominated by grasses and rushes, with bramble and some willow scrub present.

Built Land

The tracks constitute the only built land on site. The site is bounded at the south by regional road R314, and at the west by a local road to Pollatomish. Other tracks, mainly through replanted former rides, are rough and generally strewn with conifer branches.

Lands to the South of the R314

In addition to the habitats described above, a strip of land to the south of, and adjacent to, the R314 was surveyed in September 2003.

The area measures approximately 560m long by 20m wide. A rough grassy verge, approximately 1.5 m in width, runs along the edge of the road. This verge is generally dominated by robust grasses such as *Molinia caerulea, Anthoxanthum odoratum* and *Holcus lanatus*. There are occasional bushes along the grassy verge with *Salix aurita* being the main species. Behind the verge there is a rather shallow bog drain which is dominated by *Molina caerulea* and *Juncus effusus*. To the south of this drain there is a narrow zone of dried-out bog, now dominated by recently felled conifer plantation. Some plantation remains. *Molinia caerulea* is regenerating well in these recently felled areas. Plant species recorded from this area are listed in Appendix 6.1.

6.3.3 Flora – Evaluation

Method of Evaluation

The habitats are evaluated according to Regini (2000 & 2002) based on a number of criteria which include size (extent), diversity, naturalness, rarity, fragility, typicalness, potential value and intrinsic appeal. The basis for habitat evaluation is summarised in Table 6.2. The ecological evaluation value of the habitats based on the method of Regini is set out in Table 6.3.

The blanket bog habitats have been highly modified by past land-use management practices. The ecological value of the vegetation and habitats encountered within the site and immediately south of the R314 is generally Negligible to Low Local, due to the low diversity of plant species and the absence of species that are considered to be rare in a local or national context. The species rich wet rushy grassland and marshy drains are of slightly more interest in terms of vegetation but still fall into the Low Local category based on the Regini evaluation. The willow scrub, although small and patchy is of slightly more significance in terms of habitat, particularly for invertebrates and birds. Conifer plantations are, by their nature, intensively managed habitats of a transient nature. They are widely occurring throughout and not considered to be of any particular ecological significance.

Furthermore the vegetation types described from the site have resulted from reclamation of lowland blanket bog and are considered to be common on both a local and national scale. The areas of willow scrub are small and patchy.

Rare and Protected Plant Species

Information received from National Parks and Wildlife regarding their Rare Plant Database and records shows that no listed rare species of plant, including those on the current Flora (Protection) Order, are known to occur within the study area at present. In addition, of the plant species recorded during the botanical surveys of 2000, 2001 and 2003 none are listed under the current Flora (Protection) Order 1999 (SI No. 94 of 1999) under the Wildlife and Amendment Acts, 1976 and 2000.

Plant species present are for the most part commonly occurring throughout the country (Appendix 6.1). It should be emphasised that, in the context of the DAFOR assessment, values assigned to species refer to their occurrence on the site itself and not in the wider countryside, or Ireland as a whole. To put this in context, the frequency of occurrence on a nationwide basis is shown in the species lists in Appendix 6.1. To take an example: Pineappleweed (*Matricaria discoidea*) is assigned a DAFOR scale value of Rare for the site, but it is Abundant throughout the country. It is a very commonly occurring ruderal species which was recorded from 890 10km squares between 1987 and 1999 (New Atlas of the British and Irish Flora, 2002). Other such examples are *Vicia cracca*, occurring in 887 10km squares; *Rumex crispus*, 893 10km squares; and *Poa annua,* 953 10km squares.

Table 6.2 Evaluation of Habitats (Regini, 2000 & 2002)

Level of Value	Indication of importance
International	Designated or proposed as cSAC, SPA under EU Habitats or Birds Directives; Sites designated under international conventions eg. Ramsar etc.
National	Proposed NHAs or sites containing habitats or populations of nationally important species such as Red Data Book species.
High Local	Sites containing semi-natural habitat types with high degrees of biodiversity and/or naturalness (eg. old semi-natural woodland); or significant populations of locally rare species; or supplying critical elements of their habitat requirements.
Moderate Local	Undesignated site or feature considered appreciably to enrich the habit resource within the context of the district; containing some semi-natural habitat or supporting viable breeding populations of locally important for wildlife.
Low Local	Site or feature considered appreciably to enrich the habitat resource within the context of a townland, eg. species – rich hedgerow.
Negligible	Low grade and widespread habitats.

Table 6.3 Summary of Habitat Types in Terms of Their Ecological Value

Habitat Type	Frequency of occurrence in the wider area	Ecological Evaluation – after Regini (2000 & 2002)
Stoney forest tracks	A common habitat throughout much of the country and typical of gravel forestry tracks. The vegetation is dominated by common plant species typical of disturbed grassland.	Negligible
Remnant blanket bog	Although blanket bog itself is of high ecological interest, these fragmented remnants occurring along edges of forestry are small and of little conservation interest.	Low Local
Species-poor wet grassland dominated by Soft Rush (*Juncus effusus*)	This habitat is common throughout County Mayo and indeed is frequent throughout the west of the country. Typically the vegetation type dominates wet abandoned pasture	Negligible
Species–rich wet rushy grassland dominated by Soft Rush;	This more species-rich variant of Juncus effusus wet grassland is of slightly more interest due to its greater species-richness. Although the distribution of such vegetation has been poorly documented it is considered likely that it is relatively common in the general area.	Low Local
Wet drains supporting marsh vegetation;	These species-rich wetland drains add much to the botancial diversity of the site. Most of the species recorded are relatively frequent in wetland habitats elsewhere in the general area.	Low Local
Low deciduous scrub along track and plantation margins	Willow scrub is generally common throughout Ireland, there is however little on the site. This habitat is important for birds which utilise the site. The exotic species were planted for shelter and commercial use.	(Willow scrub) Low Local to Moderate Local (Exotics) Negligible
Immature conifer plantation	A habitat with low plant species diversity and frequent throughout the west of Ireland.	Negligible
Mature conifer plantation	A habitat with very low plant species diversity due to the shading of mature conifers.	Negligible
Roadside habitats south of the R314	A mix of roadside verge drain; and clear – felled forestry. Common habitats and vegetation types throughout the locality and country as a whole.	Negligible to Low Local

Introduced Exotic Species

Rhododendron ponticum has become widely established, particularly along road and track margins of blanket bog. It was originally introduced as a decorative species for shelterbelts around houses and hunting/fishing lodges (e.g. Srahmore Lodge, Co. Mayo) and being highly competitive, has invaded wide areas. It is now regarded as a pest species.

The New Zealand Flax (*Phormium tenax*), a species more associated with being planted near the sea in the south-west of Ireland, was planted as an experimental shelterbelt species on the Peatland Research Station in the late 1970s with a view to commercial use of its fibres. It is not of any ecological significance.

6.3.4 Fauna (non avian)

Introduction

Fauna surveys were carried out in July 2000, March 2001, April 2003 and a review survey was conducted in October 2003. The March 2001 survey was restricted to the proposed site area as a result of Foot and Mouth Disease restrictions. The general locality and surrounding areas were overviewed from the site or from vantage points on local public roads.

The area has a limited range of habitats and is almost entirely comprised of coniferous afforestation and wet, rushy, grassland. Watercourses on the site are mainly small drains, with some small pools and two small streams. A number of generally common and ubiquitous species are present, but this area on western blanket bog does not provide for a wide range of faunal species. However, a number of species of interest were noted on site, including badger *Meles meles*, abundant frog *Rana temporaria,* and a pine marten *Martes martes* (observed by others in 2001 and in 2003). Although the presence of otter *Lutra lutra* was expected in the initial survey (owing to the high abundance of frog as prey) no otter signs were found. However, in the later April 2003 survey considerable otter activity was identified at the east of the site and also close to the badger setts at the north-west of the site.

A list of Irish mammalian, amphibian and reptilian species found at the proposed terminal is included in Appendix 6.4 along with their adjudged status in the area.

This section presents the results of the detailed fauna study carried out in April 2003, and review survey in October 2003. It also includes principal elements of the earlier detailed survey of March 2001. The vertebrate fauna occurring on the site are described, and the likely impacts of the development on the fauna discussed, with recommendations for mitigation or remedial measures. Habitats are assessed and mapped in relation to faunal survey. The section includes assessment of mammals, amphibians and reptiles.

The general format is in accordance with guidelines recommended by the EPA (2000) Guidelines on the Information to be contained in Environmental Impact Statements. Recommendations and evaluation techniques utilised are in general accordance with Guidelines for Baseline Ecological Assessment (Institute of Environmental Assessment, UK, 1995), Wildlife Impact: the treatment of nature conservation in environmental assessment (RSPB, 1995) and Guidelines for Ecological Evaluation and Impact assessment (IEEM, Regini, M. 2000).

Survey Methodology

Survey for mammals was carried out by means of search within the site. Presence of mammals is indicated principally by their signs, such as dwellings, feeding signs or droppings, though direct observations are also occasionally made. The survey included note of potential bat roosts and a brief detector survey. It also included a search for amphibians and reptiles.

The nature and type of habitats present (see Section 6.3.2 Flora and Habitats above) are also indicative of the species likely to be present. The habitats present were assessed in general accordance with techniques adopted for the Badger & Habitat Survey of Ireland (Smal, 1995).

The field survey was supplemented through relevant published literature, and contact with National Parks and Wildlife personnel, Mr. D. Norris (Research Branch, National Parks & Wildlife) and Mr. D. Strong (District Officer).

The earlier survey (March 2001) concentrated on the western sections of the site. With regard to the proposals for the site, the survey in April 2003 concentrated on the block in which the terminal is to be located and the eastern blocks, part of which is proposed for the temporary construction lay down area. Portions of the western areas were revisited and checked for badger presence. In preparation of findings, the results from the two surveys have been incorporated in Figure 6.2.

A further survey was carried out on 14th and 15th April 2003. Weather conditions were good – warm and sunny or somewhat overcast, but with strong wind at times. Low night-time temperatures affected bat survey on the evening of 14th April. The survey was concentrated on the terminal footprint and the area to the east where the temporary construction area is proposed. The setts known from previous surveys were revisited to check for continued presence of badgers. The route of the import gas pipeline corridor on site had been surveyed previously in 2002 and was rechecked in this survey.

The latest survey was carried out on 9th and 10th October 2003. Weather conditions were poor on the 9th with strong wind and drizzle followed by heavier rain. Conditions improved substantially in the evening, with mild conditions and only very light drizzle at times, and a bat survey was conducted that night. The site was revisited on the 10th October in more favourable weather conditions.

The October surveys were conducted to review the status of mammals on site at this season, with attention paid to many of the locations where mammal signs had been identified in earlier surveys. The known badger setts on site were revisited to check for the presence of badgers. A bat survey was conducted on site and around the site by use of a heterodyne bat detector (Magenta Electronics MkII) for approximately 3 hours on evening of 9th October.

Survey Constraints

March 2001 - An outbreak of Foot & Mouth Disease had imposed restrictions on access to farmland so the survey was restricted solely to the proposed terminal site and did not include any adjoining lands, other than overview from the local road network.

April 2003 - Where cover is dense, badger setts may be obscured and not found. Considerable portions of the site were extremely difficult to search – this includes most of the mature conifer plantation at the south of the site and also scrubby areas within young planting; the latter includes the narrow conifer belts present in the central southern and the south-western blocks, and also almost all of the two eastern blocks. The search was carried out by a number of passes through these areas, usually along rides or clearfell, but much of the mature plantation at the south could not be intensively searched and is virtually impassable. However, signs at prominent boundaries or features or paths entering woodland along the boundaries did give a good indication of activity by mammals within the afforested areas.

Given the constraints of heavy cover, it was considered that no substantial improvement in survey results could be achieved without prior scrub clearance and improved access to impenetrable areas.

Cold weather on the night of 14th April 2003 resulted in no observations of bats being made during night time survey using heterodyne bat detectors.

October 2003 - Apart from the difficulty posed by dense cover, referred to above, there were no survey constraints during the October 2003 survey.

Mammals

Badger

In the survey conducted in March 2001 two active badger setts were identified (details in Appendix 6.4b). Locations where signs of badger activity were found are mapped on Figure 6.2. Several fresh latrine locations, and a great deal of badger feeding activity were observed through the plantation and nearby areas. Badgers from these setts clearly range across much of the site area. Prints and tracks suggest that this badger group extends its territory to the central southern block of the proposed terminal site, where an active boundary latrine was also identified. However, tracks and signs were few within most of the adjoining plantation in the south western block, except at the extreme south. This pattern of activity suggests the presence of a second badger group.

During the April 2003 survey, whilst every effort was made to search the entire area for badger setts, considerable portions of the rough 'rides' and the plantings of young and intermediate age were impenetrable. Other setts might be present in these areas, although this is thought to be unlikely as soil conditions through most of the area were not suitable for sett construction. Activity at the two identified setts indicated one main breeding sett. The survey results suggest that only one badger group is utilising most of the site, with the possibility of badgers from another group occasionally utilising the extreme south-west corner.

Badgers were still present in April 2003 and active on site, with continued use of the main (breeding) sett (Figure 6.2 S1 to S4) just north of the red line boundary in the north-west section of the study area. (Frequent badger prints had also been noted during other surveys in March 2003). It was not possible to estimate the number of badgers present, but they range over most of the site. Whether there is another social group present in the vicinity is uncertain from signs on site, but no other main sett is anticipated on site. A large latrine was present at the main sett and another in mature plantation nearby.

Badger prints and feeding signs were also present within the areas to the east of the terminal footprint. Some new latrine locations were identified whilst some previous latrines could not be relocated, possibly simply due to increased cover since the first survey.

Closer examination of setts in the north-west section of the study area (S1 to S4) suggested that the previously identified setts can be considered as four closely spaced setts (some inactive burrows had been discounted in first survey), but there was little overall change in sett activity in that area. It is likely that one of these setts had served as an otter holt recently also (see below).

An additional sett (S5) was found at the north-east of the south-central block (site of the proposed terminal), in an area of boundary planting, scrub and New Zealand Flax which will not be disturbed by construction. It was associated with paths and two latrines, and also two day nests, the southernmost of which might also serve as an occasional resting place for otters and foxes.

It is noted that this sett was found by following paths, but, even so, the density of scrub was such that similar setts may well be present in similar scrubby areas present within the plantation block of the proposed terminal buildings. Whilst every effort was made to search the entire area for badger setts, considerable portions of the rough 'rides' and the plantings of young and intermediate age were impenetrable. Although other setts might be present in these areas it is considered that soil conditions through most of the area are not suitable for sett construction.

Badger densities in western blanket bog areas are generally not high; however the species is widely distributed and occurs at low densities even in relatively poor habitats (Smal, 1995). A dead badger was observed on the R314 during a visit to the area on 11th May 2002. Badgers cross the local roads to feed on adjoining improved or semi-improved grasslands or adjoining plantations; increased traffic may lead to increased badger mortality as a result.

During the October 2003 review survey, all known setts on site were revisited and no signs of current activity were found. Entrances appeared to have been active until earlier in the year (with some recent digging in the past 4 months or so), but whilst entrances were not blocked, almost all had cobwebs over entrances and a small accumulation of debris. No badger footprints – formerly frequent – were identified on any part of the site, and active latrine sites were also no longer in use.

There is little doubt that badgers are no longer actively using the terminal site area. Badgers do relocate setts on occasion, and at least one badger is known to have been killed on the R314 in the past.

No specific reason can be put forward to account for the absence of badgers on site during the October 2003 survey unless the exceptionally dry weather during the summer of 2003 had forced them to move elsewhere for foraging. In any event a pre-construction survey will be required to check the setts.

Otter

Otters are often present even on small streams, and they are present on the nearby Aghoos River and on adjoining lakes and estuaries. Otters occasionally travel overland and are likely to occur on site either passing through or foraging; in particular frogs and frogspawn are favoured items in late winter and spring (frogs are abundant on the site).

The survey in spring 2003 revealed an extent of otter activity not expected from the results of the late winter survey of 2001. Many otter sprainting sites were found (in spring 2003) along a small drain or stream which runs roughly north-south though the eastern immature plantation, just inside the site boundary. Additional signs were observed at a few locations along small drains at the boundaries of the central section in which the proposed terminal will be sited.

Almost all of these spraints were not fresh and all contained frog remains, suggesting that otters had fed almost entirely on frogs for a period in early 2003. It is doubtful that otters forage regularly on the site through the entire year, but are probably opportunistic in this respect. It would be expected also that otters would have resting places and holts on site during this season; however none were found. It is possible that such holts could be concealed within heavy cover. One of the badger day nests referred to above might also serve as a resting place for otters.

Relatively fresh spraints were found during the April 2003 survey near to the badger setts to the north-west of the study area (S1 to S4), and a heavily sprainted area there suggests that some of the burrows could be used as an occasional otter holt, although this was not the case at the time of this survey. It was noted that this location is only about 80m from the nearby Aghoos River where fresh spraints were found along the banks. It is not unusual, indeed it is to be expected from studies in Britain (Kruuk, 1995), that a holt might be located at this distance from a principal watercourse.

Aspects of note in relation to otter activity on site were that otters marked very small drains such as that running through the eastern immature plantation and also parts of the rides in this area. Marking of features in the 'hinterland' is unusual and worthy of comment. Nevertheless, it is probable that heavy use and marking of these habitats is seasonal and relates to the abundance of a seasonally important prey species namely the common frog. It is doubtful, from assessment of the literature (e.g. Kruuk, 1995) that the number of otters utilising the site exceeds one or two.

Despite the activity earlier in the year, the autumn survey (October 2003) did not find any active use of the site by otters. Previous sprainting sites had become obscured, with no remains of spraints at significant sites near badger setts and elsewhere. After the spring survey it was concluded that otters visit the site in early spring to feed on frogs, and that such feeding activity would be reduced at other times of the year. This has been confirmed by the autumn survey. A visual inspection of former sprainting sites along the nearby river (to the west of the site) also revealed no signs of otter activity.

However, site security staff did report occasional sightings of otters (with a high degree of reliability according to the descriptions given), with locations of sightings not far from the two principal entrances to the site. This appears to tally with prior observations of activity near badger setts at the north-west and probable movement corridors to the south of the proposed location of the terminal site and towards the eastern area. The last sighting was in September 2003. These observations suggest that otters still do visit or patrol the site on occasion, and there is every expectation that the site will become a more significant focus of otter activity again in late winter/early spring, when otters will return to take advantage of frogs breeding on the site at that time.

Pine Marten

No signs of pine marten were noted in the earlier survey (March 2001), but as it is known to occur throughout mature plantations in north County Mayo, it was considered that the species might occur on the site albeit infrequently.

Subsequently, the presence of pine marten has been confirmed, with observations of one individual on two occasions - during a bird survey in 2001 and in 2003 when one was observed apparently feeding on frogs. During the October survey a marten footprint and a scat were observed along one of the rides through the eastern plantation. Scats were also found along another track to the east of the terminal footprint in September 2003.

From these observations is clear that one or more individual pine martens are present on site; they have large territories and so numbers are expected to be low.

Bats

Night time detector surveys on 14th May 2003 did not locate any bats, due to very cold night time conditions. It was considered that there were no suitable roosting locations for bats present on site owing to the complete absence of old, mature deciduous or coniferous trees excluding the likelihood of tree roosts. No other roosting sites in buildings or bridges were identified. The route of the incoming pipeline was surveyed in April 2002 and notes on the relevant findings are included here.

Bat activity in the area was low with only a single species being recorded, the common pipistrelle *Pipistrellus pipistrellus*. The few tall lines of scrub and edges of plantation do offer commuting and foraging areas for bats and it is anticipated that several of Ireland's bat species could occur in the area (O'Sullivan, 1994; Richardson, 2000). Species that may occur include either of the two pipistrelle species, *Pipistrellus pipistrellus* and *Pipistrellus pygmaeus*. Two other species that are likely to occur in the general area include the Daubenton's bat *Myotis daubentonii*, which forages over open water, and Leisler's bat *Nyctalus leisleri*, which forages over agricultural landscapes, scrub and woodland.

Neither of the latter two species would be expected regularly over the Bellanaboy site. The habitats present on site may provide suitable foraging areas for bats in summer, but the overall landscape of blanket bog and afforested terrain of western Mayo, and the subject site, is poor for most bat species.

The bat survey on the evening of 9th October 2003 also indicated absence of bats on most of the site, with bat detection conducted over large portions of the site. However, one (single) bat was detected at the extreme south-west of the site, close to the junction of the R314 with the local road to Pollatomish. The species was identified as a pipistrelle bat, but with only one brief pass, could not be identified to species (either *Pipistrellus pipistrellus* or *P. pygmaeus*). The October 2003 survey confirmed earlier conclusions that no bat roost locations are expected on site.

Common Species

Commonly encountered on site was the fox (*Vulpes vulpes*), of which signs were evident throughout. However, no fox dens were identified on the site during any of the surveys.

The Irish hare *Lepus timidus hibernicus* was not observed during the surveys apart from signs which were observed at the north of the site (March 2001).

However this species has been seen at least once on the site by security staff.

Also noted were signs of fieldmouse *Apodemus sylvaticus*. Another species that was confirmed as present was the pygmy shrew *Sorex minutus*. Other species common in lowland areas such as the brown rat *Rattus norvegicus* and the house mouse *Mus musculus* are likely to be absent or very occasional on site. The Irish stoat *Mustela erminea hibernica* is wide-ranging and may be present, if infrequent, in this area. No signs of hedgehog *Erinaceous europaeus* were noted; this species is wide-ranging but is certainly scarce in areas of blanket bog, coniferous plantation and poor grassland habitats.

Other Species

Deer species were not noted, and are not recorded in the locality (Hayden & Harrington, 2000). No signs of squirrels were noted and red squirrels are not known in the locality (Hayden and Harrington, 2000).

No signs were noted of American mink *Mustela vison*. The mink has only spread to Mayo relatively recently; the species is not well suited to upland habitats and is scarce on acidic streams and rivers (Smal, 1991).

Amphibians and Reptiles

Frogs

Breeding sites (spawning grounds) of the common frog *Rana temporaria* were very frequent on site in March 2001, though many comprised transient pools and puddles. The early spring/late winter of 2003 proved unusually dry with no rain over a period of c. 4-5 weeks. Whilst frogs and tadpoles were also abundant in 2003, many of the pools observed in 2001 had dried or shrunk to small proportions in the spring of 2003. This resulted in poor breeding success for frogs, with spawning concentrated in remaining wet drains. However much spawn failed as a result of desiccation and many tadpoles succumbed to high temperatures, low oxygen levels, or simply inadequate space for the concentrated numbers of tadpoles in the shrinking pools and puddles. Heavy rain in late April and in May 2003 allowed many of the surviving tadpoles to progress to later stages. This was confirmed in October 2003 when young adult frogs were frequently observed.

The distribution of frogs and pools with spawn or with tadpoles is indicated in Figure 6.2. It should be noted that since a thorough search of the western portion of the site was not conducted in 2003, the maps (which show frog distributions in both 2001 and 2003) are not strictly comparable between the two principal surveys. Considerable amounts of frog spawn had been noted in the western section of the site earlier in March 2003 - a month prior to the faunal survey. Clearly, however, the eastern portion of the site remained wetter in the late spring of 2003 – or with more small pools and drains remaining wet for longer at the east – and this also appears to be reflected, to some extent, in the abundance of otter spraints at the east of the site (see above) observed in April 2003.

In late winter or spring surveys, presence of frog spawn is to be expected, but the abundance of spawn in the area was considered to be somewhat unusual in both years, despite the dry conditions of early 2003. Many of the spawning areas (2001 and in March 2003) were located in drainage ditches and in shallow pools near roads and tracks; some of these pools had formed in old lorry tracks, others formed by runoff from the tracks. No frogspawn was present within any of the pools within mature coniferous woodland. It is known that frogs tend not to spawn in peaty water and therefore favour pools on a mineral base as can be found in ruts along the tracks and also in the drains by the roadside. The relatively uniform and level rushy grassland areas did not include many suitable locations for frog breeding sites.

It is suggested that the abundance of frogs in the area results from the relative lack of disturbance. The wet, rushy, grasslands and immature plantations provide foraging grounds for the species, whilst the forest traffic and drainage systems have provided numerous suitable sites for breeding. It is not known if the Peatland Experimental Station actually put in place an earlier suggestion for frog production. Even if this were the case however, it is considered unlikely that it would have any bearing on present frog populations in the area.

It is clear that the frogs are preyed upon by several species, including otters, foxes and probably badgers and pine martens too, and may provide a seasonally important prey resource for these species.

Other Species

The smooth newt (*Triturus vulgaris*), is present in east Mayo (Marnell, 1994, 1998) but absent from this locality as there are no suitable breeding ponds.

The common lizard (*Lacerta vivipara*), is a common species and difficult to observe. It is frequent in upland areas, more commonly on heather-dominated moors, and is a frequent prey of the kestrel (Smal, unpublished). It is likely to occur on the site, albeit infrequently.

6.3.5 Birds

Bird surveys were conducted in 2000 (July), 2001 (March, June and November), 2002 (January) and 2003 (September to October). The first two of these were undertaken in conjunction with general faunal surveys. Additional data on bird species of interest were obtained from BirdWatch Ireland.

Specialist ornithological surveys were carried out in 2001 (June and November) and 2002 (January). A transect method was chosen in order to cover the site completely and to obtain representative samples of the bird community present within each habitat type. Observations were made every 100m over 360 degrees, using a telescope and binoculars. Between stops constant observations were made, and the birds were identified either visually or aurally. The route taken through the site was the same for each survey. In January 2002 there were so few birds that, in addition to the above, stops were made in response to a visual or aural cue.

Table 6.4 lists the birds recorded during the 2000 to 2002 surveys.

The main differences between the summer 2001 and November 2001 survey were as follows:

- all the migrant birds (Warblers and Swallows) had migrated further south for the winter;
- Thrush, Chaffinch, Siskin, Bullfinch, Great Tit, Goldcrest and Woodpigeon were observed on site during the summer but were not seen in November; and
- Crossbills were recorded feeding on site in one location in November.

The most notable species observed during some of the bird surveys (Table 6.4) was the Hen Harrier which was seen flying over and adjacent to the site. The Hen Harrier is a frequent winter migrant to the area but rarely breeds locally (D. Strong, pers. comm.).

Woodcock (*Scolopax rusticola*) were observed during the March 2001 survey. About 14 birds were flushed from cover mainly in immature plantation. This species is a winter visitor and common in coniferous plantation. It was not recorded in subsequent surveys.

Figure 6.3: Transects Autumn Bird Survey 2003

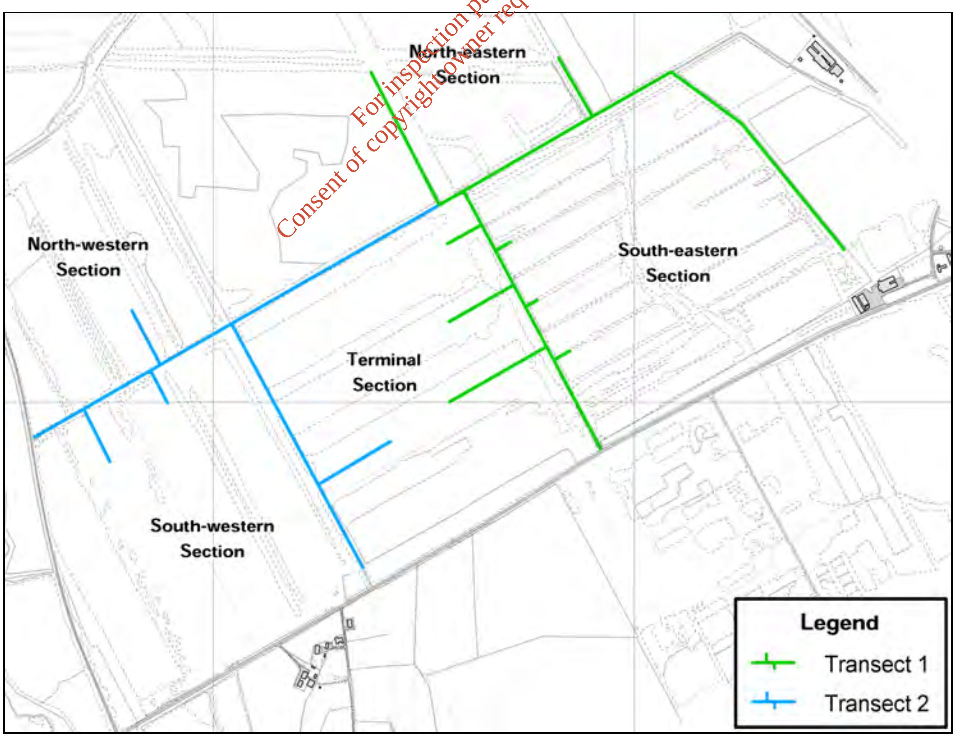


Table 6.4 Birds Recorded from Surveys During 2000, 2001 and 2002

English Name	Latin name	Status	July '00	Mar. '01	Jun. '01	Nov. '01	Jan. '02
Heron	*Ardea cinerea*	R			■		
Hen Harrier	*Circus cyaneus*	R		■ (over)	■ (over)	■*	
Sparrowhawk	*Accipiter nisis*	R				■	
Pheasant	*Phasianus colchicus*	R				■	
Snipe	*Gallinago gallinago*	R				■	
Woodcock	*Scolopax rusticola*	R		■			
Black-headed Gull	*Larus ridibundus*	R			■		
Woodpigeon	*Columba palumbus*	R			■		
Swallow	*Hirundo rustica*	M			■		
Meadow pipit	*Anthus pratensis*	R		■	■	■	
Dunnock	*Prunella modularis*	R			■	■	
Robin	*Erithacus rubecula*	R	■	■	■	■	■
Blackbird	*Turdus merula*	R	■	■	■	■	■
Song thrush	*Turdus philomelos*	R			■		
Mistle thrush	*Turdus viscivorus*	R			■		
Wren	*Troglodytes troglodytes*	R	■	■	■	■	■
Whitethroat	*Sylvia Communis*	M			■		
Willow warbler	*Phylloscopus trochilus*	M			■		
Sedge Warbler	*Arcocephalus schoenobaenus*	M			■		
Goldcrest	*Regulus regulus*	R	■	■	■		
Coal Tit	*Parus ater*	R	■			■	■
Blue Tit	*Parus caeruleus*	R	■	■	■	■	
Great Tit	*Parus major*	R			■		
Hooded Crow	*Corvus corone cornix*	R		■	■	■	■
Magpie	*Pica pica*	R		■	■	■	
Chaffinch	*Fringilla coelebs*	R	■	■	■		
Siskin	*Carduelis spinus*	R			■		
Crossbill	*Loxia curvirostra*	R		■		■	
Bullfinch	*Pyrrhula pyrrhula*	R			■		
Reed Bunting	*Emberiza schoeniclus*	R					■
Raven	*Corvus corax*	R		■ (over)			
Jackdaw	*Corvus monedula*	R		■			
Rook	*Corvus frugilegus*	R		■			

■ = recorded   * = adjacent to the site   R = Resident in Ireland   M = Migrant

Table 6.5 Birds recorded over the whole survey area September/October 2003

Common Name	Scientific Name	Status	Range of Count of Individuals
Blackbird	*Turdus merula*	M	1-3
Blue tit	*Parus caeruleus*	R	1-2
Chaffinch	*Fringilla coelebs*	M	1-16
Coal tit	*Parus ater*	R	1-9
Crossbill	*Loxia curvirostra*	M	1
Dunnock	*Prunella modularis*	M	1-9
Goldcrest	*Regulus regulus*	M	1-11
Great tit	*Parus major*	R	1
Grey heron	*Ardea cinerea*	M	1
Hooded crow	*Corvus corone cornix*	R	1-10
Linnet	*Carduelis cannabina*	M	1-12
Magpie	*Pica pica*	R	1-2
Meadow pipit	*Anthus pratensis*	M	1-10
Mistle thrush	*Turdus viscivorus*	M	1
Pheasant	*Phasianus colchicus*	R	1
Redpoll	*Carduelis flammea*	M	1
Reed bunting	*Emberiza schoeniclus*	M	2-9
Robin	*Erithacus rubecula*	M	4-39
Siskin	*Carduelis spinus*	M	5
Snipe	*Gallingo gallingo*	M	1
Song thrush	*Turdus philomelos*	M	5
Sparrowhawk	*Accipiter nisus*	M	2*
Starling	*Sturnus vulgaris*	M	1
Swallow	*Hirundo rustica*	SV	2-6
Water rail	*Rallus aquaticus*	M	1
Wood pigeon	*Columba palumbus*	M	11
Wren	*Troglodytes troglodytes*	R	1-14

M= migratory R= resident SV=summer visitor * identified as differing sexes

Autumn Migration Survey 2003

Methodology

Three recording periods were used to survey the development site study area made at fortnightly intervals between the 15th September and the 13th October 2003. Each recording period consisted of two visits corresponding to the two transects (Figure 6.3). Surveys were carried out in either the early morning or late afternoon/early evening avoiding the period between 12 pm to 3 pm when birds are usually inactive. Each transect was surveyed at least once in the morning and once in the afternoon/evening.

The visits were undertaken only in suitable weather conditions; heavy rain, strong winds over Force 4 (Beaufort Scale) and poor visibility were avoided.

The study area was walked as two linear transects; Transect 1 covered the eastern side of the study area and Transect 2 the western side (see Figure 6.3). All species seen or heard within each section were recorded. Any movement of birds observed between sections was noted and recording was made on the originating section only.

Constraints

The size and nature of the study area, with boggy ground and larger areas of woodland meant that some areas were not within the optimum survey distance of 250m. However this constraint did not apply to the proposed terminal footprint or the construction laydown area.

As with all autumn/winter surveys not all species use territorial displays to indicate their presence at this time of year.

The results given in Table 6.5 and Appendix 6.5 are collated from the raw data of all three of the recording periods. Totalling of bird data is not possible for this type of survey done over several sections and several days as the mobility of the species means errors will inevitably be introduced. These data, therefore, show the range for the whole study area and minimum number recorded in each section to indicate relative abundance.

The designations of migratory, resident and summer visitor given below relate to the general nature of the species at the time of year when the survey was undertaken. Counts for migratory species could be potentially influenced by seasonal influxes from further north as well as the numbers that may be observed all year round. Residents are those species, which are generally observed throughout the year, which stay within the locality and move only within that local area. Summer visitors are only usually observed during the warmer months of the year and move south during the autumn.

A total of 27 species were recorded in or over the study area. Of these only the Swallow is a summer visitor.

Nineteen species may be considered migratory, with potential resident populations being subject to seasonal movements, especially during the autumn. These include: Blackbird, Chaffinch, Crossbill, Dunnock, Goldcrest, Grey Heron, Linnet, Meadow Pipit, Mistle Thrush, Redpoll, Reed Bunting, Robin, Siskin, Snipe, Song Thrush, Sparrowhawk, Starling, Water Rail and Woodpigeon.

The remaining seven species are resident with only local movement; Blue Tit, Coal Tit, Great Tit, Hooded Crow, Magpie, Pheasant and Wren.

6.3.6 Fauna – Evaluation

Species of conservation interest

Mammals

A number of mammalian species are protected under the Wildlife and Amendment Acts, 1976 and 2000, some of which are known to be present on site or may occur on site occasionally. These include badger, otter, pine marten, pygmy shrew, hedgehog, Irish hare, Irish stoat, and bats. Several of these species may be considered as common species and ubiquitous through much of the Irish countryside. The badger, pine marten, stoat and Pipistrelle bats would be less common in upland or western landscapes, whereas the Irish hare would be frequent. Otters and all bat species likely to occur on site are also protected under Annexe IV (Annex II also for otters) of the EU Habitats Directive.

The pine marten is widespread throughout the conifer plantations of north County Mayo (information from NPW for the Mayo National Park Feasibility Study 1995/96).

It is an offence to wilfully interfere with or destroy the breeding or resting place of these species (Wildlife and Amendment Acts 1976 and 2000); there are exemptions for certain kinds of infrastructural construction developments.

The species of particular importance is the badger. Best practice requires provision for the humanitarian removal of this species if necessitated, or for conservation of the species on site.

Other mammals would be affected principally by loss of habitat. Pine marten and Pipistrelle bat are not known to breed on site. The Irish hare would be expected to relocate during any construction works. There would be some impact on hedgehogs, if present.

Whilst mammal activity on site during the most recent survey (2003) survey was low, it is considered that full mitigation measures (below) recommended on the basis of earlier surveys do not require revision. Badgers may return to the site in future, and other species continue to utilise the site. Adequate measures to ensure the welfare and continued use of the site by mammals need to be incorporated into any revised Planning Application.

Reptiles and Amphibians

The common lizard, the common frog and the smooth newt are all protected species under the Wildlife and Amendment Acts, 1976 and 2000.

The common frog is "considered to be widespread and common in Ireland" (Whilde, 1993) but is a listed Red Data species owing to its vulnerability in the rest of Europe. It is necessary to ensure protection of breeding sites where these have been identified and it is good practice to make provision for maintenance of the species if possible. In practice, provisions are often made for the common frog.

Birds

Most bird species are protected under the Wildlife and Amendment Acts (1976 and 2000), except for those defined as pest species and game species (where they may be hunted under conditions). It is an offence to disturb the breeding place of protected species, though there are exemptions for certain developments.

In practice, for the generally common species, provision is made to limit the season of removal of vegetation and the destruction of nesting habitat. Section 46 of the Wildlife Amendment Act, 2000 makes it an offence to destroy any vegetation growing on any uncultivated land from 1st March to 31st August. However there is an exemption for certain kinds of infrastructural construction developments.

None of the species recorded during the 2003 survey appears on Annex 1 of the EU Birds Directive. This Annex lists species that are subject to special conservation measures concerning their habitat in order to ensure their survival and reproduction in their area of distribution.

In the earlier surveys a Hen Harrier - an Annex I species under the EU Birds Directive - was seen flying over the site and over adjacent areas. There is, however, inadequate heather cover within the site to support this species. This species is known to be a regular visitor to the locality (D. Strong, NPW, pers.comm.).

Four species appear on the list of medium conservation concern used by conservation NGOs within Ireland; these were Redpoll, Snipe, Swallow and Water Rail. The Swallow has unfavourable conservation status in Europe and whilst not on the Annex 1 list, it is of European conservation concern. The other three species are included on this list as breeding species with moderate decline, rare/sporadic breeding and/or internationally important or localised.

All other species recorded appear in the 'not threatened' sections of these NGO lists.

The crossbill is an introduced species of some curiosity interest but of no particular conservation value. It is known to occur in nearby mature spruce plantations, and is relatively common in this habitat in north Mayo generally (D. Strong, pers. comm., and data from BirdWatch Ireland).

Corncrake (*Crex crex*) has been known to occur in the wider locality (data from BirdWatch Ireland) but the dense rush cover of the wet grassland areas render these grasslands unsuitable for this species. Nests or calling birds have not been recorded on the site (survey data from BirdWatch Ireland to October 2003). The nearest nest sites to the proposed terminal were recorded from Aghoos and near Pollatomish village in 1997 and 1999 respectively. The most recent records of calling birds were for Rossport and Carrowteige in 2002 and 2003.

In terms of habitat, the areas found to have the greatest diversity and numbers of birds were the areas of scrub and the forest edges.

6.3.7 Designated Areas

Designations and Legislation

The Wildlife and Amendment Acts, 1976 and 2000, their associated statutory instruments and Natural Habitat Regulations (for cSACs) are implemented and controlled by the National Parks and Wildlife (NPW) Section of the Department of the Environment, Heritage and Local Government. NPW is also responsible for the designation of sites.

Candidate Special Areas of Conservation (cSACs)

The Natural Habitat Regulations, 1997 enabled the designation of candidate Special Areas of Conservation (cSACs) under Article 3 of the Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora (the Habitats Directive), as part of the Natura 2000 network. This network comprises Annex I habitats - *"natural habitat types of community interest whose conservation requires the designation of Special Areas of Conservation"* and the habitats of Annex II species - *"animal and plant species of community interest whose conservation requires the designation of Special Areas of Conservation".* In addition, the Directive states that: *"The Natura 2000 network shall include the special protection areas classified by the Member States pursuant to Directive 79/409/EEC.".*

Special Protection Areas (SPAs)

Special Protection Areas (SPAs) are designated under Directive 79/409/EEC of 2 April 1979 on the conservation of wild birds (the Birds Directive). Under the Directive, Ireland is obliged to protect the habitats of birds, which are vulnerable to habitat change or to low population numbers. Aspects of habitat protection are in the context of pollution, deterioration of habitat and disturbance. This Directive is implemented in Ireland under Statutory Instrument (1985) and is encompassed by the Wildlife and Amendment Acts, 1976 and 2000.

Proposed Natural Heritage Areas (pNHAs)

There is provision for legal protection for Natural Heritage Areas (NHAs) under the legislation enacted in the Wildlife (Amendment) Act 2000.

Designated Areas in the Wider Locality

A number of designated conservation areas are found at varying distances from the site. Potential direct and indirect effects of the terminal development are considered in this EIS where appropriate. Further discussions can also be found in the Peat Deposition volume of this EIS, the Pipeline Environmental Report and Offshore EIS produced for the scheme.

Designated conservation areas within 10km of the proposed terminal are listed below. The distance from the proposed terminal to the nearest point of the designated area is indicated as (km) after the site number.

- Glenamoy Bog Complex - cSAC 500 (2km) (includes Sruwaddacon Bay SPA);
- Carrowmore Lake Complex - cSAC 476 (1.5km);
- Pollatomish Bog – pNHA 1548 (1.75km);
- Slieve Fyagh Bog - cSAC 542 (2km); and
- Broadhaven Bay - cSAC 472 (8km).

Site descriptions (site synopses from NPW) for these are provided for information in Appendix 6.3. It should be noted that a site synopsis description covers an entire designated area which in the case of the above sites, with the exception of the Pollatomish Bog pNHA, are very large and extensive, many parts being quite remote from the site of the proposed development at Bellanaboy.

The following paragraphs give a brief outline of the ecological interest and significance of the designated areas listed above.

Glenamoy Bog Complex / Sruwaddacon Bay SPA

Extensive areas of blanket bog within this complex are internationally important in terms of their vegetation composition (EU Habitats Directive). Those areas of cSAC blanket bog nearest to the terminal site - in the region of the Glenamoy River to the east of the site c. 2.5km distant - are generally of lesser quality in habitat terms, having been subject to much marginal turf cutting, manual and mechanical, resulting in drainage and edge effects. The more floristically important and intact areas tend to occur further to the north-east in the less accessible areas of the complex.

The drains in the north and eastern sections of the terminal site currently feed into small streams, which in turn drain into the Glenamoy River which flows into Sruwaddacon Bay, approximately 2km due north of the proposed terminal footprint. Sruwaddacon Bay is an SPA and is part of the Glenamoy Bog Complex cSAC 500. It is a shallow tidal inlet off Broadhaven Bay (cSAC 472) and is of special importance for its wintering wildfowl populations, which feed on the intertidal sand/mud flats. It forms an integral part of the Glenamoy River salmonid fishery. See also Section 7 on aquatic ecology.

Carrowmore Lake Complex cSAC

Associated areas of blanket bog and nearby reclaimed fields to the north east of the Lake are the traditional feeding grounds for a flock of Greenland White-fronted Geese (GWFG - *Anser albifrons flavirostris*), particularly those areas adjacent to the Bellanaboy River and slightly further south towards Glenturk (pers. comm. D.Strong and T. Murray, NPW, 2003). Intact areas of the blanket bog itself are of floristic interest but much of the bog, particularly the fringes adjacent to roads, has been heavily grazed with some surface erosion occurring. The lake itself is located to the south-west of the terminal site and is fed by a number of streams. Refer also to Section 7.

Pollatomish Bog pNHA

Pollatomish Bog is situated on the Glenamoy-Belmullet road about 7km south of Pollatomish. It is the nearest designated area to the proposed terminal site being to the west side of the Aghoos River and approximately 1.5km distant at the nearest point. The NPW site synopsis describes the site as "an area of uniform blanket bog with a steep slope reaching up to 100 m in the centre of the site, and is a typical Atlantic Blanket Bog area. It is quite wet with species-rich moss (*Sphagnum spp*.) lawns. Tussocks with Deergrass (*Scirpus caespitosus*) and Bog-myrtle (*Myrica gale*) are common, while pools with Bog Bean (*Menyanthes trifolium*), Bladdwort (*Ultricularia minor*) and mosses (*Sphagnum spp.)* are also found. Further up the slopes the habitat becomes drier and heathy, with Ling Heather (*Calluna vulgaris*) becoming dominant".

The site is grazed by sheep and cattle and has been drained in places. Turf cutting has been carried on peripherally in the past, now somewhat diminished in size, it remains as a good example of Atlantic blanket bog.

Slieve Fyagh Bog

Slieve Fyagh Bog is located about 2km south-east of the proposed terminal site. "It is bounded on the north by the Glenamoy River, on the east and west by forestry plantations, and on the south by the Glencullin River".

This site is "important for the occurrence of mountain blanket bog, a habitat that is uncommon in this region". The summit plateau is one of a number of traditional feeding grounds for the flock of Greenland White-fronted Geese which also uses the Carrowmore Lake Complex sites (NPW pers. comm.). "The extensive lowland blanket bog that surrounds the plateau is damaged and under threat from overgrazing and peat erosion."

Broadhaven Bay

Broadhaven Bay is a large bay situated between the north-east side of the Mullet Peninsula and the north-west Mayo coast. The nearest point of this site to the proposed terminal is 8km. "The shoreline is comprised mostly of shingle beaches and sandy beaches, as well as marginal habitats such as cutaway bog, heathland, dune grassland and machair, wet grassland, tidal rivers and dry pasture, which is used for grazing". There are several extensive areas of intact saltmarsh, which is heavily grazed in places. The presence of wintering waterfowl, including the internationally important Brent Goose and breeding Terns adds to the importance of this site. See also Section 7.

Ramsar Sites

"Ramsar" refers to an international convention in relation to wetland sites which was ratified by Ireland in 1985.

The Convention has its roots in the protection of wetland wildfowl and for many sites it is species-associated. For example, the Owenboy Nature Reserve (part of the Bellacorick Bog Complex cSAC) and the Owenduff/Nephin Complex cSAC (Mayo National Park) both have Ramsar designation primarily because they are winter feeding grounds for the internationally protected Greenland White-fronted Goose (GWFG - *Anser albifrons flavirostris*). More recently Ramsar has taken on the more, all-encompassing, wetland habitat approach which - in the context of the EU - falls in line with site protection under the Habitats Directive.

Thus, Broadhaven Bay cSAC is part of the Blacksod Bay and Broadhaven Ramsar site (no.844, with an area of 683 ha) which was designated on 11th June 1996. This site equated to the Blacksod/Broadhaven SPA prior to the site review during the 1990s and subsequent cSAC designations. Sections of these sites are now incorporated into three cSACs, namely Mullet/Blacksod Complex, Broadhaven Bay cSAC and the Glenamoy Bog Complex cSAC.

International conventions such as Ramsar are effectively recommendations to countries to implement certain protection measures. In comparison with national and EU legislation these conventions might be thought of as "soft" legislation. (Way et al 1993).

The Ramsar Convention has no statutory basis itself, it is operated through either EU or national legislation. In this case the EU Birds Directive and EU Habitats Directive, the Wildlife and Amendments Acts, 1976 and 2000. NPW are the enforcing authority for these sites.

Ramsar requires that "wise use" is carried out for wetland sites. Part of this is the EIS/EIA process. If the EIA process concludes that there would be significant damage to such a site, then NPW has to report to the Ramsar Convention Bureau. Essentially Ramsar is in line with the concept of sustainable development rather than absolute protection.

6.4 Characteristics of the Proposed Development

The proposed planning development area covers approximately 160ha. Within this, the terminal (and its associated buildings and car parking) will occupy approximately 13ha. In addition 1 ha of the eastern section of the site will be used as a temporary construction area.

6.4.1 During Construction

The construction project involves the excavation of approximately 450,000 m^3 of peat. The material, once excavated, will be removed from the site.

The construction will commence with the installation of an access road, site fencing and the construction of a site perimeter drainage system. This will substantially reduce construction impacts to the surrounding areas of bog. The site preparation phase of the construction programme is planned to commence following receipt of planning permission.

6.4.2 During Operation

During operation of the proposed terminal noise, waste water, light and air emissions would marginally increase. Clean run-off from the terminal site will also be directed into local watercourses. Measures have been taken to minimise these effects. Details are given in relevant section so this EIS and summarised in Sections 17 and 20.

6.5 Potential Impact of the Proposed Development

6.5.1 Method of Impact Assessment

The method of impact magnitude and significance assessment follows that of Regini (2000 & 2002).

Table 6.6 Impact magnitude (Regini, 2000)

Magnitude	
High magnitude	Loss of most of the site area* ie. >50%
Medium magnitude	Loss affecting 20 – 49% of the site area.
Low magnitude	Loss affecting 4 – 19% of the site area.
Very low magnitude	Loss affecting up to 4% of the site area.

* where site equates to a designated area.

In the first instance it is necessary to establish the magnitude of the impacts. In the case of the proposed development only the habitats under the terminal footprint and under the temporary construction area will be lost. However, impacts over the surrounding area also need to be taken into account.

In this case because the area to be impacted represents less than 10% of the whole development site, the impact magnitude level is Low Magnitude (Table 6.6).

The site is not designated and is of generally Low Local or Negligible value, at most Moderate Local (willow scrub). In addition the habitats and species within the survey area are not rare or unique to it.

Impact magnitude is also classified in terms of the temporal extent of the impact. In this case the temporal impact is classified as permanent, notwithstanding any mitigation measures such as compensation habitat. Even with a high magnitude classification of impact, when sites of Low Local value or less are examined in Table 6.7, it is noted that the actual impacts would be classified as Minor.

Turning then to Table 6.7, with impact at Low Magnitude, the impact significance for habitats of Low Local value is shown to be Negligible or Minor; and for those with Moderate Local value the impact is considered to be Minor

6.5.2 During Construction

Impacts on Flora and Habitats

Only the habitats under the terminal footprint and under the construction laydown area will be lost. Provision will also be made for access roads/upgrading of existing roads and tracks so it is likely that some marginal vegetation will be lost along the main access road also. The existing drainage system of narrow channels and small streams within the terminal footprint will also be affected.

Any native trees affected, such as willow, will be translocated where possible.

The affected habitats, wet grassland, coniferous plantation and small pockets of scrub, are both widespread and common. They support a limited range of generally common species and the forest belts provide limited aesthetic appeal. These habitats are generally of low ecological interest. From Tables 6.6 and 6.7 it may be seen that the impact significance is considered to be Negligible or Minor (in the case of willow scrub).

Table 6.7 Impact Significance Matrix (Regini, 2000)

Impact Magnitude	Value of feature				
	International	National	High Local	Moderate Local	Low Local
High	Critical	Major	Moderate or Major	Minor or Moderate	Minor
Medium	Critical	Major	Moderate	Minor or Moderate	Minor
Low	Critical	Major or Moderate	Moderate or Minor	Minor	Negligible or Minor
Very Low	Critical or Major	Moderate	Moderate or Minor	Minor	Negligible

In addition to the direct loss of habitat due to the excavation of the peat required for the terminal development, there is also the potential that the blanket bog surrounding the edge of the footprint will experience some degree of drying out. It is likely that the extent of such a drainage effect will be very limited because the permeability of the peat is very low and this has been proven by tests on site (see Section 9). Although there appears to be little published information regarding the long term impact of drainage on blanket bog hydrology, recent research has indicated the subsidence of the peat surface 40 m away from the edge of an area of forestry plantation within 30 years (Townsend et al., 1997). The surface water and groundwater regime of the site is addressed in detail in Section 9.

In addition to the habitat loss within the site, there will be some habitat loss in the strip of land south and adjacent to the R314. These habitats are commonly occurring throughout the locality and of Negligible to Low Local value. The impacts here are considered to be Negligible or Minor.

Impacts on Fauna

Potential impacts relate principally to loss of habitats within site affecting:

- loss of foraging habitat for species such as badger;
- loss of breeding and foraging habitat for frogs;
- loss of foraging habitat for otters owing to a potential reduction in their principal late winter/early spring prey item – the frog;
- loss of breeding or resting sites; and
- increased risk of mortality on local roads (principally badgers).

The overall impacts on fauna may be considered as Minor.

The loss of habitat in the area occupied by the terminal footprint and construction areas will restrict the presence of common faunal species. However, these species will continue to inhabit the adjoining landscape. The development will reduce the feeding habitat for species foraging over the area, such as any badgers, and frogs in particular. Disturbance due to traffic and general activity is not likely to have any significant impact on most faunal species present in the area.

There will be no development close to the formerly active main badger breeding sett to the north-west of the study area. In the case of any further setts being discovered (albeit unlikely owing to the unsuitable soil conditions) in those parts of the study area which were impenetrable and thus not surveyed, measures will be adopted to protect/remove the badgers. (see Mitigation Measures, Section 6.7).

It is suggested that the semi-mature conifer plantation be retained for badger habitat and for screening.

The potential loss of frog spawning areas will impact on this species locally. Most of the identified breeding pools (often transient) are located close to roads and tracks, so that most pools will be affected by the development. Provision of compensation habitat is recommended. (see Mitigation Measures, Section 6.7).

In view of the lack of semi-natural woodland and scrub on the site, scrub woodland planting would increase the vertebrate fauna in the area by provision of alternative foraging and breeding areas.

Potential Impacts on Surrounding Areas

Overall, the development will not affect the functioning of ecosystems, the habitats, flora and faunal diversity of adjoining afforested and blanket bog areas. Effects on the fauna of surrounding terrestrial areas are expected to be Negligible to Minor.

Impacts on the surrounding areas may be considered in terms of effects on the terrestrial habitats and fauna, the adjoining streams and rivers, and downstream impacts to the coast. Four designated conservation areas are present in the vicinity.

Minimisation of impacts on the aquatic systems and their flora and fauna, including drains on site, watercourses and the downstream lakes, estuaries and broader marine habitats, is dependent on the successful implementation of pollution control measures, including run-off control (see Section 7, Aquatic Ecology and Section 9 Hydrology and Drainage). The procedures and methods proposed will result in the development having a negligible impact.

Indirect Impacts – Designated Areas

It is not anticipated that the proposed construction and operation of the terminal facility will impact on the terrestrial habitats and constituent species of the nearby designated conservation areas - Pollatomish Bog pNHA, Glenamoy Bog Complex cSAC, Carrowmore Lake Complex cSAC and Slieve Fyagh Bog cSAC.

However, as a result of the transportation of the peat offsite there is potential, in the event of accident, for impact to sections of the Carrowmore Lake Complex cSAC which are adjacent to the Bellanaboy to Bangor Erris Road. Impacts could result from:

- pollution/fisheries issues at river and stream crossings (see Aquatic ecology Chapter 7); and
- Spillage of the peat load and fuel oil/hydraulic fluids etc. into part of the Carrowmore Lake Complex lowland blanket bog.

By putting in place basic precautions and a strictly controlled traffic management plan, the potential for such an incident will be minimised.

In this context, National Parks and Wildlife have requested that a pre-construction baseline survey of the areas of Carrowmore Lake Complex cSAC blanket bog adjacent to the road be carried out. The survey will:

- record the existing vegetation and its present condition;
- identify which areas are of particular sensitivity; and
- check on the occurrence (if any) of protected plant species.

There is, theoretically, potential for disturbance to Greenland White-fronted Goose (GWFG) whose traditional feeding areas lie between the road and Carrowmore Lake itself. Though this would only become an issue if the peat is transported during the period from October and to late February/early March. However consultations with NPW (D. Strong, personal communication) indicate that this flock of GWFG are very tolerant of traffic noise, so that little, if any, disturbance to the geese might be expected.

6.5.3 During Operation

The Terminal Site

Potential sources of impacts include noise and light disturbance and effects on watercourses through runoff from the terminal site.

The procedures and mitigation methods proposed will result in the development having negligible impact.

Worst Case Scenario

The operation of the terminal should not lead to significant impact on local flora and fauna even under 'a worst case scenario'. The exception to this would be through a major pollution incident or fire.

The otter (*Lutra lutra*), an Annex II species under the EU Habitats Directive, and other riparian species could potentially be affected downstream. The otter is susceptible to organochlorines and heavy metals. Pollution incidents could also affect several of the Annex I Birds Directive species that occur in the designated conservation areas.

In the case of fire during very dry weather, areas of adjacent blanket bog could be at risk. Owing to the capacity of peat to burn deeply for long periods this could have the potential for a highly detrimental result. Specific mitigation measures will have to be adopted during construction to take account of such non-routine events.

In the case of indirect impacts associated with the transportation of peat, a worst case scenario would occur if a truck were to leave the road and spill either its peat load or fuel/hydraulic fluid etc. into Carrowmore Lake Complex cSAC blanket bog, or any of the watercourses draining into the Lake. However, a properly implemented traffic management plan will minimise the likelihood of such an event.

6.6 Do Nothing Scenario

If the development did not proceed, the habitats affected by the proposed terminal would remain intact. However, further planting of conifers in the remaining wet grassland areas would be expected to take place in the near future.

In the absence of further planting of the wet grassland areas, it is probable that scrub encroachment would become more widespread. The presence of the aggressive Rhododendron species on the site, adjacent to these grassland areas, suggests that it would dominate rather than the native willow species. The spread of Rhododendron is known to be harmful to flora and fauna species diversity.

Over time, available foraging habitats for frogs, i.e. the areas of wet rushy grassland and immature plantations, would diminish and consequently the numbers of frogs also.

6.7 Mitigation Measures

6.7.1 General

Standard mitigation measures, as would apply to any large-scale development, will be adopted in the construction and operation of this development.

These include:

- limiting the season of disturbance to trees and vegetation, so as to reduce impacts on breeding species;
- provision for compensation habitat;

- introduction of measures to reduce pollution and sedimentation of watercourses during construction, operation and post-operation phases;
- retention of existing semi-mature plantation for screening of the development; and
- the creation of alternative habitats, e.g. planting belts of native scrub species.

6.7.2 Protection of Birds

There are areas of shrub boundary, grassland and afforestation to be removed, which provide a feeding and nesting habitat for birds as well as other fauna. The following mitigation measures will be taken:

- a breeding bird survey will be carried out prior to construction, within the preferred season of survey, i.e. late April - mid June;
- a site inspection will be carried out immediately prior to construction;
- efforts will be made to deter birds nesting prior to the first construction season;
- clearance of areas of vegetation, where required, will preferably take place outside the bird nesting season; and
- scrub areas will be enhanced by further planting of native species.

It is anticipated that construction activities on site will to some extent deter birds in the immediate vicinity of the works until completion.

6.7.3 Mammals

It has been noted that in October 2003 badgers no longer appeared to be present on site. This was not anticipated and the reasons for badger absence at this time are unclear. Lack of badger signs on site suggests that the territory is no longer occupied. However, various mitigation measures were considered for mammals on site after the earlier surveys when badgers activity was evident. So whilst mammal activity on site during the autumn 2003 survey was low, the mitigation measures recommended will nevertheless be implemented. Adequate measures to ensure the welfare and continued use of the site by mammals need to be addressed. Badgers may return to the site in future, and other species continue to utilise the site.

Protection of Badgers

It is an offence under the Wildlife and Amendment Acts, 1976 and 2000, to interfere with setts.

A detailed survey will be carried out prior to construction to identify any active setts present on site. The April 2003 survey suggested that not all setts could be found on site due to heavy cover; any unidentified setts are expected to be minor or outlier setts. The following mitigation measures will be carried out:

- all vegetation (scrub/woodland) clearance will be monitored by experts; and
- where possible, scrub clearance will take place prior to heavy construction. Any additional setts will be identified and dealt with prior to heavy construction machinery entering the vegetated portions of the site.

Any small setts identified from badger surveys or during monitoring of vegetation clearance on affected portions of the site will require attention. Affected setts must be evacuated and blocked off by experts under licence from NPW (two months is required to obtain this licence). There are, however, no particular seasonal constraints for this procedure.

No works are anticipated in the area of the main sett at the north-west. If any are considered then the following will apply:

- the area of these setts shall be fenced off prior to construction proceeding. Fencing is required to prevent construction traffic affecting these setts;
- badger-proof wildlife fencing is not a requirement, as badgers utilise the entire site. Badgers will avoid areas disturbed during construction;
- fencing will be provided to protect the setts within a distance of 30m from sett entrances; and
- the extent of fencing will be agreed prior to construction in consultation with wildlife experts.

Any additional larger setts (main breeding or annexe) identified on affected portions of the site would be evacuated and blocked off by experts under licence from NPW (two months is required in advance to obtain this licence). Experts, by means of excavation, would then destroy the setts outside the period between mid-December to the end of June (breeding season). The procedures for evacuation of larger setts require c. 3 weeks.

The terminal site may require security and stock-proof fencing. Badgers will be allowed access to all vegetated portions of the site. The following measures will be put in place:

- openings will be constructed at 100m intervals along all stock-proof and security fencing to allow wildlife to enter and leave (opening need be only c. 30cm wide x 25 cm tall);
- particular attention will be paid to provision of openings at known badger paths/crossing points

(additional advice to be sought from badger experts); and

- during construction the site will be maintained as far as possible to prevent harm to any badgers coming onto the site.

Protection of Otters

Otters were found to forage over portions of the site, and are likely to forage over most of the site in search of frog prey, principally in late winter and spring. Holts or resting places may be present within heavy scrub. They are known to access the site from the north-west and may also access along small drains and streams at the south-east. Otters will avoid disturbed areas but will continue to benefit from frog prey present on site and will utilise areas created for frogs (see below) in future also.

- all vegetation (scrub/woodland) clearance will be monitored by experts prior to check for otter holts.;
- any holts identified will require evacuation of otters in similar manner to that required for badgers, and under licence from NPW; and
- any fencing or culverting of drains or streams entering or leaving the site will allow free access for otters through them. Culverts will be large enough to allow such passage. Additional expert advice should be sought in design and construction.

Bats

All bats are protected under the Wildlife and Amendment Acts and EU Habitats Directive. It is considered that no special measures are required on site. General habitat retention or replacement measures will continue to provide feeding habitat for species foraging in the area. No bat roosts are known or anticipated on site.

6.7.4 Protection of Amphibians: Common Frogs

Frogs are common on site and there are numerous breeding pools of which many are of a transient nature. It is considered that loss of these populations may have impacts on frog populations locally, with limited impacts on frog predators also. The following mitigation measures are proposed:

- reasonable measures will be taken to protect the species locally, especially during construction;
- compensation habitat in the form of small shallow pools will be provided; together with constructed wetland. It is important that any frog mitigation should result in clear water areas preferably on mineral soil as frogs will not use black peaty pools for spawning;
- native plant species will be used and will comprise those species already occurring on the site; and
- existing breeding pools to be affected will be filled in during autumn or early winter to ensure that these cannot be used by frogs prior to the time of construction. Any frogs and frogspawn already present in a pool affected by construction will be removed and placed in alternative pools. Preference is given to translocation of adult frogs and spawn rather than tadpoles, as the latter will have poor survival rate if removed to new pools. This should be carried out by experts under licence from NPW.

6.7.5 Habitat Retention, Replacement and Landscaping

Habitat replacement and landscaping could substitute for, and enhance, the diversity of the flora and wildlife ecological value of the area and will help to integrate the development into the landscape whilst providing areas of aesthetic as well as wildlife interest.

Native species such as Willow and Alder will be used to supplement and enhance existing small areas of scrub; this will be directly beneficial for birds and invertebrates.

Additional planting will include areas of native trees and shrubs to replace those areas to be felled/cleared. Planting will reflect the native species present in the locality.

Existing semi-mature plantations that border the site to the south-east, south-west and north-west will be maintained and allowed to increase in height and structure, thus continuing to provide mature coniferous habitat for wildlife in addition to screening of the development.

Wetland compensation habitat will be created as breeding sites for frogs and managed accordingly.

6.7.6 Mitigation for Indirect Impacts

As a precaution - in case of an accident involving spillage of load or pollutants into the blanket bog areas of the Carrowmore Bog Complex during transportation of the peat - a pre-construction baseline vegetation survey of the areas of cSAC blanket bog adjacent to the Bellanaboy to Bangor Erris road will be carried out in consultation with NPW. The survey will:

- record the existing vegetation and its present condition;

- identify which areas are of particular sensitivity; and
- check on the occurrence (if any) of protected plant species.

6.8 Predicted Impact of the Proposed Development

6.8.1 Terminal Site During Construction

Flora and Habitat

Clearance of the terminal footprint for construction of the proposed terminal will result in the loss of the existing vegetation. However, as shown previously, the vegetation types currently present on the site are the result of intense habitat modification over a number of years. Little of the original blanket bog vegetation remains, and plant species diversity has been greatly reduced. The resulting loss of habitats from this site will therefore not be particularly significant in terms of the vegetation of the site. See impact assessment in Section 6.5 above.

Fauna

The predicted impact of the construction of the proposed terminal will include disturbance, loss of habitat and wildlife refuge, and impacts on watercourses in the footprint and the immediate vicinity of the terminal. However, the overall impact will be minimised through appropriate mitigation (see also Section 9).

6.8.2 The Terminal Site During Operation

The use of sympathetic lighting schemes appropriate to the rural surroundings of the site, best available technology to reduce noise levels, and appropriate drainage mitigation measures will ensure that impacts caused by noise and lighting are minimised. Further details are provided in Sections 2, Project Description and Section 12, Noise.

Flora and Fauna

If the proposed terminal is constructed and operated following the procedures described in this document, the overall impact of the development will be Negligible or Minor in terms of effects on fauna and habitats.

6.9 Monitoring

The mitigation measures, including species mitigation, habitat replacement and habitat creation, will be monitored at appropriate intervals during the initial years of operation of the terminal facility to ensure successful implementation.

Good practice also requires that adjoining and nearby areas, especially designated conservation areas, are monitored for impacts, including indirect impacts along the peat transportation route from Bellanaboy to Bangor Erris. This work will be undertaken in consultation with NPW.

6.10 Reinstatement and Residual Effects

6.10.1 Terminal Site

Suitable habitat replacement and creation should allow for an increase in the representation of flora and faunal species in the area and ameliorate losses of existing habitat on site.

In addition, in vegetation terms, re-colonisation of exposed peat etc. will result in the development of new plant communities giving rise to further study opportunities and the understanding of the dynamics of peatland plant communities. It is probable that alien species and other ruderal species will establish on the periphery of the site in the short term.

APPENDIX 6.1 List of Plant Species Recorded Within the Site During the Surveys of 2000, 2001 and 2003

Note: Frequency of occurrence in Ireland: vascular plants - according to Webb (1996);
Frequency of occurrence in Ireland: mosses - according to Smith (1978);
Frequency of occurrence in Ireland: liverworts - according to Paton (1999) and Watson (1968)

A. Tracks and Margins

Latin name	English name	Frequency of occurrence on the site - DAFOR scale (see text)	Frequency of occurrence in Ireland
Achillea ptarmica	Sneezewort	R	Very frequent in the northern half
Agrostis stolonifera	Creeping Bent	F	Abundant
Alnus incana	Grey Alder	R	Introduced – planted for timber/shelter.
Alopecurus geniculatus	Marsh Foxtail	O	Frequent
Anthoxanthum odoratum	Sweet Vernal Grass	F	Abundant
Arrhenatherum elatius	False Oat-Grass	R	Abundant
Athyrium filix-femina	Lady Fern	R	Very frequent except in the centre
Bellis perennis	Daisy	O	Abundant
Betula spp.	Birch	R	Very frequent and locally abundant
Blechnum spicant	Hard Fern	O	Very frequent
Bromus hordeaceus	Soft Brome	R	Common
Carex disticha	Brown Sedge	R	Frequent except in the south west
Carex flacca	Glaucous Sedge	R	Abundant
Carex ovalis	Oval Sedge	O	Frequent
Carex pilulifera	Pill Sedge	R	Frequent
Carex pulicaris	Flea Sedge	R	Very frequent
Carex viridula subsp. *oedocarpa*	Short-stalked Yellow Sedge	O	Very frequent to abundant
Centaurea nigra	Knapweed	O	Abundant
Cerastium fontanum	Common Mouse-Ear	F	Abundant
Cirsium palustre	Marsh Thistle	O	Abundant
Cirsium vulgare	Spear Thistle	O	Abundant
Crocosmia x crococsmiiflora	Montbretia	O	Abundant in west and south, occasional elsewhere
Cynosurus cristatus	Crested Dogs' Tail	F	Abundant
Dactylis glomerata	Cocks' Foot	O	Abundant
Digitalis purpurea	Foxglove	O	Very frequent
Dryopteris affinis	Scaly Male Fern	R	Very frequent in the west
Dryopteris dilatata	Broad Buckler Fern	F	Very frequent
Dryopteris filix-mas	Male Fern	O	Widespread and abundant
Equisetum palustre	Marsh Horsetail	F	Frequent
Euphrasia officinalis agg.	Eyebright	O	Frequent but local
Festuca rubra	Red Fescue	O	Abundant
Geranium dissectum	Cut-leaved Cranesbill	R	Very frequent
Glyceria fluitans	Floating Sweet-Grass	O	Very frequent
Gnaphalium uliginsum	Marsh Cudweed	R	Frequent
Holcus lanatus	Yorkshire Fog	F	Abundant
Hypericum pulchrum	Heath St. Johns' Wort	R	Abundant
Hypericum tetrapterum	Square Stalked St.Johns' Wort	R	Abundant
Hypochoeris radicata	Cats' Ear	O	Abundant
Isolepis setacea	Bristle Club-Rush	O	Frequent
Juncus articulatus	Jointed Rush	O	Abundant
Juncus bufonius	Toad Rush	O	Abundant
Juncus bulbosus	Bulbous Rush	O	Frequent to abundant
Juncus effusus	Soft Rush	L D	Abundant
Lathyrus pratensis	Meadow Vetchling	O	Abundant
Lolium perenne	Perennial.Rye Grass	O	Abundant
Lotus uliginosus	Marsh Bird's Foot Trefoil	O	Abundant
Luzula multiflora	Heath Woodrush	O	Very frequent
Lysmachia nemorum	Yellow pimpernel	R	Frequent
Lythrum portula	Water Purslane	O	Frequent in the southwest, occasional elsewhere
Lythrum salicaria	Purple Loosestrife	O	Abundant in the west
Matricaria discoidea	Pineapple Weed	R	Abundant

Molinia caerulea	Purple Moor-Grass	O	Frequent throughout, abundant in the west
Nardus stricta	Mat Grass	R	Abundant in the north and west
Odontites verna	Red Bartsia	O	Abundant
Olearia macrodonta	Daisy Bush	R	Introduced – planted in a number of areas in the west
Persicaria maculosa	Redshank	R	Abundant
Phragmites australis	Common Reed	O	Very frequent
Plantago lanceolata	Ribwort Plantain	O	Abundant
Plantago major	Greater Plantain	O	Abundant
Poa annua	Annual Meadow-Grass	O	Abundant
Poa trivialis	Rough Meadow-grass	F	Abundant
Potentilla anserina	Silverweed	O	Abundant
Potentilla erecta	Tormentil	A	Abundant
Primula vulgaris	Primrose	R	Frequent in most places
Prunella vulgaris	Self Heal	F	Abundant
Pteridium aquilinum	Bracken	O	Abundant
Ranunculus acris	Meadow Buttercup	A	Abundant
Ranunculus flammula	Lesser Spearwort	R	Frequent
Ranunculus repens	Creeping Buttercup	Fr	Abundant
Rhododendron ponticum	Rhododendron	O	Introduced – extensively naturalized in woods and on bog margins and mountain sides
Rubus fruticosus agg.	Bramble	F	Abundant
Rumex acetosa	Sorrel	F	Abundant
Rumex crispus	Curled Dock	R	Abundant
Rumex obtusiflous	Broad-Leaved Dock	O	Abundant
Sagina procumbens	Procumbent Pearlwort	O	Abundant
Salix aurita	Eared Willow	F	Frequent in most districts
Salix caprea	Goat Willow	R	Fairly frequent
Salix cinerea subsp. *oleifolia*	Grey Willow	F	Very frequent
Scrophularia auriculata	Water Figwort	O	Frequent in the south and west
Senecio aquaticus	Marsh Ragwort	O	Common, especially in the west
Senecio jacobea	Ragwort	O	Abundant
Sonchus asper	Prickly Sow-thistle	R	Very frequent
Sorbus aucuparia	Rowan	O	Frequent
Taraxacum officinale agg.	Dandelion	O	Abundant
Trifolium dubium	Lesser Trefoil	O	Abundant
Trifolium repens	White Clover	O	Abundant
Ulex europaeus	Gorse	O	Abundant in the east, more local in the west
Urtica dioica	Common Nettle	O	Abundant
Veronica beccabunga	Brooklime	O	Abundant
Veronica chamaedrys	Germander Speedwell	O	Abundant
Veronica officinalis	Heath Speedwell	R	Very frequent
Veronica serpyllifolia	Thyme-Leaved Speedwell	R	Abundant in most districts
Vicia cracca	Common Vetch	R	Abundant
Vulpia bromoides	Squirreltail Fescue	O	Frequent in the south and west, occasional elsewhere
Mosses			
Calliergon cuspidatum		F	Common, sometimes abundant

B. Wet rushy grassland

Latin name	English name	Frequency of occurrence on the site (DAFOR scale see text)	Frequency of occurrence in Ireland
Agrostis canina	Velvet Bent	O	Frequent
Agrostis stolonifera	Creeping Bent	F	Abundant
Angelica sylvestris	Wild Angelica	O	Abundant
Anthoxanthum odoratum	Sweet Vernal Grass	F	Abundant
Bellis perennis	Daisy	O	Abundant
Calluna vulgaris	Ling	F	Abundant
Calystegia sepium	Hedge Bindweed	O	Frequent throughout
Carex echinata	Star Sedge	O	Frequent & locally abundant
Carex nigra	Common Sedge	O	Abundant in the north and west, frequent elsewhere
Carex pulicaris	Flea Sedge	R	Very frequent
Cerastium fontanum	Common Mouse-Ear	F	Abundant
Cirsium palustre	Marsh Thistle	O	Abundant
Dactylis glomerata	Cocks' Foot	O	Abundant
Dactylorhiza incarnata	Early Marsh Orchid	O	Frequent
Dactylorhiza maculata	Heath Spotted Orchis	R	Frequent
Dryopteris aemula	Hay-Scented Buckler	O	Frequent in the west
Dryopteris dilatata	Broad Buckler Fern	F	Very frequent
Epilobium palustre	Marsh Willowherb	F	Frequent
Erica tetralix	Cross-leaved Heath	O	Abundant
Glyceria fluitans	Floating Sweet-Grass	O	Very frequent
Holcus lanatus	Yorkshire Fog	F	Abundant
Hydrocotyle vulgaris	Marsh Pennywort	R	Frequent
Juncus articulatus	Jointed Rush	O	Abundant
Juncus bulbosus	Bulbous Rush	O	Frequent to abundant
Juncus effusus	Soft Rush	L D	Abundant
Leontodon autumnalis	Autumn Hawkbit	O	Frequent
Lolium perenne	Perennial.Rye Grass	O	Abundant
Myosotis laxa	Tufted Forget-me-not	O	Frequent and widespread
Osmunda regalis	Royal Fern	O	Very frequent in most of the west
Plantago lanceolata	Ribwort Plantain	O	Abundant
Platanthera bifolia	Lesser Butterfly Orchid	R	Frequent in the west and centre
Poa trivialis	Rough Meadow-grass	F	Abundant
Potentilla erecta	Tormentil	A	Abundant
Prunella vulgaris	Self Heal	F	Abundant
Ranunculus acris	Meadow Buttercup	A	Abundant
Ranunculus flammula	Lesser Spearwort	R	Frequent
Ranunculus repens	Creeping Buttercup	Fr	Abundant
Rumex acetosa	Sorrel	F	Abundant
Sagina procumbens	Procumbent Pearlwort	O	Abundant
Senecio aquaticus	Marsh Ragwort	O	Common, especially in the west
Stellaria uliginosa	Bog Stitchwort	O	Very frequent
Succisa pratensis	Devils' Bit Scabious	O	Widespread and abundant
Taraxacum officinale agg.	Dandelion	O	Abundant
Trifolium repens	White Clover	O	Abundant
Vicia cracca	Common Vetch	R	Abundant
Viola palustris	Marsh Violet	O	Very frequent in the north, west & south
Mosses, liverworts and lichens			
Aulacomium palustre		R	Common and locally abundant
Bryum pseudotriquetrum		O	Common
Calliergon cuspidatum		F	Common, sometimes abundant
Eurhynchium praelongum		O	Common, sometimes locally abundant
Lophocolea bidentata		F	Common and locally abundant
Marchantia polymorpha		R	Widespread throughout
Peltigera spp.		R	Common
Philonotis fontana		R	Frequent to Common
Plagiomnium affine		O	Generally distributed
Plagiomnium undulatum		O	Common
Polytrichum commune		O	Frequent to abundant
Pseudoscleropodium purum		F	Very common, sometimes abundant
Rhytidiadelphus squarrosus		O	Common, sometimes locally abundant
Thuidium tamariscinum		O	Frequent to common

C. Drains

Latin name	English name	Relative frequency of occurrence on the site - DAFOR scale	Frequency of occurrence in Ireland
Vascular plants			
Blechnum spicant	Hard Fern	O	Very frequent
Callitriche stagnalis agg.	Common Water-starwort	O	Frequent
Cardamine pratensis	Cuckoo Flower	O	Very frequent
Carex disticha	Brown Sedge	R	Frequent except in the south west
Carex echinata	Star Sedge	O	Frequent & locally abundant
Carex nigra	Common Sedge	O	Abundant in the north and west, frequent elsewhere
Dryopteris dilatata	Broad Buckler Fern	F	Very frequent
Epilobium palustre	Marsh Willowherb	F	Frequent
Epilobium parviflorum	Hoary Willowherb	R	Very frequent
Equisetum palustre	Marsh Horsetail	F	Frequent
Eriophorum angustifolium	Cottongrass	O	Abundant
Festuca arundinacea	Tall Fescue	O	Very frequent
Filipendula ulmaria	Meadowsweet	O	Frequent
Galium palustre	Marsh Bedstraw	O	Frequent and widespread
Hydrocotyle vulgaris	Marsh Pennywort	R	Frequent
Hypericum tetrapterum	Square Stalked St.Johns' Wort	R	Abundant
Iris pseudacorus	Yellow Flag	O	Abundant
Juncus articulatus	Jointed Rush	O	Abundant
Juncus bulbosus	Bulbous Rush	O	Frequent to abundant
Juncus effusus	Soft Rush	L D	Abundant
Lemna minor	Common Duckweed	R	Very frequent
Lythrum salicaria	Purple Loosestrife	O	Abundant in the west
Myosotis laxa	Tufted Forget-me-not	O	Frequent and widespread
Phalaris arundinacea	Canary Reed-Grss	O	Common
Phragmites australis	Common Reed	O	Very frequent
Ranunculus flammula	Lesser Spearwort	R	Frequent
Rorippa nasturtium-aquaticum	Water Cress	R	Very frequent in most districts
Rumex crispus	Curled Dock	R	Abundant
Stellaria uliginosa	Bog Stitchwort	O	Very frequent
Typha latifolia	Bulrush	R	
Veronica beccabunga	Brooklime	O	Abundant
Viola palustris	Marsh Violet	O	Very frequent in the north, west and south
Mosses			
Aulacomium palustre		R	Common and locally abundant
Bryum pseudotriquetrum		O	Common
Calliergon cuspidatum		F	Common, sometimes abundant
Philonotis fontana		R	Frequent to Common

D. Remnant blanket bog

Latin name	English name	Relative frequency of occurrence on the site - DAFOR scale	Frequency of occurrence in Ireland
Vascular plants			
Anagallis tenella	Bog Pimpernel	R	Abundant in the west
Calluna vulgaris	Ling	F	Abundant
Carex binervis	Green-Ribbed Sedge	R	Very frequent
Carex panicea	Carnation Sedge	O	Abundant
Carex viridula subsp. *oedocarpa*	Short-stalked Yellow.sedge	O	Very frequent to abundant
Cirsium dissectum	Meadow Thistle	R	Very frequent in the north, west and centre.
Dactylorhiza maculata	Heath Spotted Orchis	R	Frequent
Drosera rotundifolia	Round-Leaved Sundew	R	Frequent and locally abundant
Erica tetralix	Cross-leaved Heath	O	Abundant
Eriophorum angustifolium	Cottongrass	O	Abundant
Galium saxatile	Heath bedstraw	R	Frequent
Luzula multiflora	Heath Woodrush	O	Very frequent
Molinia caerulea	Purple Moor-Grass	O	Frequent throughout, abundant in the west
Nardus stricta	Mat Grass	R	Abundant in the north and west
Narthecium ossifragum	Bog Asphodel	R	Very frequent
Pedicularis sylvatica	Lousewort	R	Very frequent
Pinguicula lusitanica	Pale Butterwort	R	Frequent in the extreme west
Polygala serpyllifolia	Heath Milkwort	R	Very frequent and locally abundant
Potentilla erecta	Tormentil	A	Abundant
Rhynchospora alba	White-beaked Sedge	R	Very frequent in the west and centre
Schoenus nigricans	Black Bog Rush	O	Very frequent and abundant in the west
Succisa pratensis	Devils' Bit Scabious	O	Widespread and abundant
Taraxacum officinale agg.	Dandelion	O	Abundant
Trichophorum caespitosum	Deer Grass	R	Very frequent and locally abundant
Veronica officinalis	Heath Speedwell	R	Very frequent
Mosses, liverworts and lichens			
Cladonia portentosa		R	Common
Hypnum cupressiforme		O	Very common
Pleurozium schreberi		O	Common, sometimes locally abundant
Polytrichum commune		O	Frequent to abundant
Rhytidiadelphus loreus		O	Frequent or common
Rhytidiadelphus squarrosus		O	Common, sometimes locally abundant
Sphagnum auriculatum		R	Very common in the north and west
Sphagnum capillifolium		O	Abundant in the north and west
Sphagnum palustre		R	Abundant in the north and west
Sphagnum papillosum		O	Abundant in the north and west
Thuidium tamariscinum		O	Frequent to common

E. Immature plantation

Latin name	English name	Relative frequency of occurrence on the site - DAFOR scale	Frequency of occurrence in Ireland
Betula spp.	Birch	R	Very frequent and locally abundant
Epilobium angustifolium	Rosebay	F	Locally frequent
Olearia macrodonta	Daisy Bush	R	Introduced – planted in a number of areas in the west
Phormium tenax	New Zealand Flax	O	Introduced - planted
Picea sitchensis	Sitka Spruce	LD	Widely planted
Pinus contorta	Lodgepole Pine	F	Widely planted
Betula spp.	Birch	R	Very frequent and locally abundant
Rhododendron ponticum	Rhododendron	O	Introduced – extensively naturalized in woods and on bog margins and mountain sides
Rubus fruticosus agg.	Bramble	F	Abundant
Salix aurita	Eared Willow	F	Frequent in most districts
Salix cinerea subsp. *oleifolia*	Grey Willow	F	Very frequent
Ulex europaeus	Gorse	O	Abundant in the east, more local in the west

F. Roadside/forestry margins to the south of the R314 – 2003 survey

Latin name	English name	DAFOR	Frequency of occurrence in Ireland
Achillea millefolium	Yarrow	O	Abundant
Agrostis capillaris	Common Bent	O	Abundant
Anagallis tenella	Bog pimpernel	O	Abundant in the west
Angelica sylvestris	Wild Angelica	O	Abundant
Anthoxanthum odoratum	Sweet Vernal Grass	F	Abundant
Blechnum spicant	Hard Fern	O	Very frequent
Calluna vulgaris	Ling	O	Abundant
Carex echinata	Star Sedge	O	Frequent and locally abundant
Carex flacca	Glaucous Sedge	O	Abundant
Carex panicea	Carnation Sedge	O	Abundant
Centaurea nigra	Knapweed	O	Abundant
Cerastium fontanum	Common Mouse-Ear	F	Abundant
Cirsium palustre	Marsh Thistle	O	Abundant
Cirsium vulgare	Spear Thistle	O	Abundant
Cladonia portentosa	A lichen	O	Common
Cynosurus cristatus	Crested Dogs' Tail	O	Abundant
Dactylis glomerata	Cocks' Foot	F	Abundant
Digitalis purpurea	Foxglove	O	Very frequent
Equisetum palustre	Marsh Horsetail	O	Frequent
Erica cinerea	Bell Heather	F	Very local in centre, abundant elsewhere
Erica tetralix	Cross-leaved Heath	F	Abundant
Holcus lanatus	Yorkshire Fog	F	Abundant
Hydrocotyle vulgaris	Marsh Pennywort	O	Frequent
Hypericum tetrapterum	Square Stemmed St. John's Wort	R	Abundant
Hypnum cupressiforme	A moss	O	Very common
Hypochoeris radicata	Cats' Ear	F	Abundant
Juncus actutifloris	Sharp-flowered Rush	O	Very frequent
Juncus articulatus	Jointed Rush	O	Abundant
Juncus bulbosus	Bulbous Rush	O	Frequent to abundant
Juncus effusus	Soft Rush	F	Abundant
Lathyrus pratensis	Meadow vetchling	O	Abundant
Lolium perenne	Perennial Rye Grass	F	Abundant
Lotus uliginosus	Marsh Bird's Foot Trefoil	O	Abundant
Luzula multiflora	Heath Woodrush	O	Very frequent
Molinia caerulea	Purple Moor-Grass	F	Frequent throughout
Narthecium ossifragum	Bog Asphodel	O	Very frequent
Odontites verna	Red Bartsia	O	Abundant
Phragmites australis	Common Reed	R	Very frequent

APPENDIX 6.2 Dominant Habitat Types Which Occur on or Adjacent to the Bellanaboy Site.

The composition and ecology of the main habitat/vegetation types present at and near the proposed terminal (including ancillary works) site is outlined below. The equivalent habitat in the JNCC Phase 1 Survey Guidelines is given where possible, as are the phytosociological affinities of the vegetation and the Irish habitat classification (Fossitt, 2000).

Coniferous Plantation

Equivalent Phase 1 Survey Habitat Classification: Coniferous plantation (A1.2.2) and recently-felled coniferous woodland (A4.2)
Fossitt: (WD4) Conifer plantation
Substantial sections of the proposed pipeline route in Co. Mayo are dominated by coniferous forestry on blanket peat. These areas of forestry are at various stages of development ranging from saplings of less than 2m to mature trees in excess of 10m in height. The main tree species in these plantations are *Pinus contorta* and *Picea sitchensis*. In areas of mature plantation there is little vegetation present due to the shade cast by the trees, however in areas of plantation less than 10 years old the original blanket bog vegetation can still be seen, albeit in a drained and ungrazed state. In such circumstances *Molinia caerulea* and *Calluna vulgaris* are typically the dominant plant species. The habitat is of low ecological interest.

Wet Grassland Dominated by Juncus effusus

Equivalent Phase 1 survey habitat classification: Neutral grassland (B2) and Marsh/marshy grassland (B5)
Phytosociological synonymy: Holco-Juncetum effusi *Page 1980*
Equivalent N.V.C. community: *Holcus lanatus-Juncus effusus* rush pasture (MG10)
Fossitt: Wet grassland (GS4)
This type of wet grassland is very commonly encountered in the damp acid soils of Co. Mayo and is especially common in revegetating areas of cutaway blanket bog and abandoned wet pastures. The dominant plant species is the tall rush *Juncus effusus* and in many instances the cover of the species can be so complete that few other plant species co-occur. Vegetation where there is a very high cover of *Juncus effusus* coupled with saturated soils corresponds to the marsh/marshy grassland habitat outlined in Phase 1 survey guidelines. In slightly better drained and more open situations *J. effusus* is generally accompanied by species such as *Holcus lanatus, Agrostis stolonifera, Ranunculus acris, Ranunculus repens, Rumex acetosa, Anthoxanthum odoratum, Cardamine pratensis, Trifolium repens* and *Poa trivialis*. This type of more species-rich *Juncus effusus* grassland corresponds to the neutral grassland category (B2) outlined in the Phase 1 Survey guidelines and is transitional to the semi-improved grassland described in the next section. The vegetation of the habitat is generally of low ecological interest due to its rather species-poor nature and the general absence of rare plant species.

Improved/Semi-improved Grassland Dominated by Holcus lanatus and Lolium perenne

Equivalent Phase 1 survey habitat classification: Semi-improved neutral grassland (B2.2) and Improved grassland (B4)
Phytosociological synonymy: Lolio-Cynosuretum cristati *Braun-Blanquet et De Leeuw1950*
Equivalent N.V.C. community: *Lolium perenne – Cynosurus cristatus* grassland (MG6).
Fossitt: (GA1) Improved agricultural grassland.
This grassland type encompasses the better-drained, more agriculturally productive grasslands encountered during the pipeline route survey in Counties Mayo and Galway. In north-west Mayo many areas of this grassland occur on recently reclaimed blanket bog and thus have a damp, acid soil. The dominant species in the vegetation is usually either *Holcus lanatus* or *Lolium perenne* however *Cynosurus cristatus* and *Poa pratensis* can also be locally dominant. Other common and ubiquitous species include *Plantago lanceolata, Trifolium repens, Ranunculus acris, Bellis perennis, Taraxacum officinale, Cerastium fontanum* and *Agrostis capillaris*. In the more intensively managed examples of this grassland type ruderal species such as *Rumex obtusifolius, R. crispus*, *Cirsium arvense* and *C. vulgare*, are frequently conspicuous. Areas of grassland which have been recently reseeded and are subject to heavy manuring tend to be dominated by floristically poor swards of *Lolium perenne* with few other grass species present. The habitat is generally of low ecological interest due to its species-poor composition, however in some areas of Mayo where pastoral agriculture is of a less intensive nature the grassland vegetation can approach that of unimproved hay-meadow.

Blanket Bog

Note: this occurs nearby – there is no intact blanket bog on the site itself, only small modified remnants of blanket bog).

Equivalent Phase 1 survey habitat classification for intact areas: Blanket bog (E1.6.1)
Equivalent Phase 1 survey habitat classification for cutaway or overgrazed areas: Wet modified bog (E1.7)
Equivalent Phase 1 survey habitat classification for industrially cutaway areas: Bare peat (E4)
Phytosociological synonymy: Pleurzio purpureae – Ericetum tetralicis *Braun-Blanquet et Tüxen 1952.*

Equivalent N.V.C. community: *Scirpus cespitosus – Eriophorum vaginatum* blanket mire (M17).
Fossitt: (PB3) Lowland Blanket Bog.

Lowland blanket bog vegetation is frequently encountered along the proposed route of the pipeline in Co. Mayo. Generally the vegetation is dominated by either *Molinia caerulea* or *Schoenus nigricans*, with the low-growing shrubs *Erica tetralix* and *Calluna vulgaris* also frequent. Other common vascular plant species in the vegetation include *Potentilla erecta, Carex panicea, Eriophorum angustifolium, Eriophorum vaginatum, Pedicularis sylvatica, Trichophorum cespitosum, Rhynchospora alba, Narthecium ossifragum* and *Polygala serpyllifolia*. In the drier areas of blanket bog, e.g. cutaway banks, species such as *Calluna vulgaris, Carex panicea, Hypnum cupressiforme* and *Leucobryum glaucum* are more prominent in the vegetation. Areas of blanket bog, which have not been grazed for a considerable time, e.g. along fenced-off fire-breaks, tend to be dominated by *Molinia caerulea*, accompanied by conspicuous *Calluna vulgaris*, a grazing sensitive species. Areas of blanket bog subject to overgrazing by sheep and cattle tend to be characterised by a high proportion of bare surface peat and sparse vegetation which is typically dominated *by Nardus stricta, Eriophorum angustifolium, Eleocharis multicaulis* and the moss *Campylopus introflexus*.

Bryophyte cover in lowland blanket bogs is generally well-developed, especially in wet areas. Species such as *Sphagnum capillifolium, Sphagnum papillosum, Campylopus atrovirens, Rhacomitrium lanuginosum* and *Hypnum cupressiforme* are common and ground cover generally exceeds 30%. In the more undisturbed, waterlogged, deep peat areas there can be well-developed Sphagnum carpets (mostly *S. papillosum, S. magellanicum* and *S. cuspidatum*) accompanied by *Eriophorum angustifolium* and *Rhynchospora alba.* One of the most conspicuous cryptogamic species of Atlantic blanket bog is the purple liverwort *Pleurozia purpurea*, one of the character species of the association. Another striking feature of lowland blanket bog is the presence of extensive carpets of mucilaginous algae (*Zygogonium* spp.) in wet hollows. In areas of deep blanket bog there may be pool areas, however no well-developed pool areas occur within 50 metres either side of the proposed pipeline route. The characteristic plant species of pools are *Menyanthes trifoliata, Sphagnum cuspidatum, Sphagnum auriculatum, Drosera anglica*, *Eriophorum angustifolium* and *Eriocaulon aquaticum*. Intact areas of blanket bog are of high ecological interest.

APPENDIX 6.3 Designated conservation areas in the wider locality – site synopses

Note: these synopses cover the whole of each designated area – in most cases these sites are very large and extensive, stretching up to tens of kilometres distant from the proposed site at Bellanaboy. Dates (date) at the end of each synopsis refer to date in the NPW files.

Glenamoy Bog Complex cSAC - 00500

This large site is situated in the extreme north-west of County Mayo, where the climate is wet oceanic and gales from the Atlantic are frequent. This area is underlain by metamorphic rocks, comprising mainly schists and quartzites of Moinian age. From sea-level, the site reaches 379m O.D. at Maumakeogh. The soils are predominantly peats, with underlying glacial tills usually only visible along water channels and roads. Four main river systems drain the site: the Glenamoy, the Muingnabo, the Belderg and the Glenglassra Rivers. One medium-sized lake, Lougherglass, occurs on the site.

Blanket bog, a priority habitat under Annex I of the E.U. Habitats Directive, dominates the site. Glenamoy Bog is a prime example of the extreme oceanic form of lowland blanket bog and is one of the most extensive tracts of bog in the country. The bog occupies a gently undulating plain, but extends uphill to cover the slopes of Maumakeogh and Benmore in the eastern sector of the site, and northward, out toward the sea cliffs of the north-west Mayo coastline. Peat depth reaches 6m in the low-lying areas. A large flush occurs at Rathavisteen, which supports species-rich vegetation, including Cranberry (*Vaccinium oxycoccos*) and a moss (*Homalothecium nitens*), which is nationally rare. Three other Annexed habitats occur in close association with the blanket bog - dystrophic lakes, wet heath and Juniper heath. Dystrophic lakes, which lie in peaty basins and have peat-stained water, are a common feature of lowland blanket bog. At Glenamoy, the lakes are particularly well-developed. Juniper (*Juniperus communis* subsp. nana) occurs scattered over the blanket bog, often in association with Crowberry (*Empetrum nigrum*) and hummocks formed of mosses (*Racomitrium lanuginosum*). On steep slopes where the peat is shallow, the blanket bog grades into wet heath. Here, Ling Heather (*Calluna vulgaris*), Cross-leaved Heath (*Erica tetralix*), Tormentil (*Potentilla erecta*) and Purple Moor-grass (*Molinia caerulea*) are found. Where the heath is drier, and especially towards the northern coastal zone of the site, scattered Bearberry (*Arctostaphylos uva-ursi*) occurs with Ling and Juniper.

The coastal habitats at Glenamoy are extensive and varied. Sea cliffs extend for about 20km along the north coast and achieve a height of 253m, at Benwee Head. They vary in physical character from sheer cliff-face to slopes of varying gradients. Typical cliff-face vegetation includes Thrift (*Armeria maritima*), Sea Campion (*Silene vulgaris subsp. maritima*) and Red Fescue (*Festuca rubra*). Sea stacks and several islands occur, of which Illaunmaistir is the most notable. A feature of the cliffs is the well developed cliff-top vegetation, which ranges from typical Plantain-dominated vegetation (Plantago sward) to coastal heath. South of Benwee Head, the rocky coastline grades into an estuarine system, Sruwaddacon Bay, which contains sand dunes and a machair system. Machair is a form of sandy, flat, coastal grassland, and this particular machair is unusual in that it extends upslope at Garter Hill - most machairs occupy flat, low-lying plains. It is, however, now very degraded owing mainly to over-grazing by sheep. *Petallophyllum ralfsi*i, a rare bryophyte which is listed on Annex II of the E.U. Habitats Directive, occurs abundantly on the machair habitat and this may be the most important site in the country for this species.

The sea cliffs and islands provide excellent habitat for breeding seabirds. An internationally important population of Storm Petrel (7,500 - 10,000 pairs, pre-1987), occurs on Illaunmaistir . A large Puffin colony (c.2,000 pairs, pre 1987) and a small colony of Manx Shearwaters (c.100 pairs) also occurs on Illaunmaistir. The mainland cliffs was the first breeding site in Ireland for Fulmar and now has a very substantial colony (c.2,000 pairs, pre 1987). There is a sizeable Kittiwake colony (c.400 pairs pre 1987) and small colonies of Guillemots and Razorbills (less than 100 individuals of each). Peregrine Falcon and Chough, both Annex I Bird Directive species, breed on the cliffs. Another Annex I species, Merlin, breeds on the blanket bog, as does Golden Plover. In winter, a small flock (less than 50 individuals) of Barnacle Geese visit Illaunmaistir and Kid Island.

Otter, an EU Habitats Directive Annex II species, occurs on the site, as well as two other Red Data Book mammal species: Badger and Irish Hare. The Glenamoy River holds Salmon and Sea Trout.

A number of landuse practices have damaged parts of this site. Grazing by sheep and cattle is widespread and over-grazing, which leads to soil erosion, has caused damage to parts of the blanket bog, heath and machair habitats. Peat cutting, by hand and to a lesser extent by mechanised means, is widespread throughout though mostly confined to near roads and tracks. The region in general has been heavily afforested with conifers and much of the site is bounded by plantations. Within parts of the site afforestation continues and poses a threat to the blanket bog.

This site is of immense ecological importance because of the presence of a number of E.U. Annex I habitats, including two priority habitats - blanket bog and machair. It supports populations of an Annex II mammal species, an Annex II plant species and six Annex I Birds Directive species. It also has nationally important populations of other seabirds. Despite serious damage to parts of the site in recent years, large areas remain in good condition. Considerable archaeological interest is contained within the site, including the renowned Céide Fields. Furthermore, the site is of outstanding scenic value. (17.1.1997)

Broadhaven Bay cSAC - 000472

Broadhaven Bay is a large bay situated between the north-east side of the Mullet Peninsula and the north-west Mayo coast. Exposure to prevailing winds and wave action diminishes from the mouth toward the head of the bay. Subsidiary inlets along the length of the bay provide further areas of additional shelter. The bay encompasses a range of habitats from extremely exposed bedrock at Benwee Head to sheltered sediments and saltmarsh in the inner bay.

Broadhaven Bay contains excellent examples of four habitats listed on Annex I of the EU Habitats Directive, namely Atlantic saltmarsh, tidal mudflats, reefs and large shallow bay. The shoreline is comprised mostly of shingle beaches and sandy beaches, as well as marginal habitats such as cutaway bog, heathland, dune grassland and machair, wet grassland, tidal rivers and dry pasture, which is used for grazing. There are several extensive areas of intact saltmarsh, with Thrift (*Armeria maritima*), Saltmarsh Rush (*Juncus gerardii*), Buck's-horn Plantain (*Plantago coronopus*), Sea Arrowgrass (*Triglochin maritima*), Common Scurvygrass (*Cochlearia officinalis*) and Common Saltmarsh-grass (*Puccinellia maritima*). Parts of the saltmarsh are heavily grazed.

Sheltered littoral sediments in Broadhaven Bay are characterised by fine sand. Sand hoppers live under drift weed in the upper shore. Lugworms (*Arenicola marina*) are present in the mid-shore, whereas different worm species (*Scolelepis foliosa* and *Spiophanes bombyx*) and crustacea (*Bathyporeia elegans* and *Crangon crangon*) live in the lower shore. Bivalve molluscs (*Cerasteraderma edule* and *Angulus tenuis*) occupy both the middle and low shore. Sublittoral sediments range from coarse sand in exposed areas to fine sand in more sheltered areas in the inner bay. The coarse sand is characterised by the bivalve *Lutraria lutraria*. *Echinocardium* and bivalves characterise the sediment moderately exposed to wave action. In sheltered areas with medium sand and moderate current, communities of burrowing anemones, bivalves, the red seaweed *Gracillaria verrucosa,* and a community of hydroids, in particular *Sertularia argentea* occur.

There are good examples of wave-surged cave communities in shallow water with the anemone, *Phellia gausapata* typically found in areas very exposed to wave action. The rare anemone *Parazoanthus anguicomus* and the soft coral *Alcyonium glomeratum* are present in a deeper water cave. *Dercitus bucklandi*, which is characteristic of caves and crevices, has also been recorded.

The reef communities of Broadhaven Bay are subject to a range of conditions, from very exposed to wave action to very sheltered from wave action. Tidal streams are weak or negligible. Much of the bedrock is ridged with steeply sloping sides and gullies between the ridges. Shallow, exposed and very exposed communities at the mouth of the bay are dominated by *Laminaria hyperborea* forest with an understorey of red algae. In the kelp park at approximately 15 – 25 m, and below the kelp, foliose brown algae (*Dictyota dichotoma* and *Dictyopteris membranacea*) and red algae (*Delesseria sanguinea*) are more dominant. Species richness in the latter zone can be high (up to 72 species). The southern brown algae *Taonia atomeria* occurs here close to the northern limits of its distribution. Gullies and small cliffs in and below the kelp are dominated by jewel anemones *Corynactis viridis* and Dead Man's Fingers *Alcyonium digitatum*, while small horizontal ledges support foliose red and brown algae. The sheltered reefs east of Ballyglass are distinguished by the presence of mobile boulders and cobbles that are colonised by the kelps *Saccorhiza polyschides* and *Laminaria saccharina*. In the outer part of Broadhaven Bay, animal dominated communities occur at depths greater than 23 m. Many of the reefs at these depths are characterised by the Axinellid sponge community which has a wide variety of sponges.

Broadhaven Bay supports an internationally important number of Brent Geese (average peak 292, 1983/84-86/87), as well as regionally important populations of Ringed Plover (234), Golden Plover (103), Dunlin (271), Bar-tailed Godwit (85), Curlew (186) and Redshank (80) - all figures are average peaks for the period 1984/85-1986/87. Two pairs of Common Gulls bred in 1994. Inishderry island holds an important colony of terns; Sandwich Tern (160-170 pairs in 1994), Common / Arctic Terns (28 pairs in 1984; 15+ pairs of Common Terns in 1994), Little Tern (6 pairs in 1984). Black-headed Gulls were also present in 1984 with 150 individuals.
Broadhaven Bay is a fine example of a coastal bay and associated habitats. It contains excellent

examples of four habitats listed on Annex I of the EU Habitats Directive and supports a number of unusual marine communities and species. The presence of wintering waterfowl and breeding Terns adds to the importance of the site.
(7.3.2000)

Carrowmore Lake Complex cSAC - 000476

This site is located north and east of Bangor Erris, in County Mayo. There are two main parts to the site: Carrowmore Lake, a large, shallow oligotrophic /mesotrophic lake, and Largan More Bog, an impressive tract of blanket bog. From an altitude of 6m at the lake, the site grades upwards in a general south-easterly direction, reaching 199m on Largan More Bog.

Three areas of blanket bog are incorporated into the site: Glenturk, Carrowmore (or Glencullin) and Largan More. Glenturk Bog has a relatively uniform vegetation and Carrowmore Bog is more diverse, with quaking lawns formed by bog mosses (*Sphagnum* spp.), hummocks (including some formed by *Sphagnum fuscum*), bog pools and an interconnecting pool system. Largan More is the most extensive and interesting, with a fine interconnecting pool system and large areas of typical, intact blanket bog vegetation. Bog pools are a feature of the bog surface, and these are colonised by a range of mosses and higher plants including Lesser Bladderwort (*Utricularia minor*), White Water-lily (*Nymphaea alba*), Water Lobelia (*Lobelia dortmanna*) and Pipewort (*Eriocaulon aquaticum*). Species-rich flush communities occur on streamsides and stream-heads. Sedges, including *Carex limosa*, *C. rostrata*, *C. lepidocarpa*) are abundant in flushes, with a rich variety of calcicole herbs and mosses. Cranberry (*Vaccinium oxycoccos*) occurs in some flushes - this species is uncommon outside the centre of Ireland.

Carrowmore Lake is a large (960ha), shallow lake, with a maximum depth of approximately 2.5m and a generally stoney bottom. The lake water is almost neutral in terms of acidity (i.e. pH) and generally rather nutrient-poor. The shallow waters support species such as Common Spike-rush (*Eleocharis palustris*), Shoreweed (*Littorella uniflora*), Bulbous Rush (*Juncus bulbosus*), Marsh Pennywort (*Hydrocotyle vulgaris*) and Perfoliate Pondweed (*Potamogeton perfoliatus*). The shoreline is dominated by Soft Rush (*Juncus effusus*), Yellow Iris (*Iris pseudacorus*) and stands of Common Club-rush (*Scirpus lacustris*) or Common Reed (*Phragmites australis*). This emergent vegetation grades landward into freshwater marsh and acid wet grassland, backed by blanket bog. Along this transition zone, bushes of Mediterranean Heath (*Erica erigena*) are prominent. This species is frequent in parts of west Mayo, but rare in west Galway and unknown elsewhere in Ireland.

The rare Marsh Saxifrage (*Saxifraga hirculus*) occurs at the site. This species is protected under The Flora Protection Act (1987) and is listed under Annex II of the European Habitats Directive. It is confined in its distribution to north-west County Mayo.

The site supports a number of bird species which are of international conservation significance and which are listed on Annex I of the European Birds Directive. In winter, Greenland White-fronted Geese arrive to feed around the lake and in some nearby fields. These birds are a sub-flock of the nationally important Bog of Erris flock. In summer, Merlin and Golden Plover breed on the boglands within the site. An Irish Tern Survey (1984) revealed that Sandwich Tern (164 pairs) and Arctic Tern (18 pairs) formerly bred within the site, and although the terns have not bred in recent years, Derreen's Island still supports a large and important colony of Common Gulls (600 individuals, 1993).

A variety of wildfowl also occur, including Tufted Duck, Pochard and Wigeon. Goosander, a very rare species in Ireland, has been recorded.

Blanket bog in the site is used for grazing cattle and sheep and for turf-cutting, which is largely done by machine. Angling and water abstraction are the main landuses at Carrowmore Lake.

This site is of considerable ecological value, primarily for its extensive, intact blanket bog, which has a typical range of good quality habitats, but also as a site for the very rare Marsh Saxifrage. The north-western part of the site supports a number of Greenland White-fronted Geese, while other important bird species which occur are Golden Plover, Merlin, Sandwich Tern and Arctic Tern.
(28.1.1997)

Pollatomish Bog pNHA - 001548

Pollatomish Bog is situated on the Glenamoy-Belmullet road about 7km south of Pollatomish. The site is an area of uniform blanket bog with a steep slope reaching up to 100 m in the centre of the site.

The site is a typical Atlantic Blanket Bog area - it is quite wet with species-rich moss (*Sphagnum* spp.) lawns. Tussocks with Deergrass (*Scirpus caespitosus*) and Bog-myrtle (*Myrica gale*) are common, while pools with Bog Bean (*Menyanthes trifolium*), Bladdwort (*Ultricularia minor*) and mosses (*Sphagnum* spp.) are also found. Further up the slopes the habitat becomes drier and heathy with Ling Heather (*Calluna vulgaris*) becoming dominant.

The land is used for rough grazing of sheep and cattle, while there has been some channels cut into the bog for drainage. Marginal cutting of turf by hand has also taken place in the past. Although the bog has diminished in size somewhat, and despite overgrazing, drainage, burning and forestry, the site is still a good example of blanket bog and typical of this habitat type. In addition, the site is relatively large, scenically located and easy to access.
(June 1997)

Slieve Fyagh Bog cSAC - 000542

Slieve Fyagh Bog is located about 6km north-east of Bangor. It is bounded on the north by the Glenamoy River, on the east and west by forestry plantations, and on the south by the Glencullin River. Slieve Fyagh itself is a plateau of shales and sandstone rocks, reaching an elevation of c. 300m.

The plateau supports mountain blanket bog vegetation, unusually for this part of Mayo, where most of the mountains are covered by heath or acid-grassland vegetation. The flatter parts of the plateau have numerous lakes and blanket bog pools, interconnected by quaking, *Sphagnum*-dominated areas. The largest lake, Lough Naguroge, is colonised by Bottle Sedge (*Carex rostrata*) and Water Lobelia (*Lobelia dortmanna*). The scarce orchid, Lesser Twayblade (*Listera cordata*) occurs along its rocky shores.

Several streams descend from the plateau to the lower-lying ground below. These provide suitable habitat for aquatic lichen and moss species, such as *Dermatocarpon fluviatile* and *Fontinalis squamosa*. The stream banks are grassy, with species such as Sweet Vernal-grass (*Anthoxanthum odoratum*), Yorkshire-fog (*Holcus lanatus*) and Great Wood-rush (*Luzula sylvatica*). The mosses *Campylium stellatum* and *Philonotis fontana* occur where flushes seep from mineral soils.

Extensive areas of lowland blanket bog occur on the sloping terrain below the plateau, typified by the occurrence of Black Bog-rush (*Schoenus nigricans*), Common Cottongrass (*Eriophorum angustifolium*), Purple Moor-grass (*Molinia caerulea*), Cross-leaved Heath (*Erica tetralix*), White Beak-sedge, (*Rhynchospora alba*) and Deergrass (*Scirpus cespitosus*). Pool systems occur below the northern slopes of Slieve Fyagh, the best examples being found at Bellagelly Bog. The pools support aquatic plants such as Bogbean (*Menyanthes trifoliata*), Pipewort (*Eriocaulon aquaticum*) and Lesser Bladderwort (*Utricularia minor*).

Further downslope, particularly in the vicinity of farmland, the blanket bog is heavily grazed by sheep, while peripheral areas are cut for turf. Serious peat erosion is occurring over much of the low-lying areas, where the peat is criss-crossed by erosion channels.

Slieve Fyagh Bog is important for the occurrence of mountain blanket bog, a habitat that is uncommon in this region. The extensive lowland blanket bog that surrounds the plateau is damaged and under threat from overgrazing and peat erosion.
(9.1.1997)

APPENDIX 6.4 FAUNA

Appendix 6.4a: List of Vertebrates and Adjudged Status

		Status in study area 2001/March 2003	Oct. 2003
Mammals			
Insectivora			
Hedgehog	*Erinaceous europaeus*	Potential, uncommon	ditto
Pygmy Shrew	*Sorex minutus*	Present (observed)	ditto
Chiroptera			
Common Pipistrelle[1]	*Pipistrellus pipistrellus*	Present in area	ditto
Soprano Pipistrelle	*Pipistrellus pygmaeus*	Potential	ditto
Nathusius's Pipistrelle	*Pipistrellus nathusii*	Absent. Rare migrant.	ditto
Brown Long-eared	*Plecotus auritus*	Absent	ditto
Leisler's	*Nyctalus leisleri*	Unlikely/potential	ditto
Lesser Horseshoe	*Rhinolophus hipposideros*	Absent	ditto
Whiskered	*Myotis mystacinus*	Absent	ditto
Natterer's	*Myotis nattereri*	Absent	ditto
Daubenton's	*Myotis daubentoni*	Absent	ditto
Lagomorpha			
Rabbit	*Oryctolagus cuniculus*	Potential, uncommon	ditto
Irish Hare	*Lepus timidus hibernicus*	Present, frequent	ditto
Rodentia			
Red Squirrel	*Sciurus vulgaris*	Absent	ditto
Grey Squirrel	*Sciurus carolinensis*	Absent	ditto
Bank Vole	*Clethrionomys glareolus*	Absent [2]	ditto
Wood Mouse/Long-tailed Field Mouse	*Apodemus sylvaticus*	Present	ditto
House Mouse	*Mus musculus*	Unlikely [3]	ditto
Brown Rat	*Rattus norvegicus*	Potential, uncommon	ditto
Black Rat	*Rattus rattus*	Absent	ditto
Carnivora			
Fox	*Vulpes vulpes*	Present, common.	ditto
Badger	*Meles meles*	Present. Main sett on site.	absent
Pine Marten	*Martes martes*	Present, infrequent	ditto
Irish Stoat	*Mustela erminea hibernica*	Potential, infrequent	ditto
Otter	*Lutra lutra*	Present; foraging, holt	absent
American Mink	*Mustela vison*	Absent	ditto
Artiodactyla			
Red Deer	*Cervus elaphus*	Absent	ditto
Sika Deer	*Cervus nippon*	Absent	ditto
Red/Sika Hybrids	*Cervus elaphus/nippon*	Absent	ditto
Fallow Deer	*Dama dama*	Absent	ditto
Feral Goat	*Capra*	Absent	ditto

[1] Two species of Pipistrelle bat are present in Ireland, recent taxonomic revision. The species are identified by the frequency they use for echolocation (46Hz [Common] and 55Hz [Soprano]), and both are common and occur in similar habitats.
[2] Bank voles restricted to south-western counties.
[3] House mouse is infrequent in upland areas (Fairley & Smal, 1987).

Appendix 6.4a: List of Vertebrates and Adjudged Status (continued)

		Status in study area 2001/March 2003	Oct. 2003
Amphibians			
Smooth Newt	*Triturus vulgaris*	Absent	ditto
Frog	*Rana temporaria*	Present, abundant	ditto
Natterjack Toad	*Bufo calamita*	Absent	ditto
Reptiles			
Common Lizard	*Lacerta vivipara*	Likely/infrequent	ditto

Note 1: references given in main section of text.
Note 2: the study area falls into 10km square of the National Grid: F83.

Appendix 6.4b: Details of Badger Setts Identified Within the Surveyed Area 2001 and March 2003

Sett reference as shown in figures	Location and habitat	Type of sett	Status and description
S2	coniferous plantation GPS: F85503-33215	subsidiary	active, latrines present, fresh spoil, prints, tracks, paths, rooting. Open 1/2/0; one entrance over hollow created by stream in peat
S1	coniferous plantation GPS: F85520-33234	main	active main sett, bedding, latrines (15 pits, 5 with copious fresh dung), fresh spoil, medium spoil heaps, prints, tracks, paths, rooting. 2 open entrances, 1 defunct. 3/1/0.
S3	coniferous plantation GPS: F85523-33193	minor	2 entrance, over a stream hollow, not far from S2
S4/OTTER HOLT	coniferous plantation GPS: F85521-33177	minor	0/2/0; entrances not v. active, but large quantity of OTTER spraints very close by; by hollow and stream running through peat
S5	scrub/young plantion GPS: F86571-33415	outlier	active outlier with 1 medium spoil heap; 1/0/0. Fresh latrine and bedding. Close to New Zealand flax.

Notes:

- Main sett = breeding sett, focus of most badger activity
- Annexe sett = large sett, usually within 50m of Main sett
- Subsidiary sett = smaller sett, not peripheral within territory of badger social group
- Outlier sett = small sett, usually on periphery of group territory.
- Minor sett = small incidental sett, not an outlier.
- Entrances (*e.g.* 5/2/2) = no. of entrances well used/partially used/disused.

APPENDIX 6.5 Birds Recorded in Different Sections of the Study Area During the 2003 Survey

a. Birds Recorded Using the North-Eastern Section

Common Name	Scientific Name	Count of Individuals
Blackbird	*Turdus merula*	1
Chaffinch	*Fringilla coelebs*	1
Coal tit	*Parus ater*	2
Crossbill	*Loxia curvirostra*	1
Dunnock	*Prunella modularis*	2
Goldcrest	*Regulus regulus*	3
Hooded crow	*Corvus corone cornix*	1
Linnet	*Carduelis cannabina*	3
Meadow pipit	*Anthus pratensis*	4
Pheasant	*Phasianus colchicus*	1
Robin	*Erithacus rubecula*	10
Wren	*Troglodytes troglodytes*	3

b. Birds Recorded Using the South-Eastern Section

Common Name	Scientific Name	Count of Individuals
Blackbird	*Turdus merula*	3
Blue tit	*Parus caeruleus*	1
Coal tit	*Parus ater*	1
Dunnock	*Prunella modularis*	9
Goldcrest	*Regulus regulus*	8
Hooded crow	*Corvus corone cornix*	10
Linnet	*Carduelis cannabina*	4
Meadow pipit	*Anthus pratensis*	4
Mistle thrush	*Turdus viscivorus*	1
Robin	*Erithacus rubecula*	39
Song thrush	*Turdus philomelos*	5
Swallow	*Hirundo rustica*	6
Wood pigeon	*Columba palumbus*	11
Wren	*Troglodytes troglodytes*	14

c. Birds Recorded Using the North-Western Section

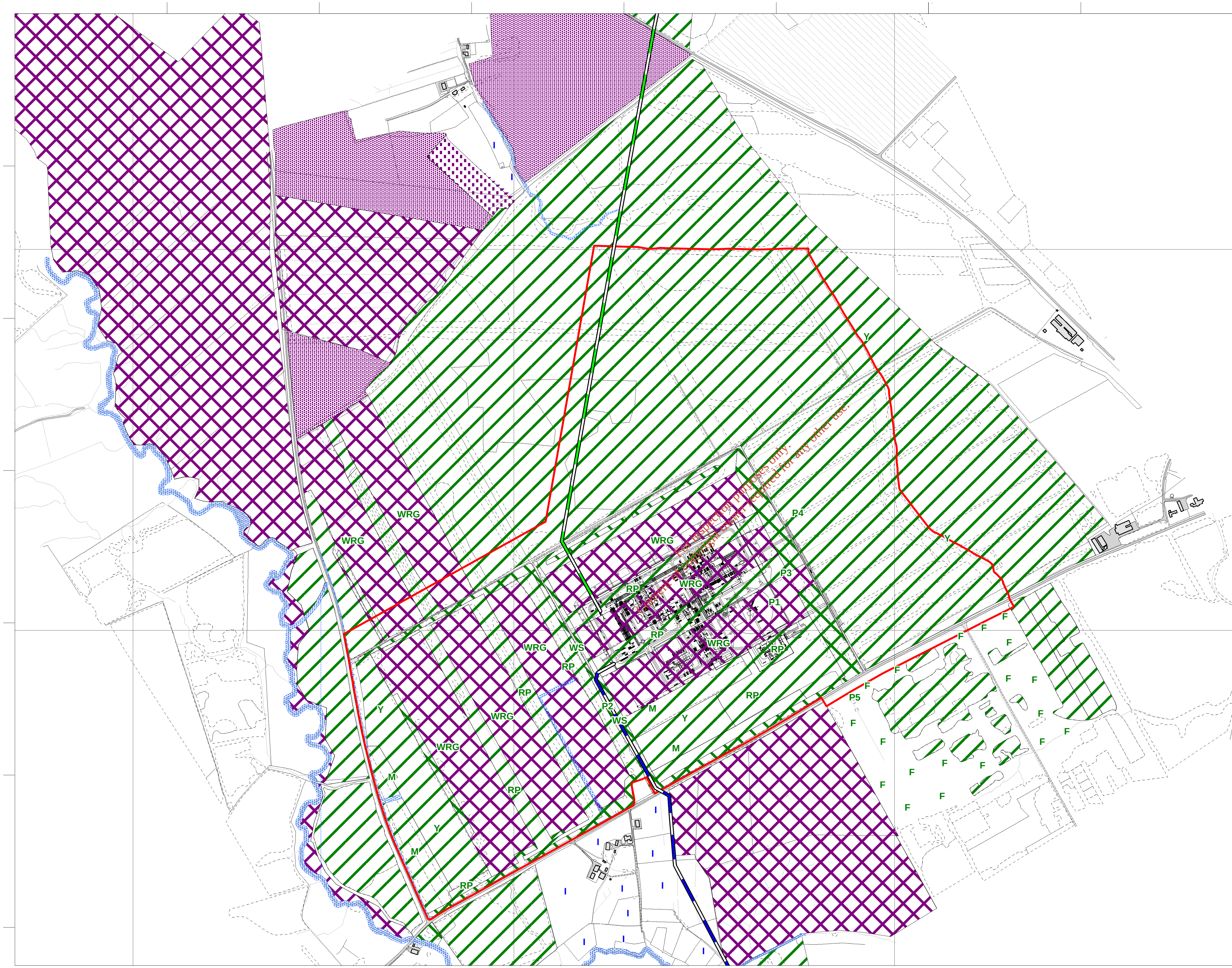
Common Name	Scientific Name	Count of Individuals
Blackbird	*Turdus merula*	2
Blue tit	*Parus caeruleus*	2
Chaffinch	*Fringilla coelebs*	1
Coal tit	*Parus ater*	9
Dunnock	*Prunella modularis*	1
Goldcrest	*Regulus regulus*	8
Hooded crow	*Corvus corone cornix*	1
Linnet	*Carduelis cannabina*	4
Meadow pipit	*Anthus pratensis*	4
Redpoll	*Carduelis flammea*	1
Reed bunting	*Emberiza schoeniclus*	2
Robin	*Erithacus rubecula*	17
Siskin	*Carduelis spinus*	5
Song thrush	*Turdus philomelos*	5
Wren	*Troglodytes troglodytes*	7

d. Birds Recorded Using the South-western Section

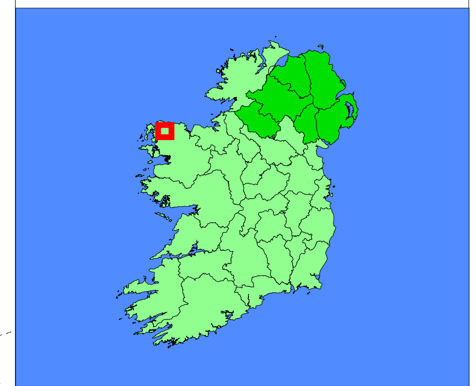
Common Name	Scientific Name	Count of Individuals
Blackbird	*Turdus merula*	1
Blue tit	*Parus caeruleus*	2
Chaffinch	*Fringilla coelebs*	4
Coal tit	*Parus ater*	3
Dunnock	*Prunella modularis*	3
Goldcrest	*Regulus regulus*	7
Great tit	*Parus major*	1
Hooded crow	*Corvus corone cornix*	1
Linnet	*Carduelis cannabina*	2
Magpie	*Pica pica*	2
Meadow pipit	*Anthus pratensis*	13
Reed bunting	*Emberiza schoeniclus*	9
Robin	*Erithacus rubecula*	35
Sparrow hawk	*Accipiter nisus*	1 female
Starling	*Sturnus vulgaris*	1
Wren	*Troglodytes troglodytes*	9

e. Birds Recorded Using the Terminal Section

Common Name	Scientific Name	Count of Individuals
Blackbird	*Turdus merula*	2
Blue tit	*Parus caeruleus*	1
Chaffinch	*Fringilla coelebs*	16
Coal tit	*Parus ater*	4
Crossbill	*Loxia curvirostra*	1
Dunnock	*Prunella modularis*	5
Goldcrest	*Regulus regulus*	11
Great tit	*Parus major*	1
Grey heron	*Ardea cinerea*	1
Hooded crow	*Corvus corone cornix*	2
Linnet	*Carduelis cannabina*	12
Magpie	*Pica pica*	1
Meadow pipit	*Anthus pratensis*	10
Mistle thrush	*Turdus viscivorus*	1
Pheasant	*Phasianus colchicus*	1
Redpoll	*Carduelis flammea*	1
Robin	*Erithacus rubecula*	21
Snipe	*Gallingo gallingo*	1
Sparrow hawk	*Accipiter nisus*	1 male
Swallow	*Hirundo rustica*	2
Water rail	*Rallus aquaticus*	1
Wren	*Troglodytes troglodytes*	9



Ross Port (Preferred Option)
BGE Mayo to Galway Gas Pipeline
Planning Application Boundary
Proposed Terminal Site
Coniferous Plantation
Scrub
Wet Modified Blanket Bog (Including cutover)
Bare Peat
Blanket Bog
I Improved Grassland
Water Course
WRG Wet Rushy Grassland
WS Willow Scrub
P1 Plate Locations
M Mature Plantation
Y Young/Immature Plantation
RP Remnant Plantation
F Recently Felled Coniferous Plantation



Rev	Date	Description	Drn	Chk	App
02	16.12.03	Revised Title Bar	DL	HR	DT
01	2.12.03	Add aditional phase 1 data	IM	HR	DT

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BELLANABOY BRIDGE TERMINAL

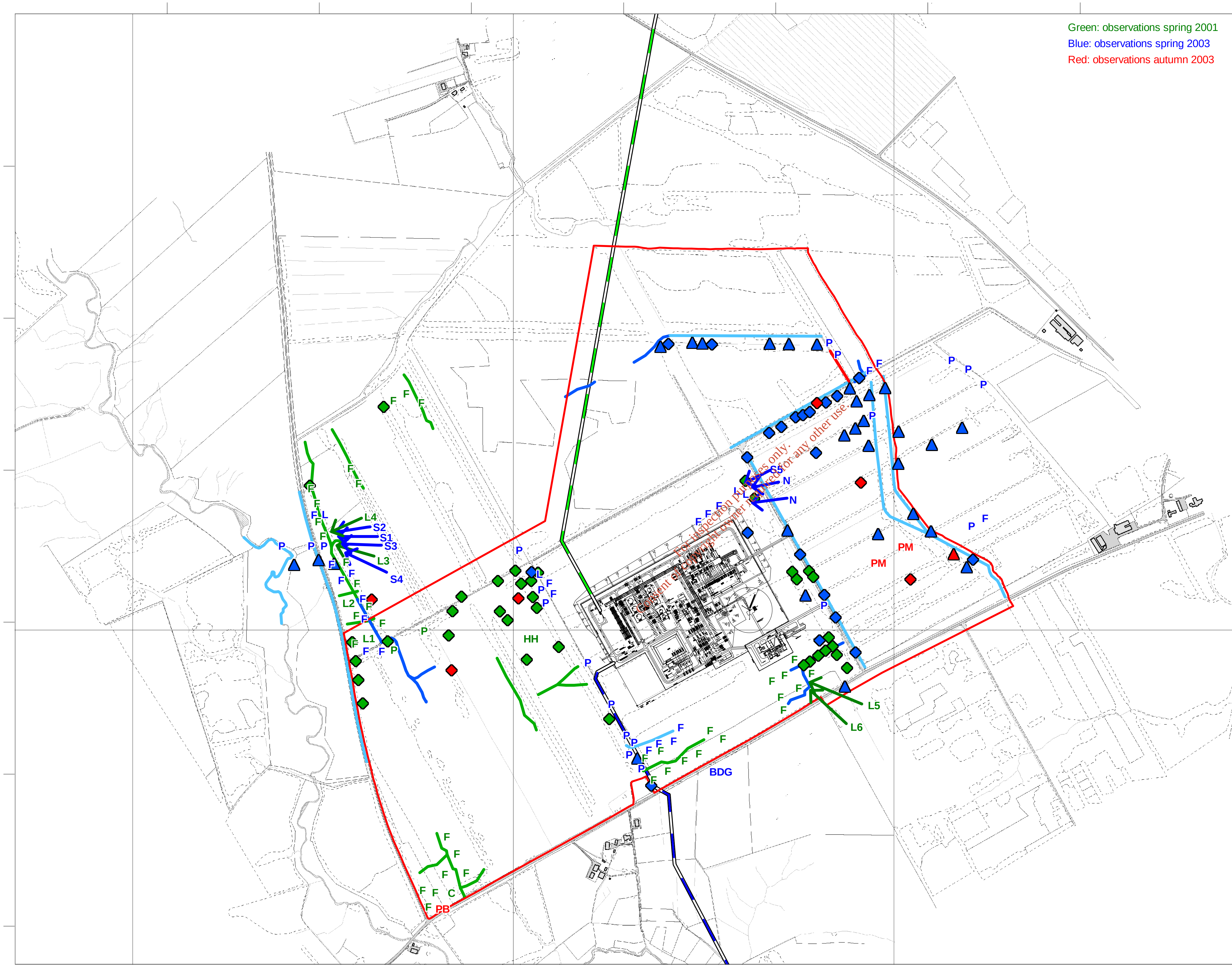
Corrib natural gas

TITLE: **Fig 6.1**
Ecological Assessment: Habitats

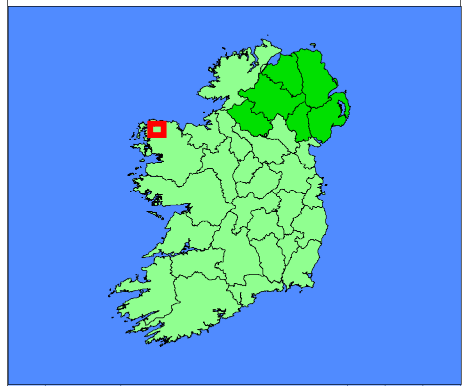
SCALE: 1:10,000

REV 02

FILE NAME: P40036\CT-Phase1 habitat.WOR



	Ross Port (Preferred Option)
	BGE Mayo to Galway Gas Pipeline
	Planning Application Boundary
	Proposed Terminal Site
S1	Badger sett
L1	Badger latrines
F	Badger feeding signs
P	Badger prints
	Principal badger paths
BDG	Badger road mortality
N	Nest (badger; may also be used by otters, foxes)
	Otter spraints; other otter signs
	Frog spawn, tadpoles, frogs
HH	Hen harrier
PM	Pine marten scats
PB	Pipistrelle bat sighting
	Streams and drains



Rev	Date	Description	Drn	Chk	App
01	16.12.03	Revised Title Bar	Drn	Chk	App

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BELLANABOY BRIDGE TERMINAL

Corrib natural gas

TITLE: **Fig 6.2 SIGNS OF PRINCIPAL VERTEBRATE FAUNA**

SCALE: 1:10,000

REV 01

FILE NAME: P40036ICT - fauna.WOR

Seven

Aquatic Ecology

7 Aquatic Ecology

7.1 Introduction

This Section assesses the likely impacts of the proposed development on the aquatic ecology of the terminal site and its surroundings. The area surrounding the location of the treated effluent discharge point is also described in terms of the habitats present, together with the constituent flora and fauna species. The approach and methodology has been undertaken with due regard to the revised EPA Advice Notes on Current Practice (2002).

The terminal site is located on part of the former Peatland Experimental Station, Glenamoy. The study area is more or less rectangular in outline and slopes gently down to the south west (see Figure 3.1). It includes the numerous narrow drains that run throughout the site and the rivers into which these drains flow.

The end of the treated waste water effluent discharge pipe is in approximately 60m water depth, more than 2km from the closest shoreline (as shown in Figure 3.1).

7.2 Study Methodology

The aims of the study and surveys were to investigate the quality of the macroinvertebrate assemblages present and to assess the quality of the Ballina fishery including the distribution and age of salmon and trout in the vicinity of the terminal. For the treated waste water effluent the objective was to characterise the habitats in the vicinity of the discharge point (these are described in the Offshore EIS).

The study included the identification of baseline macroinvertebrate assemblages (undertaken by Wood Environmental Management Ltd), and collection of electrofishing data to ascertain the quality of the northern region of the Ballina fishery area (undertaken by Aquens Ltd). Water samples were collected from the surrounding watercourses and Carrowmore Lake at the same time as the macroinvertebrates. An assessment of the quality of the streams and ditches sampled is provided in Section 9. Studies of the ecological characteristics along the discharge pipeline route (which is along the same alignment as the offshore gas pipeline) have been carried out, they are provided in full in the Offshore (Field to Terminal) EIS submitted to DMNR in 2001[1].

The baseline data collected enabled an assessment to be made of the sensitivity of the aquatic systems. Potential impacts on adjoining areas and nearby designated conservation sites were also evaluated from an aquatic perspective. Appropriate mitigation or remedial measures will be implemented in the context of likely impacts on species and habitats within the ecosystems. The location of the proposed terminal development is not subject to any conservation designation, proposed, candidate or otherwise under current legislation by the statutory authority (National Parks and Wildlife, Department of the Environment - NPW). The offshore location of the treated waste water discharge point is also outside any designated area, however it will be constructed from the shoreline through the Broadhaven Bay cSAC to that point. Environmental impacts from that construction activity are covered in the Offshore EIS.

Sections 6, 9 and 10 of this EIS also present data that are relevant to this Section. Section 6 presents information on the mammals and other non-fish vertebrates of the area which use the watercourses (such as otter and frogs), as well descriptions of the aquatic vegetation. Results of the aquatic flora surveys are presented in Appendix 6.1. Section 9 presents the water quality data drawn from surveys of the site and surrounding waterbodies, including Carrowmore Lake. Section 10 describes the various potential effluent discharges to the aquatic environment.

7.2.1 Baseline Studies and Surveys

Freshwater

Shell commissioned biological and chemical analyses of the watercourses in the locality of the terminal site and electrofishing operations in the northern region of the Ballina fishery area. These studies consisted of monthly surface water samples over a one year period for the determination of river water quality, data logging for continuous physio-chemical properties (information is presented in Section 9), quarterly standard kick sampling for macroinvertebrate analysis and annual electrofishing sampling. All surveys were carried out in consultation with the North Western Regional Fisheries Board (NWRFB), the fisheries protection authority for this area. Additional consultation took place with the Marine Institute, Salmon Management Services Division, and data from surveys were provided to the Institute. It is understood that the Marine Institute incorporate such information in assessing the quality of habitats in relation to their ability to support populations of salmonids.

[1] Environmental Impact Assessment submitted to the then Minister for the Marine and Natural Resources in Support of the Foreshore Licence Application (granted May 2002), and in support of the application for Pipeline Consent (granted April 2001)

Marine

The route of the offshore gas export pipeline was subject to a biological survey in 2000. This involved taking grab samples from the seabed and identifying the invertebrates which were present in those samples. Photographs of the seabed were also taken during that survey. Since then further surveys of the habitats along the pipeline route have also been completed.

7.3 Receiving Environment

7.3.1 Introduction and Past Management of the Terminal Site

A description of the general layout of the site, together with the main habitats found, and the historical land management can be found in Section 6.3.1.

In terms of the aquatic interest, drainage from the site is via a network of drains; these are described more fully in Section 9.

Drainage

The site has been extensively drained in the past. The actual types of drainage used are not precisely known, but they could include:

- open drains – about 1 m. deep and at different spacings from 2.5 m. to 30 m;
- clay pipes or similar "field drains";
- sod drains (a traditional method);
- slotted plastic pipes; and
- gravel drains (tunnel drains using "tunnel" plough technology. Non-calcareous gravel was laid onto plastic sheet as the base of the "tunnel").

7.3.2 Aquatic Habitats on the Terminal Site

Numerous north-south ditches drain the area, the majority of which are narrow with minor flows. The largest flows were observed in three drains: a ditch between the south-western and the central southern blocks, a north south stream within the eastern portion of the south western block, and a small partially subterranean stream in the north western block. The drainage from the terminal area will be to the south west, to the Bellanaboy River and Carrowmore Lake (see Figure 3.1). There are also a number of shallow pools which have formed in depressions such as vehicle tracks across the site.

7.3.3 Aquatic Habitats in the Wider Area

The tributaries feeding into Sruwaddacon Bay and Carrowmore Lake are small spawning and nursery streams, probably mostly for sea trout. However, in the tributary in the nearby townland of Muingingaun, salmon are known to spawn. Some tributary streams appear to be somewhat torrential, suffering from significant bank-side erosion, and show strong signs of peat siltation and some nutrient enrichment. Evidence of heavy silt deposition was frequent in most of the streams surveyed, a common problem in overgrazed areas.

The most important spawning areas are upstream of the terminal (Figure 7.1).

Offshore, the seabed in the area is generally sandy, with occasional rock outcrops and exposure of glacial deposits.

7.3.4 Fauna

Amphibians

Breeding sites (spawning grounds) of the common frog (*Rana temporaria*), were very frequent in the area. Most of the spawning areas were located in drainage ditches and in shallow pools near roads and tracks. The abundance of frogs in the area is likely to be due to the relative lack of disturbance of the wet grasslands, which provide foraging grounds for the species. Additionally the forest tracks and drainage systems have provided numerous suitable sites for breeding.

The smooth newt (*Triturus vulgaris*) is present in east Mayo (Marnell, 1994, 1998) but absent from this locality as there are no suitable breeding ponds.

Amphibians are discussed in Section 6.3.3 in more detail.

Fish

Electrofishing surveys for brown trout (*Salmo trutta*) and salmon (*Salmo salar*) were carried out in the rivers and streams in the vicinity of the terminal site (see Table 7.1 and Figure 7.1). Discussions were held with the NWRFB prior to these surveys taking place in order to determine the most advantageous locations to fish. Nursery areas for these species were also targeted. The surveys were carried out in August 2001, September 2002 and September 2003. Stickleback (*Gasterosteus aculeatus*), minnow (*Phoxinus phoxinus*), freshwater European eel (*Anguilla anguilla*) and lamprey (*Lampetra fluviatilis* or *Lampetra planeri*) were identified during the surveys, however they were scarce in all sites sampled.

Alterations to sampling sites were made in 2002 in order to strengthen the earlier results, with an additional two sites introduced, and a further site (7) was added in 2003 at the recommendation of the NWRFB. The sampling methodology was also changed in 2003 to the standards set by the Marine Institute (previous surveys had used only 1 or 2 passes of each section, depending upon the catches made, while the new standard is that all sections are fished 3 times, regardless of diminishing catches).

Table 7.1 – Electrofishing Sampling Locations

Site No.	Location
1	Muinigerroon
2	NW of Aghoos
3	Confluence of site 1 and 2
4	Bellanaboy near Carrowmore Lake
5	Muingingaun
6	Bellanaboy Bridge
7	Downstream of Site 3
8	Tributary of Glenamoy River
9	Leenamore
10	Srahnaplaia (dropped after 2001)

A similar length of watercourse was sampled at each site.

The majority of the trout and salmon sampled in the nursery streams were young fry and fish in their second year. Young salmon were scarce in the streams with the exception of site 4. Figure 7.2 illustrates the age class density (m^{-2}) (0 and 1+) of brown trout caught at the sample sites. Only six year 2+ individuals were caught during the surveys.

Over the three survey years, sites 1-Muinigerroon, 2-NW of Aghoos and 3-Confluence of 1 and 2, 5-Muingingaun and 6- Bellanaboy Bridge always contained reasonable numbers of 0+ trout for the limited type of habitat available. Sites 1, 2 and 3 were identified as the most important spawning grounds in the survey area.

Sample site 4-Bellanaboy located south west of the proposed terminal recorded the greatest density of salmon, with 37 fry and a further 17 young salmon (in 2002). This site, near Carrowmore Lake, has an increased gradient, which in turn increases water flow as well as oxygen content, encouraging the presence of young salmon. The juveniles at this site were considered to be moving towards Carrowmore Lake where they would remain until they became smolts and migrated to sea.

The surveys concluded that the growth of trout in the area was poor but was linked to the water chemistry and overall the density figures are typical of spaty, low conductivity streams. The area to the north west of the proposed terminal is considered to contain the most important trout nursery and spawning areas, however, the system as a whole is vital for the success of local salmonid fish, as found in the electrofishing survey with fry and young salmonids being found at all sample locations. It was also concluded that both salmon and trout move downstream early in their life histories to better feeding grounds and eventually into Carrowmore Lake.

Macroinvertebrate Assemblages

Due to the extensive range of freshwater habitats in Ireland, freshwater macroinvertebrates are well represented with 73% of the British assemblages. Two key groups of taxa are the stoneflies (Plecoptera) and Mayflies (Ephemeroptera).

Stoneflies are predominantly found in well-oxygenated waters and can constitute up to 50% of the macroinvertebrate fauna found in fast flowing streams. Mayflies can constitute 25% of the macroinvertebrate fauna and are an important group in relation to fish diet.

Freshwater macroinvertebrate assemblages have been used extensively to assess freshwater pollution. Predictable assemblage responses to changes in water quality enables their use as biological indicators of water quality. Biological indices have been developed to measure pollution using macroinvertebrates; including the Q-index. This index uses species sensitivity to pollution, assigning a score, which can be used to cross reference with a pollution index, rating the pollution of a site.

The Q-index system was developed and is now routinely used by the Environmental Protection Agency (EPA) as part of their water quality surveying of Ireland. For the purpose of the EPA assessment process, macroinvertebrate families are divided into five indicator groups, based on sensitivity to organic pollution. Using these faunal groups the Q-value index is calculated and the quality of the stream classified as indicated in Table 7.2.

Table 7.2 - Classification of Water Quality in relation to Q-Value Index

Biotic Index	Quality Status	Quality Class
Q5, Q4-5, Q4	Unpolluted	Class A
Q3-4	Slightly polluted	Class B
Q3, Q2-3	Moderately polluted	Class C
Q2, Q1-2, Q1	Seriously polluted	Class D

Figure 7.1 Electrofishing Sample Locations

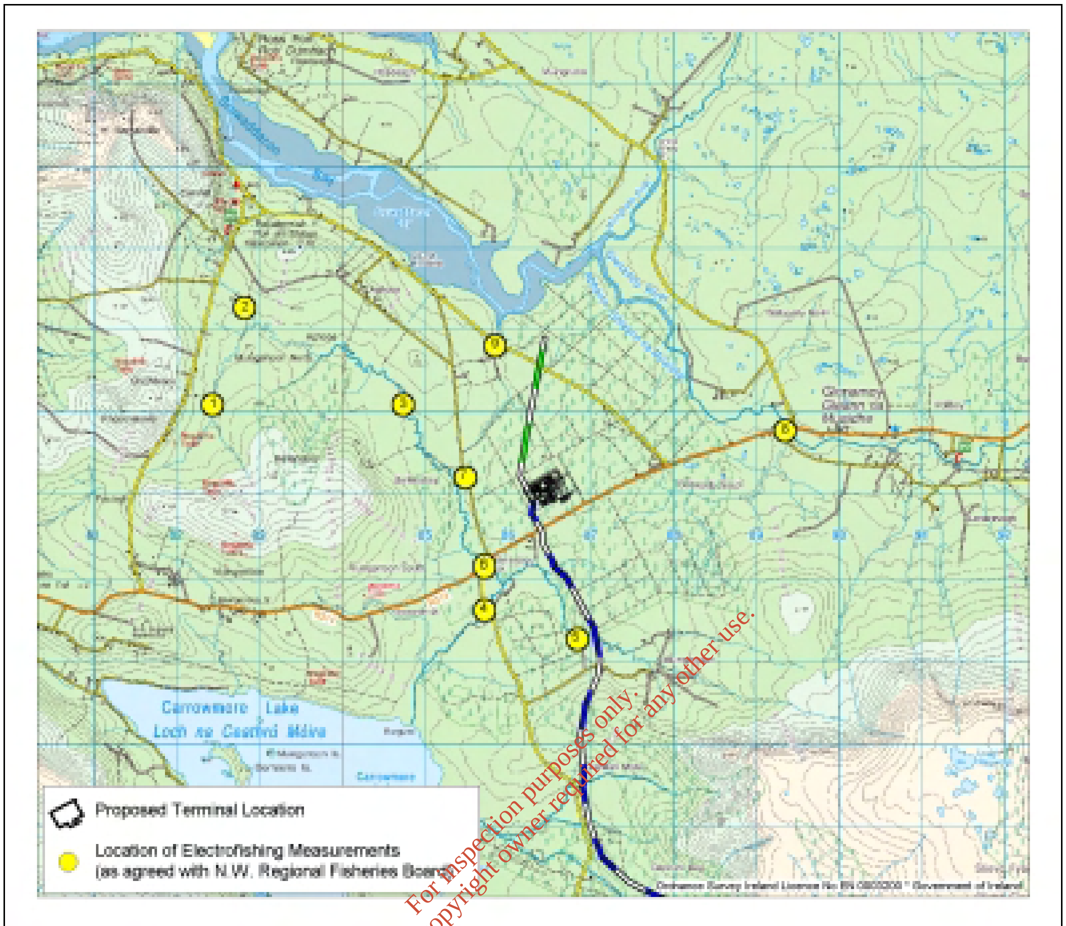


Figure 7.2 Density of 0+ and 1+ Age Classes of Trout Caught at Sample Locations

Macroinvertebrate assemblages were recorded quarterly in the four rivers (sites 4, 5, 7 and 10) near the proposed development site in the locations shown in Figure 7.3 and Table 7.3. Surveys were undertaken over the course of a year to obtain baseline data for the area, covering any seasonal variations. These sites correspond to sites used for collecting physio-chemical data for water quality sampling (data summarised in Section 9).

Table 7.3 – Macroinvertebrate Sampling Locations and Numbers of Faunal Groups Identified

Location Ref.	No of Faunal Groups Identified	Range of seasonal Q values calculated
Site 4 Bellanaboy Bridge	12	Q4 Q3-4 to Q3
Site 5 Muingingaun River	10	Q3-4
Site 7 Aghoos River	15	Q3 to Q3-4
Site 10 Glenamoy Bridge	16	Q2-3 to Q3-4

Samples were taken using the standard kick sampling technique and standard Freshwater Biological Association (FBA) net usually in riffle areas. Three samples were collected for replication, using a three minute kick sample at each site.

Invertebrates were removed from the net and preserved for later identification in a laboratory. Identification was to species level where possible. Recorded groups included stoneflies, mayflies, beetles, caddis flies, gammarus, snails and leeches. In total, 35 species were identified during the sampling period. In general the species were typical of running water with 14 of the 35 species identified being found at all of the four sampling sites.

The total species number of ephemeroptera (mayflies) occurring at a site is generally related to pollution. The average number of species for a river sample is around seven while less than five species can be attributed to influences from the impact of pollution, therefore the fact that all four rivers contained five or six species of mayfly is a good indication of high water quality for these rivers.

No single faunal group dominated the macroinvertebrate assemblage data collected. Lack of single taxon dominance also indicates good water quality at the sample sites. Species intolerant of organic pollution were also recorded providing further evidence.

The Q-value index varied during the sampling year due to environmental conditions and seasonal changes:

- for Bellanaboy Bridge Q-index was Q4 (June), Q3-4 (March) and Q3 (September and December);
- for Muingingaun River Q-index was Q3-4 for three sampling periods with December difficult to assign a Q-value due to the uncommon structure of the community recorded;
- for Aghoos River the Q-index varied over the year ranging from Q3 to Q3-4; and
- for Glenamoy Bridge the Q-index ranged from Q2-3 to Q3-4.

Table 7.3 summarises the range of Q-index values for each site, together with the number of faunal groups recorded over the year.

Construction and post construction monitoring work will generate data which can be compared with results from similar times of the year from the 2001 – 2002 study. This will allow continued comparison of any effects of the proposed terminal on the macroinvertebrate assemblages, which, together with other biological indicators (e.g. Cladophora, sewage fungus and other slime complexes), reflect the quality of the water.

Offshore Fauna

The treated waste water discharge location is in a similar depth of water, and sediment type to that present at site 10 (see Offshore EIS). The benthic community located around that site corresponds to the "*Amphiura filiformis*" community as described by Boelens *et al*. (1999), after Thorson (1957). This type of community is well represented in Irish waters. There were no species recorded during the pipeline route survey which were of conservation importance.

The marine waters off the Mullet Peninsula and in the vicinity of Broadhaven Bay in general are important in terms of fisheries and for marine mammals. More details of the fisheries interest and the marine mammals in the area are provided in the Offshore EIS.

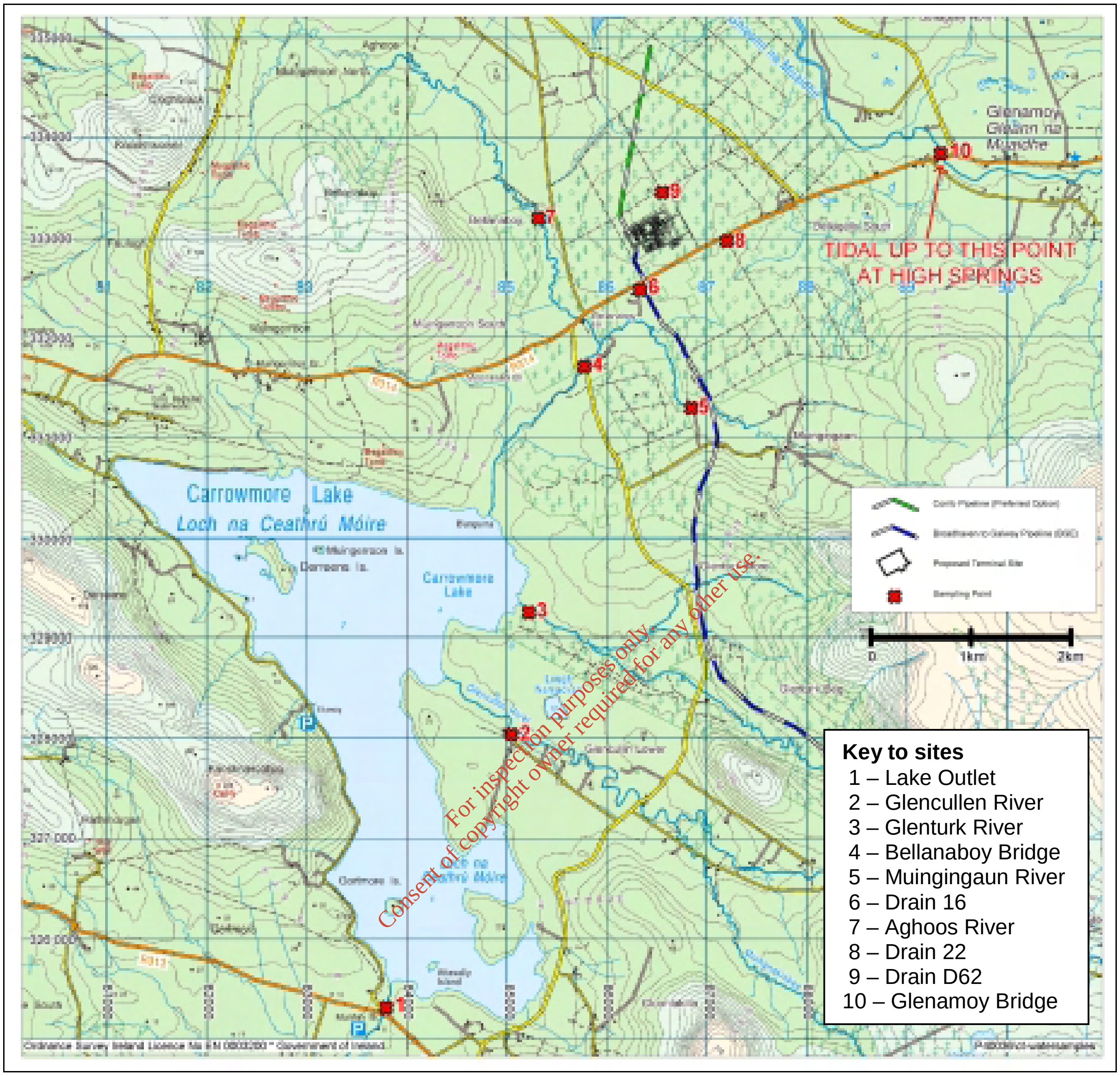
7.3.5 Evaluation – Receiving Environment

Species of Conservation Interest

Mammals

Protected aquatic mammal and amphibian species recorded as present, and potentially using the freshwater ecosystem are described in Section 6.

Figure 7.3 Sampling Locations for Freshwater Invertebrates



Fish

All streams and rivers in the vicinity of the site should be classed as highly sensitive receptors, including the flora and fauna found within them. The nursery areas for trout and salmon, as with the whole river ecosystem, are sensitive to disturbance or excessive suspended solids. Therefore, it is necessary to ensure protection of the system as a whole. It should be noted that high levels of suspended solids occur naturally in these streams.

Trout were found in all sample locations and salmon at most sampling locations surrounding the site of the proposed terminal giving a further indication of the importance of the whole freshwater ecosystem.

Three lamprey species are found in Ireland, all of which are protected under the European Union Habitats Directive. It was not possible to distinguish the species of lamprey which were caught in the electrofishing surveys due to the immaturity of the specimens. These fish were either *Lampetra fluviatilis* or *Lampetra planeri*, it should be noted that there has been recent controversy regarding the ability of present keys to identify immature specimens to species level.

The Atlantic Salmon and the lamprey species are listed on Annexes II and V of the EU Habitats Directive. Annex II lists animal and plant species of community interest whose conservation requires the designation of special areas of conservation; Annex

V lists animal and plant species whose taking in the wild and exploitation may be subject to management measures.

Freshwater macroinvertebrates

In general, the species identified were typical of running water. Fourteen of the thirty-five species recorded were present at all four sampling sites. *Chloroperla tripunctata*, found only at Bellanaboy Bridge has a limited distribution and was found only in small numbers. However, this group is best represented in small, fast flowing, upland streams, which may account for the few individuals present in the kick samples.

All species of Ephemeroptera, apart from *Procloeon bifidum,* would be considered common and abundant or widespread and dominant, with *Procloeon bifidum* given a status of limited distribution.

Marine species

No protected marine invertebrate species have been recorded from the vicinity of the outfall location. For details of location see Section 10.

The grey seal, and the dolphin species seen in the area are listed on annexes II and V of the EU Habitats Directive.

7.3.6 Designated Areas in the Wider Locality

A number of designated conservation areas are found some distance from the site (see Section 6).

- Broadhaven Bay – candidate Special Area for Conservation (cSAC) 472;
- Blacksod Bay and Broadhaven Ramsar site - 844;
- Glenamoy Bog Complex – cSAC 500 (includes Sruwaddacon Bay Special Protection Area);
- Pollatomish Bog – Natural Heritage Area (NHA) 1548;
- Carrowmore Lake Complex – cSAC 476; and
- Erris Head – cSAC 1501.

Potential direct and indirect effects of the terminal development on these sites are considered in this EIS and further discussions can also be found in the Offshore EIS (2001).

Full site synopses are provided in Appendix 6.3. The conservation areas of most relevance to freshwater ecology from the proposed terminal development are:

Sruwaddacon Bay SPA

The drains in the north eastern and eastern blocks of the terminal site feed into small streams, which in turn drain into the Glenamoy River which flows into Sruwaddacon Bay approximately 1.5km due north of the most northerly part of the terminal site.

Sruwaddacon Bay is an SPA and is part of the Glenamoy Bog Complex cSAC 500. It is a shallow tidal inlet off Broadhaven Bay (cSAC 472) and is of special importance for its wintering wildfowl populations, which feed on the intertidal sand/mud flats. It forms an integral part of the Glenamoy River salmonid fishery.

Broadhaven Bay cSAC 472

Broadhaven Bay cSAC contains excellent examples of four habitats listed on Annex I of the EU Habitats Directive, namely Atlantic saltmarsh, tidal mudflats, reefs and large shallow bay.

The citation for the Broadhaven Bay cSAC is provided in Appendix 6.3.

Broadhaven Bay cSAC is also part of the Blacksod Bay and Broadhaven Ramsar site (no.844 - area 683 ha) which was designated 11th June 1996 (see Section 6.3).

Carrowmore Lake cSAC

Carrowmore Lake is a large, shallow, oligotrophic lowland lake which occupies an area of approximately 960 hectares, has a maximum depth of 2.5 to 3 m and a circum-neutral pH. The lake is a Special Protection Area (SPA) and part of a larger, complex cSAC (cSAC 476) (see Appendix 6.3). In addition to these designations, it is an important local amenity in terms of angling and scenic quality (Section 5). It is also important in terms of water abstraction.

This lake is located to the south west of the terminal site and is fed by a number of streams. Of these, the Bellanaboy River, to the west, together with the stream which flows through the Muingingaun townland – to the south - are two of the nearest watercourses to the terminal site. Their confluence is near Bellanaboy Bridge, just south west of the terminal site, from where the flow is in a south westerly direction into the lake itself. These rather small tributaries flowing to the eastern shore of Carrowmore Lake are small spawning and nursery streams, probably mainly for sea trout (*Salmo trutta*) - but salmon (*Salmo salar*) are known to spawn in the tributary in the townland of Muingingaun.

Erris Head cSAC 1501

This cSAC covers sea cliffs which are an Annex I habitat. This land based cSAC is to the south of the proposed discharge location and will be unaffected by the development.

7.4 Characteristics of the Proposed Development

The proposed planning development area covers 160 ha. Within this, the terminal (and its associated buildings and car parking) will occupy 13 ha. A small proportion of the remainder will be used for temporary construction facilities Most of the site area will not be disturbed.

The treated effluent from the operations of the terminal will be discharged outside of Broadhaven Bay, at a depth of more than 60m (see also Section 2.13).

7.4.1 During Construction

It will be necessary to excavate approximately 650,000 m^3 of peat and unsuitable mineral soils. The peat, once excavated, will be transported to a cutover bog at Srahmore works owned and operated by Bord na Mona. The remaining material will be reused during construction on site.

The secondary / emergency access road will be upgraded, by peat improvement, followed by placing fill and geotextile membrane, along the line of the existing forest track, which gives access from the Pollatomish Road.

Peat/Soil improvement is a technique used to increase the strength of soft materials such as peat and silt. A binder such as lime or cement is mixed with the in-situ peat. When the binder sets, the resultant mixture has a far higher strength than the original peat. For the Terminal, it is proposed to use 'dry deep mixing' where an augur drills a hole, into which compressed air and dry cement is injected. Columns of stabilised material are created that overlap to form a cellular pattern.

Construction will commence with the installation of an access road, site fencing and the construction of a site perimeter drainage system. This will substantially reduce construction impacts to the surrounding areas of bog, drain networks and local watercourses. The site preparation phase of the construction programme is planned to commence following receipt of planning permission.

Construction of the treated waste water discharge pipeline will take place in the same trench constructed for the offshore gas pipeline.

7.4.2 During Operation

During operation of the proposed terminal there will be a treated discharge to sea. Measures have been taken to minimise this discharge and details are given in Section 10. Clean runoff from the terminal site will be directed into local watercourses via silt ponds.

Section 2 describes the management routes for the different water sources, these include rainwater, produced water and, in accidental events, firewater.

The site water management system will be constructed to manage surface water, produced water, chemical drains, oily water, sanitary waste water and firewater.

7.5 Potential Impact of the Proposed Development

Methods of ecological impact assessment are provided in Section 6.

7.5.1 During Construction

Potential impacts to aquatic resources relate principally to:

- loss of habitats within the site, in particular: loss of breeding and foraging habitat for frogs leading to the potential for the reduction in food source for otters;
- excessive suspended solids within watercourses;
- leaching of lime or cement binder into the ground and surface water; and
- pollution incidents resulting in discharges to watercourses.

Potential Impacts on the Terminal area

Potential impact upon frogs is discussed in Section 6. Potential impacts of the lime/cement binder leaching out are discussed in Section 9.

Potential Impacts on Surrounding Areas

Minimisation of impacts on the aquatic systems, watercourses and the downstream lakes, estuaries and broader marine habitats, is dependent on the successful implementation of pollution control measures, including run-off control (see Section 9). The procedures and methods proposed will result in the development having a negligible impact on surrounding areas.

Potential Impacts of Excessive Suspended Solids

Smothering of Fish Spawning Redds

Salmon and trout eggs or fry present in spawning redds may be smothered by excessive deposits of silt, or spawning fish may avoid traditional spawning areas if these are covered in silt deposits. It is likely that spawning lampreys would suffer the same fate, as their spawning requirements are very similar to those of salmonids, however lampreys were scarce in all sampling locations. It should be noted that the most important salmonid spawning sites in the vicinity of the terminal, are upstream of it, and therefore unlikely to suffer siltation as a result of activities on the terminal site. Salmonids spawn and fry hatch from October to the end of April.

Coarse fish spawn in the period from May to June, generally laying their eggs among aquatic weeds. It is reasonable to assume that these too would succumb to excessive amounts of suspended solids in the water column.

Fish Health Damage

Fish gills are susceptible to abrasion by excessive exposure to elevated suspended solids levels, which in turn can give rise to health problems in the form of gill disease. Younger fish tend to be more susceptible than older individuals. Direct fish mortality from elevated inert solid levels is rare.

Interference with Angling

Excessively turbid waters are likely to reduce or eliminate angling success (game and coarse angling), which would be particularly problematic during periods of intense angling activity, fishing competitions and in waters where anglers are paying large fees to fish. It is this impact from suspended solids which is recorded first, before damage to fish health (NWRFB, pers comm). A tourist survey (Section 5) indicated that fishing was popular with those visitors staying in Westport and Erris.

Smothering of Macroinvertebrates

Aquatic macroinvertebrates including insect larvae, molluscs (snails and bivalves), crustaceans (shrimps and crayfish), leeches and worms, etc., may be smothered by excessive deposits of silt from suspended solids. Moreover, deposits of silt in otherwise stony substrates gives rise to a change in the macroinvertebrate species composition, often favouring less diverse assemblages.

Smothering or Stunting of Aquatic Plant Communities

Aquatic plant communities (especially submerged growths) are likely to be eliminated or stunted by excessive deposition of suspended sediment, and effects may also occur through reduction in photosynthesis due to excessive water turbidity.

Accidental Spillages

Pollution from Fuel Oil

Spillage of fuel, lubrication or hydraulic oils either from bulk storage or from construction vehicles or plant and equipment operating close to watercourses or drainage ditches which connect to watercourses could cause damage to aquatic flora and fauna communities.

Offshore construction

The discharge pipeline will be laid in the same trench as that constructed for the offshore gas pipeline. It will also be laid at the same time as the gas pipeline, reducing the impacts. Impacts from construction of the offshore gas pipeline are covered in the Offshore EIS. Mitigation measures to ensure that impacts of installation of these pipelines are reduced as far as possible are described in that EIS, and since then these measures have been developed further in consultation with various statutory and non statutory bodies.

7.5.2 During Operation

The Terminal Site

During normal operation the only potential source of impacts on local watercourses would be run off from the terminal site. However, the procedures and methods proposed in mitigation will result in the development having negligible impact.

Worst Case Scenario

The operation of the terminal should not lead to significant impact on freshwater ecology. Under a "worst case scenario" such as a major pollution incident or fire there is potential for impact on the freshwater ecology.

Such incidents could potentially damage nearby watercourses, water bodies and designated conservation areas. This could reduce or eliminate invertebrates and vertebrates (fish and amphibians) and lead to loss of feeding habitat for predators. Recovery would be expected, but could take considerable time.

Species such as the otter (*Lutra lutra*) (Annex II species, EU Habitats Directive) could be affected.

Impacts on Offshore Areas

The treated waste water will contain extremely low concentrations of some contaminants, including trace metals. The expected concentrations of these contaminants in the waste water are presented in Section 9.

In the absence of a treatment system for these contaminants they would have the potential to accumulate in biota, such potential impacts are described in the Offshore EIS.

7.6 Do Nothing Scenario

If the development did not proceed, the habitats affected by the proposed terminal would remain intact.

7.7 Mitigation Measures

7.7.1 General

Standard mitigation measures, as would apply to any large-scale development, will be adopted in the construction and operation of this development. These include:

- limiting the season of disturbance;
- introducing measures to minimise emissions and sedimentation into watercourses during construction, operation and post-operation phases; and
- giving consideration to the creation of compensation habitats, e.g. ponds and wetland features.

Further details are given below.

7.7.2 Protection of Amphibians: Common Frogs

The measures which will be taken to protect the frogs and provide alternative habitat are described in Section 6.7.5.

7.7.3 Pollution Hazards: Construction and Operational Phase

From the outset, and throughout the planning and implementation phase of the project, close contact will be maintained with the NWRFB. Liaison procedures and contact personnel will be agreed in advance between the developer and the Fisheries Board and all relevant statutory bodies. At all times the developer will provide adequate notice (to be agreed) to the Fisheries Board when they are beginning any works in the vicinity of streams or main drains.

Measures to reduce the potential impacts of construction and operation on the freshwater ecology are described in Section 9. In summary, the design of the construction works will minimise the entry of suspended particulates, and eliminate the entry of pollutants into the local drainage system and natural watercourses in the area. Two drainage systems will be used on site, the closed drains from paved areas feeding to the water treatment plant and the open drains feeding from unpaved areas to the silt ponds. This system is discussed in more detail in Section 9.

7.7.4 Protection of Natural Flows and Hydrology

Natural runoff from the site discharges ultimately into designated conservation areas. Any substantial alterations to the flow regime in local watercourses may impact upon the functioning of the ecosystem of these areas, which include Carrowmore Lake cSAC/SPA and Sruwaddacon Bay SPA.

Measures will be taken to ensure that the flows in local rivers are maintained close to present levels such that the hydrology of the natural watercourses and water bodies, especially within designated conservation areas, is maintained. These measures will include the use of weirs on the outlet of the silt ponds, which will act as flow attenuating ponds and will only release water at a flow rate related to the flow in the receiving watercourse.

7.7.5 Habitat Retention, Replacement and Landscaping

Habitat replacement and landscaping can substitute for, or add to, the diversity of the flora and wildlife ecological value of the area. These techniques will help to integrate the development into the landscape and provide areas of aesthetic as well as wildlife interest. Specific measures will include the creation of a series of small ponds fed by natural run-off, to act as breeding sites for frogs (see Section 13.13).

7.7.6 Treatment of waste water

Before water is discharged to the Atlantic Ocean, it will be subject to three stages of treatment (see Section 9). These treatments will reduce the levels of any trace metals or organic material to the EQS (Environmental Quality Standard) level. The EQS levels are determined by the EPA as a requirement of the IPPC licence and apply generally to open waters.

In the EPA procedure for setting EQS standards "the aim is that the suggested standards should reflect the maximum amount of a substance which may be present in a water body without affecting the biological communities in their functional processes or otherwise giving rise to unacceptable, adverse effects on the ecosystem or accumulation of substances that are harmful to the biota (including man), whether via the food chain or otherwise. The EQSs could thus be lower than the "ecosystem NOEC" [No Observed Effect Concentration] values, which can only be determined experimentally by long term multi-species experiments", (Environmental Quality Objectives and Environmental Quality Standards, The Aquatic Environment, A Discussion Document; pp38; EPA, 1997).

7.8 Predicted Impact of the Proposed Development

7.8.1 The Terminal Footprint During Construction

The potential impacts on watercourses (sedimentation and pollution) will be much reduced through the mitigation measures proposed and hence the overall impact will be reduced to a negligible or minor level.

7.8.2 Site and Surrounding Areas During Construction

Provided that the protection measures described above are used to minimise the release of high suspended solids loads into the surrounding watercourses which support salmonids, the predicted impacts will be negligible or minor. The timing of site works may also be an important factor in relation to the effects of suspended solids.

The discharge pipeline, which will be laid in Broadhaven Bay, will be installed at the same time, and in the same trench, as the gas pipeline. It is likely that the discharge pipeline will be "piggy-backed" onto the larger gas pipe in order to assist in the construction. This method of installation will not result in any additional disturbance to the sediments of the Bay, to that caused by the installation of the gas export line itself. A more detailed description of the impacts can be found in the Offshore EIS, but in summary, the pipeline will initially be laid on the seabed, then a sediment jetting or trenching machine will run along the route, removing sediment from beneath the pipe. This will enable the pipeline to sink into the trench. The jetting or trenching machine will then cover the pipe with the sediment that was removed.

The likely impacts to the ecosystem in Broadhaven Bay from this pipelaying activity, which would include smothering of the adjacent fauna (both mobile and sessile) and flora, are considered minor and comparable to the natural disturbance from wave action. The larger and more mobile species present within Broadhaven Bay (such as fish and crabs) are likely to temporarily move away from the area of seabed which is being disturbed by construction operations. However, once the operations are completed, the animals are then likely to move back to their original habitats, and any sessile invertebrates are likely to re-colonise the area through natural means (i.e. juveniles are likely to settle).

7.8.3 The Terminal Footprint During Operation

There will not be any aquatic species living on the terminal footprint during operation.

7.8.4 Site and Surrounding Areas During Operation

The treated waste water discharge will introduce such low levels of contaminants (see Section 10) that the impacts are predicted as negligible. The potential impacts described earlier will be fully mitigated by the treatment processes which will be installed on the terminal site. The impacts associated with the construction and operation of the outfall pipeline from the terminal are described In the Offshore (Field to Terminal) EIS. The EIS accompanied the application for a Pipeline Consent (Gas Act), Foreshore Licence (Foreshore Act) and Plan of Development, all granted 2002.

In summary, the magnitude of these impacts were assessed to be:

- trench construction – temporary, minor-negligible;
- pipelaying – temporary, minor negligible; and
- outfall discharge – negligible.

If the proposed terminal is constructed and operated following the procedures described in this document, the overall impact of the development may be considered as negligible or minor in terms of effects on the aquatic ecology.

7.9 Monitoring

The freshwater biological monitoring programme will be agreed with the NWRFB prior to the construction phase commencing. However, it is envisaged that it will follow the same lines as that which has been undertaken to date, though probably on a reduced scale. It is proposed that sampling locations on the site would be restricted to those sites where discharge leaving the site can be measured. One or two sites would also be sampled in the Bellanaboy

River, at the bridge and probably upstream of the terminal site (in order to have a site which cannot be affected by construction of the terminal).

The parameters measured during the surveys will be the same as before to maintain continuity. This will include quarterly macro-invertebrate kick sampling/monitoring at the Bellanaboy Bridge site.

Additional baseline monitoring is currently taking place in Broadhaven Bay to further characterise the background levels more fully. This monitoring is being carried out in agreement with the Department of Communication, Marine and Natural Resources (DCMNR).

The proposed offshore monitoring survey is described in the Offshore EIS. It covers analysis of sediment and biota. The biota sampling will include both benthic invertebrate diversity and abundance, as well as bioaccumulation studies (for contaminants discharged).

It is anticipated that the frequency of both the freshwater and offshore surveys will reduce after the first few years of terminal operation, but again this will be agreed with the regulatory authorities depending on the results of the initial surveys.

7.10 Reinstatement and Residual Effects

7.10.1 Terminal Site

Suitable habitat replacement and creation should allow for an increase in the representation of flora and faunal species in the area and ameliorate losses of existing habitat on site.

Over time peat deposition areas will provide the opportunity to look at habitat enhancement and the creation of new wetland habitats. This would be undertaken in consultation with the statutory authority (NPW).

7.10.2 Wider Area

Provided construction can be undertaken during the periods agreed and that if any spawning beds are affected by the works they are reinstated to approved specifications, then there should be no impact on the spawning capacity of any of the watercourses affected by the proposed terminal. Nor should there be any other impacts on the other freshwater habitats and species.

7.10.3 Offshore Area

It is anticipated that the biota along the route on which the discharge pipeline is constructed will return in the few years following installation, if not earlier.

Eight

Soils, Geology and Hydrogeology

8 Soils, Geology and Hydrogeology

8.1 Introduction

This section describes the solid geology, superficial geology and soils underlying the proposed Bellanaboy Bridge Terminal Site and discusses the influence of these on the hydrogeology of the site. It is important to have an understanding of the physical nature of the ground as this may affect the location and construction of the site in terms of:

- direct or indirect effects upon both aquatic and terrestrial habitats; and
- ease of terminal construction and thus costs and logistics.

The description of the physical environment is followed by a summary of the impacts arising from construction and during operation and the measures proposed to mitigate those impacts.

This section has been prepared by RSK ENSR Environment Ltd.

8.2 Study Methodology

For the purposes of this report, the geology has been divided into the superficial 'drift' geology and the underlying 'solid' geology. The engineering properties of both the drift and solid geology, together with the hydrogeology will have a significant impact on the design of the groundworks for the terminal.

Information on solid geology was obtained from the Geological Survey of Ireland (GSI) - Sheet 6 'Geology of North Mayo' and the accompanying booklet (1992). Any description of 'soil' in this report has been included within an overall description of drift.

In addition a number of investigations have been carried out at the site over the last few years. Various techniques appropriate to the differing ground conditions have been employed comprising conventional shell and auger drilling of drift deposits, rotary coring of rock including the weathered surface layers, trial pits, cone penetration tests (CPTs), Mackintosh probes, in situ vane tests and gouge samples. The results of these investigations have been assessed to supplement the published geology on the site and provide extensive new information about the site.

The detail of the geology of the site has been investigated by Arup Consulting Engineers, with additional work and review by Applied Ground Engineering Consultants (AGEC). Their work is summarised in this section. A detailed presentation of their work is given in the Technical Appendix to this EIS: Geology, Hydrogeology and Global Stability.

8.3 Receiving Environment

A synthetic geological cross-section of the site has been prepared by Arup (see Figure 8.1). In addition hydrogeological information is included on the synthetic section, which will assist in an understanding of later parts of this section.

The synthetic section represents a mean, or average, of all possible sections drawn from the highest to the lowest point on the site and was compiled from digital survey data for the site as a whole. The vertical axis represents units of ground elevation (at 1m intervals), as in a conventional section, the horizontal axis represents cumulative percentage area (the area enclosed by each 1m contour expressed as a percentage of the total site area).

8.3.1 Drift Deposits Including Soil

Little information could be gained from official published sources on superficial deposits underlying the proposed terminal site. No published drift geological maps are available and the published guide (Geology of North Mayo, 1992) only gives general information on Quaternary sediments. According to the General Soil Map of Ireland (1980), the terminal site is underlain by "rolling lowland blanket peat (low level)".

The following information was therefore gathered from the site investigations carried out both on the proposed terminal footprint itself and the larger site as a whole. Whilst information gained from the numerous investigations outwith the terminal footprint may be considered not directly relevant to the excavation and construction of the terminal itself, they provide invaluable information about the geology of the wider area of the site and greatly assist in its interpretation.

Peat

Peat tends to form in this region on both high and low lying ground. It suffers very high consolidation on loading and a high level of shrinkage is experienced on drying. Peat is often waterlogged, leading to difficulties for trafficking of construction plant. Fibrous peat consolidates quickly with the more clay-rich amorphous peaty soils consolidating over a longer period.

Figure 8.1: Synthetic Geological Cross-section with Hydrogeological Information (Arup)

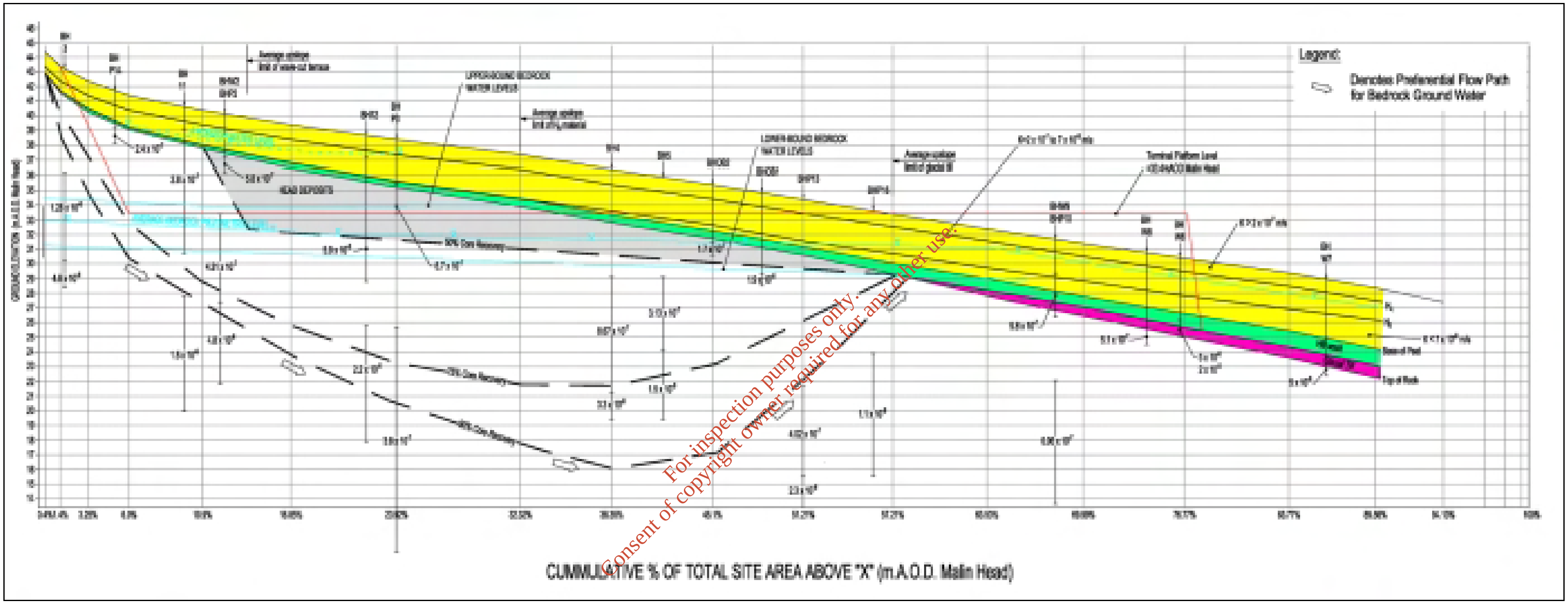


Table 8.1: The Von Post Humification Scale (after Von Post and Granlund 1926)

Class	Description
H1	Completely unhumified plant remains, from which by hand only almost colourless water can be squeezed.
H2	Almost unhumified plant remains; the squeeze water is light brown and almost clear.
H3	Very poorly humified plant remains; the squeeze water is light brown and almost clear.
H4	Poorly humified plant remains; peaty substances do not escape from between the fingers by squeezing.
H5	Moderately humified plant remains; the structure is still however clearly visible; the squeeze water is dark brown and very cloudy, while some peat escapes between the fingers.
H6	Fairly highly humified plant remains the structure (texture) is unclear, about a third part of the peat escapes through the fingers. The part remaining in the hand has a more clear plant structure than the part that was squeezed out.
H7	Highly humified plant remains; about half of the material escapes when squeezed. The water that may escape is dark brown in colour.
H8	Very highly humified plant remains; two thirds will escape through the fingers on squeezing. The remainder consists of bits of resistant bits of roots, wood etc.
H9	Almost completely humified plant remains; almost all the peat escapes through the fingers. Structure is almost absent.
H10	Totally humified plant remains; amorphous peat; all the peat escapes the fingers without any water being squeezed out.

Across the site as a whole the peat varies in thickness from less than 1m to in excess of 5m with peat thickness generally varying inversely with elevation. Over the footprint of the terminal it varies from about 1.5m in the north-east to 3.5m in the south and south-west.

The peat is typically dark brown and fibrous near the surface becoming progressively more humified with depth. Deep peat is amorphous and gelatinous with little recognisable herbaceous material. During excavation of trial pits, some peat was found to be very soft, often with severe undermining and collapse of the pit sidewalls. Oedometer consolidation tests confirmed that the peat is highly compressible.

The degree to which the peat is humified can be expressed as different classes using the Von Post Humification Scale (Von Post and Granlund 1926). His scale registers H1 to H10 with H1 reflecting the least humified, herbaceous peat and H10 the most humified, totally amorphous peat. The Von Post Scale is described in Table 8.1.

The degree of decomposition of the peat is an important measure of its mechanical behaviour. The Von Post indices obtained from gouge holes across the site were therefore assessed by Arup. To identify the variation in quality of peat, both in depth and across the site, the distributions of two values, H4 and H8, were considered. Both these values were well represented in the data set and indicate significant transitional boundaries within the peat profile. H4 represents the boundary between relatively un-decomposed peat and decomposed peat whilst H8 represents the boundary between peat with remnant fibres and non-fibrous, essentially gelatinous, peat.

From this assessment the following general statements may be made:

- the thickness of less decomposed peat (H1-H4) increases progressively upslope;
- highly decomposed peat (>H8) thins to nothing upslope and is not present above a ground elevation of about 36m AOD (Malin); and
- moderately decomposed but still fibrous peat (H4-H8) reaches a maximum thickness of about 2m mid slope but thins both upslope and downslope.

The variation in peat thickness on the slope is thought to be due partly to the way in which peat grew starting in low-lying wet hollows, with therefore the greater thickness on the lower slope. However, the additional thickness of highly decomposed peat is also due to the fact that some of the lower peat is fen peat, which grew in wetter environments and was less fibrous.

Hillwash and Glacial Till

These two mineral soils are present directly beneath the peat. They are of different origins and age but in many of the investigation locations are not clearly distinguished.

The Glacial Till is the older deposit and is only present on the lower slopes of the site where it reaches a maximum thickness of about 1.5m. It is not present beneath the footprint of the terminal. It probably dates from the penultimate glacial period and comprises a very stiff slightly cohesive mineral soil.

The Hillwash layer extends across the whole site increasing in thickness downslope, again to a maximum of about 1.5m. Beneath the footprint of the terminal it reaches a maximum of about 1m.

The Hillwash layer is thought to be derived from local material that has been transported down the slope by run-off at a time when the site was devoid of vegetation. Higher up the slope it is less than 1m thick and rather clayey in character and is typically described as a firm to stiff grey sandy gravelly clay. Further downslope it is thicker and has become more differentiated into sand and silt layers. This change is marked below an elevation of about 33.5m AOD (Malin) and is thought to be due to the presence of a significant spring line, which would have provided additional water for segregating the material.

Deposition of the Hillwash layer is thought to have been initiated towards the end of the last glacial period and appears to have continued until relatively recent times.

Terrace and Overlying Deposits

A sequence of deposits has been identified mainly from the rotary-cored boreholes. They are present beneath the footprint of the terminal as well as to the east and north-east. The base of these deposits appears to occur over an elevation 29.5 to 32.5m AOD (Malin). Over the terminal site the terrace deposits range up to 5m in thickness.

Their formation is thought to predate the above-mentioned Glacial Till. The terrace deposits probably originated as a scree or head deposit derived by gravitational transport of surface rock debris from the hill above. It has been described from the boreholes as a very dense light green slightly gravelly sand. Deep weathering has affected this deposit as well as the underlying rock (see below).

8.3.2 Solid Geology

An interpretation of the solid geology beneath the site has been obtained from the Geological Survey of Ireland (GSI) - Sheet 6 'Geology of North Mayo' and the accompanying booklet (1992), supplemented by lithological data from the boreholes sunk across the site. Since the former was based on very limited bedrock exposure within 1km of the site the latter provides a significant improvement to an understanding of the geology of the site.

The Inver Schist Formation underlies the terminal footprint as well as much of the remainder of the site. It is described in the published literature as dark, graphitic, semi-pellitic schists, with occasional discontinuous grey marbles, and bands of psammitic schist. All the formations in the area have been affected to varying degrees by regional metamorphism, which has changed the lithology and fabric of the rock. Beneath the site the Inver Schist contains approximately equal proportions of psammite, semi pellite and pellite. Quartzite is only occasionally present. The varying amounts of quartz and mica give the rock a varying strength and susceptibility to weathering.

To the east of the site the Benmore Formation is exposed in the quarry where it is seen to comprise a strong quartzitic sandstone. The Srahlaghy Formation was also identified in cored boreholes in the east of the site and comprised a strong medium to coarse-grained quartzite.

Rockhead was encountered generally at depths between 3m and 7m beneath the site. However, extensive weathering of the rock has occurred, particularly beneath the terminal site.

Surface weathering has resulted in a loss of strength and intactness of the rock. These changes to the rock have a direct influence on the core recovery achieved in the boreholes. The action of pressure and water flush on the weathered rock during boring often results in a reduction in total core recovery. This parameter has therefore been utilised in assessing the depth of weathering. Total core recoveries of 50%, 75% and 90% have been assessed from the cored boreholes and envelopes of the depths below which these have generally been obtained are superimposed on Figure 8.1.

The 50% core recovery envelope has been taken to represent the base of the terrace described above. Beneath the terminal footprint extensive weathering of the Inver Schist is indicated by the 75% core recovery line extending to a maximum of about 10m below the terrace.

Weathering also extends upslope of the terrace into the hill but the bedrock underlying the uppermost part of the hill is largely unweathered. There is also the absence of significant bedrock weathering in the area downslope of the terminal.

8.3.3 Structural Geology

The Dalradian sediments are over 590 million years old and have undergone much deformation resulting from periods of extremely high temperature and pressure. As a result, the beds are intensely folded and fissured. Faulting and cleavage are commonplace and provide the main planes of weakness (discontinuities) within the body of the rock.

8.3.4 Topography

The topography of the site does not present many constructional difficulties in terms of steep slopes or side slopes. The 13-hectare development footprint proposed for the terminal location is gently sloping. The natural fall of the ground is from the NE to the SW, S and SE.

The gradient is approximately 1 in 30 (circa 2 degrees). The ground at the terminal site falls by 12m over the total site from NE to SW.

8.3.5 Hydrogeology

The geology of the site, and the groundwater levels and flows within/through both the superficial deposits and bedrock are interrelated.

As part of the various investigations piezometers have been installed and permeability tests have been carried out to provide relevant data to understand the groundwater conditions beneath the site.

In broad terms three groundwater units are recognised. These comprise the bedrock groundwater unit (which also includes the terrace deposits, glacial till and hillwash) and the peat groundwater unit together with a secondary unit referred to in the Arup report as the 'A' horizon groundwater unit.

The various units are controlled by the permeabilities of the ground (soil and rock) through which the water flows and are in the main separated by the least permeable material. The permeability tests indicate uniformly low permeability in the order of 10^{-7}m/s for the hillwash, terrace deposits and very weathered bedrock whilst a higher permeability of 10^{-6}m/s is indicated for the less weathered rock (core recovery 75-90%). The permeability of the bedrock again reduces with depth and also downslope where it is overlain by the glacial till and exhibits minimal weathering. The values of permeability for the different layers are indicated on Figure 8.1.

Within the peat the permeability is related to the degree of humification. In general the near surface, least humified peat (H1-H4) has permeability greater than $2x10^{-7}$m/s and the most humified peat (>H8), a value less than $6x10^{-9}$m/s (i.e. virtually impermeable).

Bedrock Groundwater Unit

The water level in the bedrock groundwater unit comes very close to the existing ground surface between ground elevations 31.0m – 33.5m AOD (Malin) whilst above this elevation there is a clear trend of increasing depth to groundwater in progressing upslope.

On the upper parts of the slope the lower permeabilities of the more weathered rock and the mineral soils acts as a confining wedge. Recharge water entering the ground near the crest of the hill, where the peat is thinner and more permeable and the rock is less weathered but still rather fractured, cannot flow laterally from the hill crest but is forced beneath this confining wedge to flow through the more fractured rock. This presumed flow is indicated on Figure 8.1. The more permeable rock zone rises again towards the surface at an elevation of about 33m AOD (Malin) creating an area of potential outflow or up-welling of bedrock groundwater.

Lower down the slope, below the area of the terminal footprint, the permeability profile is different. The permeability of the bedrock and the overlying glacial till are similar and what water does flow through the bedrock is not confined by the till but leaks into the hillwash layer, which is generally of higher permeability. Over the lower parts of the site the hillwash is again capped by a lower permeability material, humified peat, but the covering is not fully watertight. In some places deep drains on the site (e.g. D22) expose the hillwash allowing sub-peat groundwater to reach the surface. However, where relief drainage does not occur, or locally where the hillwash is more clayey (less permeable), artesian conditions may exist down slope.

'A' Horizon Groundwater Unit

Above an elevation of about 36.5m AOD (Malin) a number of water level data points indicate water levels within the terrace deposits at relatively shallow depth. These indicate the presence of a perched water table. It is considered that this is maintained on a thin iron pan layer formed by the concentration of iron oxides and other minerals, which were leached from the sub-peat surface and form a rather impermeable cemented layer. This leaching is known to have occurred in this part of Ireland, prior to peat formation, and is referred to as a leached 'A' horizon within the hillwash layer.

In progressing downslope this perched water (which is recharged from the hillcrest area and from water draining downwards through the peat) becomes more confined by the highly humified peat. It is reasonable to assume that the 'A' horizon does not connect with the more permeable hillwash material downslope since water levels in the former are much closer to the surface. It more likely peters out in the area where up-welling of bedrock groundwater occurs.

Peat Groundwater Unit

On site measurements of permeability are not available for the top 0.5m of the peat. However, known values for the near surface of peat are of the order of 10^{-5}m/s. It is this higher permeability, which allows a separate near surface perched water table to develop but this can only be maintained if precipitation exceeds run-off and evapo-transpiration. At this site this is likely to be the case throughout much of the year.

Water levels recorded in piezometers installed within the peat indicate that the depth to water level is generally less than 0.3m below the surface. At elevations between 30.5m-35.5m AOD (Malin) the water level is even closer to the surface. This is the same area as where groundwater in the bedrock intersects rockhead. The shallow groundwater levels in the peat therefore appear to mirror the zone of up-welling of bedrock groundwater.

Outside this zone under-drainage of the peat occurs, upslope into the lower water levels of the 'A' horizon groundwater unit and the bedrock unit, and downslope to the lower water levels in the more permeable hillwash.

8.4 Potential Impacts

8.4.1 Engineering Geology

Foundation Options for Buildings and Tanks

Because of its low shear strength, the peat in its existing condition is unsuitable as a founding medium. Therefore where peat remains beneath buildings it will generally be necessary to support these on piled foundations taken down through the peat into the underlying weathered bedrock.

Alternatively, for the more lightly loaded areas/units, improvement of the peat is being considered whereby in situ mixing of the peat with cement binder will improve its strength. This will enable roads, parking areas and hardstanding, together with lightly loaded structures to be placed directly on the peat. Where, this process is employed the areas will be contained within lines of sheet piling to prevent loads being transferred to adjacent peat. (See Section 3.2.5).

In areas of cut the exposed formation will comprise either the underlying dense silty sands of the terrace deposits or the firm to stiff clay of the Hillwash, or weathered bedrock. All these materials should have adequate strength to support lightly loaded structures with either pad footings or raft foundations. However, due to the limited thickness of the Hillwash materials foundations will be taken through this layer into the underlying sand. The formation will be susceptible to disturbance and therefore softening, particularly in contact with water and therefore care will be required during construction to minimise this effect.

More heavily loaded structures will need to be supported on piles, as will structures, which span the sand and weathered bedrock in order to minimise differential settlements. Piled foundations will also be necessary for buildings located in the south-western area of the terminal site where several metres of fill will be placed to raise the site level up to formation following excavation of all the peat.

Stability of Excavation Side-Slopes

Peat, when saturated lacks any degree of competency. Experience of bulk peat excavation confirms that shallow sideslopes are required and even then local failure may occur. Consequently all cut slopes through peat will be supported by gabion gravity walls keyed into the underlying mineral soils. These walls will be constructed in short bays to minimise the risk of failure of the peat during construction. (See Section 3.2.6).

Side slopes of excavations formed through mineral soil or weathered rock will be cut back to slopes of 1 in 3 or 1 in 2, respectively, whilst slopes in unweathered rock should stand safely at a slope of 1 in 1.

Excavatibility of Rock Mass

Because of the proposed formation level of the terminal site, it is expected that some rock will have to be removed in order to level the site prior to construction. The majority of rock to be excavated will be weathered and its removal should be possible with a combination of digging and ripping techniques using conventional tracked backactors. In the extreme north-eastern corner of the terminal site relatively unweathered rock is expected to be encountered. Even here, due to the close spacing of the fractures excavation should be achieved by ripping possibly assisted by a mechanical breaker. The breaking of this rock will be more difficult and may be noisy and time consuming.

Dewatering of Excavations

As described in the section on hydrogeology of the site above there are two major groundwater units:

- in the peat; and
- in the bedrock and overlying mineral soils.

The majority of the materials present on the site are of low permeability and therefore even when excavating below the groundwater tables inflow into excavations is not generally expected to result in significant quantities of water. The exception may be the terrace deposits, which also contain significant clay and silt sized particles but in zones could be relatively permeable and may release quantities of entrapped water. This water will need to be pumped from local sumps into the temporary site drains.

Any water accessing the construction formation will rapidly result in deterioration of the ground making excavation very difficult, and therefore any pre-excavation dewatering that could minimise the inflow will be beneficial.

Drainage of the peat will be commenced as soon as possible before starting the main excavation work for the terminal site. This could be achieved by forming shallow drainage trenches at close centres. As the adjacent peat is drained the depth of the drains would be progressively increased. Not only will this assist in dewatering of the site but, due to shrinkage of the peat as its water content is reduced, will also reduce the volume of peat to be removed off site.

With regard to the bedrock groundwater unit, the main points to consider in relation to dewatering are:

- the predominant flow of water in the bedrock is through the moderately weathered material (75%-100% core recovery); and
- where the zone of moderately weathered bedrock subcrops beneath the peat, there is a potential up-welling of groundwater.

Cross-sections (N-S and E-W directions) have been produced to show the geological structure of the site. The least thickness of both peat overburden and bedrock weathering appears to coincide with a NNW-SSE aligned ridge, which whilst evident from the surface topography is slightly more obvious when seen on the sub-peat surface.

This ridge extends from the crest of the hill north of the terminal footprint and links to the south of the R314 road. This ridge forms a surface drainage divide between the Glenamoy and Carrowmore catchments and is also thought to exert an important influence on the groundwater. Fractured bedrock flow paths occur away from the ridge.

It is proposed that a number of wells are installed in the bedrock to lower the water table and reduce the potential for inflow into excavations. Two groups of wells are proposed and their locations are indicated on Figure 8.2. One to capture the bedrock groundwater that emanates from the hillcrest and the NNW-SSE aligned ridge, and the other to intercept the zone of bedrock groundwater up-welling.

Re-use of Excavated Materials for Engineering Fill

Peat

All peat excavated from site will not be suitable for re-use as an engineering material. The peat will be taken off site.

Hillwash Deposits

The Hillwash deposits are generally about 1m thick over the footprint of the terminal site. Excavated soils are likely to comprise sandy gravelly clay. In its undisturbed state it has been described in the borehole records, as being of firm to stiff consistency but because of its relatively high moisture content it is likely to be much softer when excavated. This material is not considered suitable as an engineering fill unless its moisture content could be substantially reduced which would be difficult to achieve. Treatment with lime/cement would improve its compaction properties but it would be more suitable to be used as a fill for landscaping purposes. Some of the weakest materials will be disposed of off site.

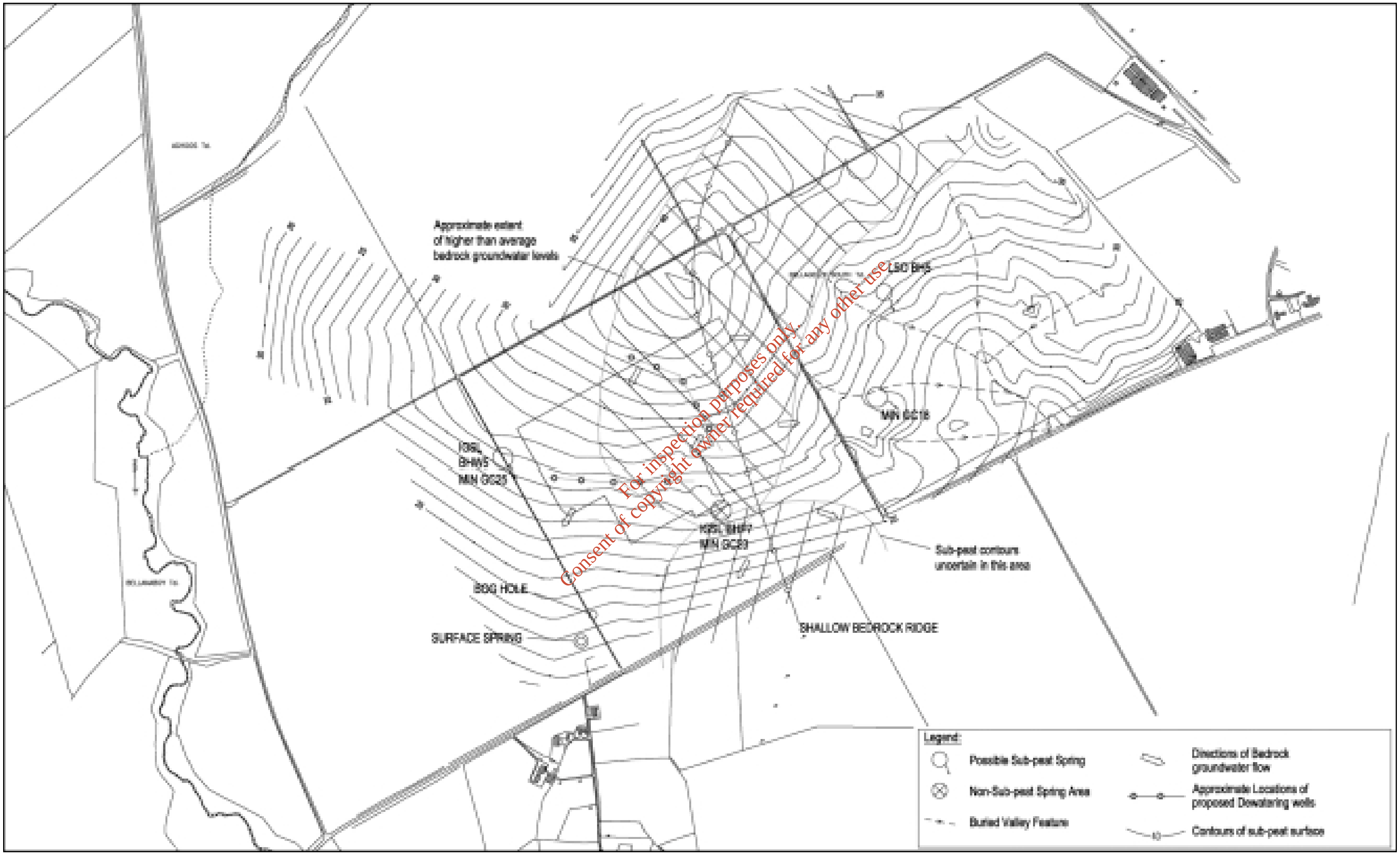
Head (Terrace) Deposits

The Head deposits have been described as dense to very dense sands but due to their low permeability they are likely to have a relatively high fines (clay) content. When excavated their moisture content is expected to be high and therefore the material would not be suitable for engineering fill. However, if it were stockpiled and allowed to drain it should be possible to utilise this material as general fill.

Weathered Rock

It is estimated that much of the excavated non-peat material will be weathered rock. Core recoveries of this material were generally in the range 50% to 75% indicating that a significant proportion of the intact rock has weathered to clay/silt/sand sized particles, which were washed away during the drilling operation. The permeability test results in this material indicate it to be of relatively low permeability and hence have a high fines content. When excavated it is likely that the material will be well graded with particles ranging in size from clay to gravel/cobbles with some even larger. At the right moisture content it should be possible to compact it to raise the southern sector of the terminal site. Foundations in this area will need to be piled and therefore the fill will not be load bearing.

Figure 8.2: Location of Possible Springs (also Shallow Bedrock Ridge and Proposed Well Locations) Arup)



Careful management of the excavated weathered rock will be required and specialist personnel will be in attendance during this activity to ensure that only material of correct moisture content is used as fill. If the material is too wet it will be stockpiled and allowed to drain.

In places, as stated above, this material is expected to be both saturated and freely draining and so mitigation measures to prevent silty runoff entering watercourses will be implemented. These measures will include the following:

- keeping regular traffic away from the storage area;
- construction of stockpiles on flat ground;
- constructing piles at an angle of repose suitable for the material to ensure slumping does not occur; and
- ensuring that any runoff does not enter the local watercourse without being directed through one of the silt settlement ponds that will be constructed around the site.

Unweathered Rock

Limited quantities of relatively unweathered rock will be excavated from the north-eastern corner of the terminal site. Core recovery of this material was generally 90% or better. It should therefore be suitable as rockfill, although, due to its constituent minerals, it will not have sufficient durability or be of sufficient uniformly high strength to be suitable for surface stone dressing, aggregate or drainage material.

8.4.2 Global Stability

Two failures of peat slopes have recently occurred (2003), one close to the site at Pollatomish and one at Derrybrien, Co. Galway. The global stability of the terminal site and its surroundings has therefore been considered by Arup Consulting Engineers and a section is included within their report.

The three primary objectives of the global stability study are:

- To demonstrate that the chosen site is acceptable from a geotechnical stability standpoint
- To consider the potential of the development to impact adversely on the geotechnical stability of its surroundings, and vice versa
- ·To identify any residual stability issues, so that these can be mitigated by engineering design

Global stability in the context of the terminal site has to do primarily with slope stability and the potential for mass movement, specifically in relation to the peat and the mineral soils immediately underlying the peat.

Historic review of peat slope instability and mass movement

The dominant cause for most bog failures appears to be unusually intense rainfall and this was considered to be the case in the recent landslide at Pollatomish. Slope angle also has significant bearing with sliding failures associated with slope angles above 6 degrees and natural bog failures at angles between 3 degrees and 5.5 degrees. Bog failures with man interference have occurred on slopes as shallow as 2 degrees. Both natural and man-made drainage measures have also often been identified as a contributory cause of some failures. The use of trackways across peat land can also impose additional loads, which could contribute to slope failures.

The terminal site slopes typically at 1 degree to 3 degrees and precautions will be incorporated into the construction procedures to mitigate the effects of man's intervention.

Morphological Study

The study area extended over about 20km^2 surrounding the site. A conclusion of the study was that except for minor slippages of the peat along the edge of the Bellanboy River floodplain, due to erosion by the river, there appears to be no manifestations of peat slope instability within the study area.

Stability Analyses

Analyses were carried out to assess the stability of the natural peat slopes within the site boundary and also to assess the impact of construction activities on the overall stability of existing slopes. A review of relevant Codes indicated that a minimum factor of safety of 1.4 would be appropriate to the site.

A number of representative cross-sections in various directions across the site were analysed. Conservative values of the appropriate geotechnical parameters were adopted for the analyses, with a lower bound estimate of shear strength and an upper bound unit weight of the peat.

The analyses carried out on the existing slope profiles indicated a minimum factor of safety of 2.4, which is considered acceptable. During construction, with regard to the stability of the whole site (global stability) the worst condition would be if all the peat was removed at the toe of the slope without any external support being provided. For this condition the lowest calculated factor of safety was 2.0, which again is considered adequate. However, in this situation local failure of the unsupported peat at the face of the excavation could occur. Downslope of the excavation this would not have a significant effect on global stability with stability actually being marginally improved. However, on the upslope face, the loss of toe support would result in a reduction in stability and local failure could occur which, if uncontrolled, could lead to a progressive collapse mechanism, called retrogressive failure, where the failure gradually extends upslope from the excavation.

To prevent such mechanisms developing all excavations in to peat will be supported by sheet pile retaining walls. A number of sheet pile walls will be installed approximately parallel to the existing ground contours which will in effect divide the existing slope in to two or more sections.

Geotechnical Assessment

A geotechnical assessment has been carried out by Arup Consulting Engineers (Technical Appendix: Geology, Hydrogeology and Global Stability). This has been reviewed and confirmed by AGEC Ltd Geotechnical Consultants.

8.4.3 Economic Geology

A search and review of available references and records was undertaken to assess the past, present and planned future extent of mining and mineral extraction in the vicinity of the site. Reference was made to the following sources of information:

- Environmental Protection Agency;
- Mayo County Council;
- Geological Survey of Ireland (GSI) –Geology of North Mayo, Map Sheet 6 and Geological Description, GSI (1992);
- Arup Consulting Engineers Feasibility Report – Corrib Pipeline and Terminal (November 1999); and
- Geofilm, and aerial video survey of the site.

There are no known mineral extraction areas in the vicinity of the proposed terminal site location with the exception of a small quarry on the eastern edge of the forest, on the main Pollatomish Road.

8.4.4 Aquifers

The aquifer beneath the site is categorised as being of poor quality. This is because of the generally very low permeability of the underlying Inver schist bedrock.

As discussed above, a zone of more permeable weathered rock is present beneath the footprint of the terminal site and water flow direction within this layer is governed by the NNW-SSE aligned ridge. The proposed dewatering wells (see Sections 8.4.1 and 3.2.8) will extract groundwater flowing towards the west off the ridge as well as southwards from the crest of the hill.

The only abstraction well located within the vicinity of the site is associated with a facility located to the southeast. This is on the opposite side of the ridge from the terminal site and also beyond the zone of influence of dewatering activities on the site. It is therefore considered that site activities will have no impact on any known water abstractions.

8.4.5 Landfill Sites

There are no known landfill sites in the vicinity of the proposed terminal site location.

8.4.6 Contaminated Land and Pollution Incidents

There are no known public records of contaminated land or recorded pollution incidents in the vicinity of the proposed terminal site location. However, during an earlier geotechnical investigation to address peat stability issues a trial pit located in the south-eastern corner of the Coillte landholding, encountered various animal carcasses. This is outside of the area that will be disturbed by construction activities.

8.4.7 Phosphate Mobility

During geological and hydrogeological investigation at the site, occasional high levels of phosphorus were detected in the peat samples.

Phosphorus tends to be mobile only in some peat soils and sands. Phosphate is generally very immobile in soils, but can be carried into streams with soil in runoff.

In the majority of soils, phosphate is adsorbed by minerals that are held within the soil structure. Due to the low mineral content of peat, phosphate is more easily leached than it is from other soils and fertiliser loss rates can therefore be quite significant. It has been suggested by research that this added mobility is due to the low clay content and free-draining nature of such soils.

As the concentration of phosphorus tends to be higher in layers of peat closer to the surface, fairly high levels of phosphorus are exposed to the actions of surface waters and may be leached into drainage channels.

Surface run-off or erosion of surface soil may also lead to the release of some of the phosphorus into surface waters.

Phosphorus may be adsorbed by surface peat or used by plants and later incorporated in the peat after the death of the plant. As plant debris transforms into peat, the phosphorus is released into pore-water. Peat generally decays extremely slowly due to the presence of lignins.

Drying of peat can lead to the release of nutrients and other chemical species stored in the peat when it is later re-wetted.

Both organic and inorganic phosphates can be adsorbed, and phosphate has a high sorption affinity for iron oxides.

It has been suggested that the capability of peat to react with elements of environmental concern (such as phosphorus) may be affected by the duration of wet periods and the amount of nutrient input.

The acidity of pore water within the peat leads to chemical reactions that force the swifter release of phosphates.

8.5 Characteristics of the Proposed Development

The proposed terminal (and its associated buildings and car parking) will cover an area of 13 hectares. An additional 1ha will be used as a temporary facilities area during construction.

Due to the very poor load-bearing capacity of peat, which overlies the site, it will be necessary to excavate through the peat down to the underlying mineral soil or bedrock in order to provide a suitable foundation for the proposed terminal and the majority of its associated buildings. The excavated peat will be taken off site. In order to minimise the quantities of peat to be excavated, some buildings (e.g. administration) will be supported on piles with the peat being left in place. Only the lightest structures and terminal roads will be supported directly on peat and in this case the peat will be improved by the mixing in of cement.

8.6 Predicted Impact of the Proposed Development

8.6.1 During Construction

Drift Geology

The proposed terminal will involve the excavation of about 450,000m^3 quantity of peat and about 200,000m^3 of mineral soils, terrace deposits and weathered rock. The majority of the non-peat material will be reused on site. Refer to Section 16 for a discussion on material balance and disposal of surplus material. The impact of the proposal, with respect to the drift geology, would be the loss and damage to a part of the local peat ecosystem. Indirect impacts such as the loss of groundwater storage are addressed in the Hydrology and Drainage Section (Section 9) of this report.

Consolidation

One of the characteristics of peat is that it consolidates when loaded. In general terms, bulk density values for peat are substantially dependent on moisture content, degree of humification, mineral content and depth of burial. Loading of the peat and therefore consolidation may occur as a result of vehicle movement, road construction, temporary storage and the construction of un-piled facilities.

Shrinkage

Shrinkage of peat is directly related to drainage. Successful construction and remediation of side effects therefore requires very careful drainage consideration. This effect is highly variable and differential shrinkage has been recorded even within individual fields. These impacts as well as proposed monitoring and mitigation are detailed in the Hydrology Section (Section 9).

Constructing Foundations

The main issues relating to the optimum layout and foundation solution are:

- dealing with a sloping site;
- terracing versus a flat plot;
- dealing with the peat;
- cutting and filling; and
- drainage.

The site of the terminal has been chosen with the prime objective of minimising the visual impact.

The peat is an unsuitable bearing medium and therefore all foundations to the principal items of equipment will be either taken down to the underlying weathered bedrock, or piled. The lightest -structures and the terminal roads will be supported on peat improved by a lime/cement strengthening process (see Section 3).

Peat is not reusable as engineering fill material, see Section 8.4. It cannot be laid down to meet engineering criteria that will enable assessments to be made on its carrying capacity. Treatments to improve the characteristics of peat have been proven in Ireland. Extensive practical experience and research work have been carried out in Scandinavia.

For the majority of the site the total peat removal approach is considered to be the only acceptable solution taking account of the engineering confidence it offers in respect of the foundation necessary to support the terminal structures.

Most of the excavated mineral soil and weathered bedrock will be retained on site and used within the construction and landscaping of the site. Only the weakest materials will be taken off site.

Phosphate Release

In order to address the potential impact of this aspect, samples have been taken of the peat and the surface and ground water to assess the phosphate content and the potential for those media to release phosphate. This has been considered in the design of the silt ponds in order to ensure that the silt concentration is reduced as much as possible (see Section 8.7).

Phosphate is strongly adsorbed to soil minerals, which means that leaching is generally poor. Adsorption of phosphate is pH dependent. Phosphate is most strongly adsorbed in acid soils at a pH of approximately 4. At lower pHs a large decrease in adsorption is noted. The strength of adsorption also decreases at pHs higher than 4. The results of pH tests on surface water from the site give a range of from pH4.4 to pH6.

As an extreme case, experiments in sandy soil found that residual phosphate was still present 11 years after the application of phosphate fertiliser.

The ionic strength of soil water may have an influence on the sorption of phosphate. An increased ionic strength will enhance the effect of sorption, reducing leaching capabilities. Desorption of phosphate is a vital process in phosphate transport, as it makes the phosphate available for leaching.

Phosphate is generally readily leached through peat during rainfall (Tunney, H. 2001) and it would ordinarily be expected that the phosphate applied to peat in one year would be leached to water in less than twelve months.

The excavation area has very limited areas where phosphate levels are considered anomalous. These areas were formed as a result of agricultural activities in the distant past and are not considered a likely significant threat to the water courses in the area.

Solid Geology

Excavation down to the formation level for the terminal will involve the excavation of both weathered and unweathered bedrock. Much of the excavated rock will be used as fill to raise the platform level in the south western sector. The remainder, together with the excavated mineral soil, will be used elsewhere in the construction or in landscaping of the site.

The geotechnical properties of the bedrock are principally dependent on the extent of fissuring and weathering. Where the Inver schist is weathered at the surface, few problems are anticipated during construction. Where the schist is unweathered, it will be more difficult to excavate and may require rock breaking. However, from the results of the site investigation the extent of this is likely to be very limited.

Economic Geology

The terminal location will have no negative impact upon the economic geology of the area. Some importation of road stone will be required and that is likely to come from local quarries.

8.6.2 During Operation

It is not anticipated that the terminal would have any major impact upon the soil and geology during operation.

8.7 Mitigation Measures

When constructing on areas where the peat remains in situ, certain special construction techniques will be considered. The peat beneath both temporary and permanent roads will be improved by the mixing in of cement. Soil compaction during construction will be minimised by the use of tracked vehicles or vehicles fitted with low pressure tyres.

Draining of the peat will possibly result in shrinkage. It is anticipated however, that because of the low permeability of the peat, any such impact will be very localised, to the excavation area.

If land drains in the surrounding peat are exposed in the sides of the surrounding excavation then these will be diverted or intercepted. Leaving open drains in the side of the excavation will increase the water runoff into the workings and would probably result in a greater area of peat affected by dewatering and shrinkage. The groundwater levels and any evidence of shrinkage in this surrounding peat will be monitored.

Some seepage is expected from the mineral soils and weathered rock exposed beneath the peat in the sides of the excavation. These seepages are expected to be minimal and should be accommodated within the toe drains installed around the perimeter of the excavation area. However, any seepages will be monitored and if necessary slope face drainage (such as counterfort drains) will be introduced.

The reuse of excavated materials, as proposed in this document, will ensure that certain environmental impacts of the development are minimised. In this case there will be a reduced requirement to import significant amounts of fill and landscaping materials from outside the site.

The runoff water from the site will be tested for phosphate content as necessary. The use of iron oxide mesh in the settlement ponds will be considered if elevated phosphate levels are encountered at monitoring points down stream of pond discharge area. Local water courses will be monitored for phosphate as back up to on site monitoring; see Section 9.0 for further details.

Notwithstanding the settlement ponds, the contractor will be required to adopt methods including drip trays, bunding etc to ensure that there is no contamination of soils, surface water or groundwater from site activities (see Section 3.9.5 and Section 20).

8.8 Do Nothing Scenario

If the development did not proceed, the area would remain available for agroforestry, as at present.

8.9 Monitoring

Periodic monitoring of the peat will be carried out to detect evidence of shrinkage, desiccation and consolidation. The proposed surface and groundwater monitoring will be directly beneficial to the prediction and understanding of any impact on peat structure.

8.10 Reinstatement and Residual Impacts

Some of the excavated mineral soils will be used in the landscaping and screening around the terminal site.

The terminal site may have a minor long-term impact on the surrounding peat largely as a result of the alteration of groundwater level in the surrounding peat; see Section 9.

Dewatering of the peat as a result of excavation may result in some local shrinkage immediately adjacent to the excavation. For the reasons given above, this will only occur in the peat around the perimeter of the terminal. It is anticipated however that any such impact will be very localised and is not considered significant. It will be monitored and remedial actions taken involving use of seeding and geotextiles as appropriate.

Phosphate release whilst possible is not expected to be of significant impact due to the implementation of the mitigation measures and monitoring described above and discussed further in Section 9.

Nine

Hydrology and Drainage

9 Hydrology and Drainage

9.1 Introduction

In order to assess the impacts of the project on the aqueous environment and vice versa, all the water disposal related issues are dealt with in this Section and Section 10. Water management during construction is dealt with in detail in Section 3. For discussion of drainage design details please refer to Technical Appendix: Site Drainage Report.

This Section has been prepared by RSK ENSR Environment Ltd. It deals with impacts on ground and surface water due to the construction of the development and its subsequent operation. Section 10 deals with the impacts associated with the disposal of water including produced water as a result of the operation of the terminal. The receiving environment is the same for both cases, except that for produced water the main receptor will be the coastal waters to the north of Erris Head.

An assessment has been made of the site for the proposed terminal development with respect to the likely impacts from the construction and operation of the terminal on the hydrology of the surrounding area. In addition an assessment has been carried out of the drainage design for the terminal.

This assessment included the potential and predicted impacts from the drainage of the site including mitigation measures to reduce these impacts. Data gathering surveys for baseline information were undertaken and a proposed pre and post-project monitoring program is summarised in Section 7.9.

Baseline Studies and Surveys

Commencing in 2001 an extensive suite of hydrological baseline data has been collected across the proposed site. In addition, considerable amounts of data have been collected from the key watercourses in the adjacent land surrounding the site. From desk study research and consultation with Mayo County Council and the North West Regional Fisheries Board it was evident that there was the potential for environmental impact in those areas.

9.2 Receiving Environment

9.2.1 Regional Rainfall

The West of Ireland experiences relatively high annual rainfall. Met Eireann have a recording station at Belmullet. Rainfall data for the Belmullet Station is given below. This data shows the amounts of rainfall that might be expected in extreme conditions based upon historical recordings and using forward prediction to give the worst case expected. Hence the extreme 1 in 100 year storm might give 31 mm in one hour, as shown in Table 9.1.

Table 9.1: Extreme Rainfall Return Periods

Event/basis	Rainfall
1 in 100 year event, Belmullet	31mm/hr
Highest recorded level (Sept 2003, Pollatomish)	Approx 40 mm/hr
Design basis	45mm/hr

9.2.2 Designated Areas in the Wider Locality

A number of designated areas are found some distance from the site. Potential direct and indirect effects of the terminal development on these designated areas are considered in this EIS where appropriate.

Designated conservation areas in the wider locality are:

- Broadhaven Bay – candidate Special Area for Conservation (cSAC) 472;
- Glenamoy Bog Complex – cSAC 500 (includes Sruwaddacon Bay Special Protection Area);
- Pollatomish Bog – Natural Heritage Area (NHA) 1548; and
- Carrowmore Lake Complex– SAC 476.

Site descriptions are provided in Section 6. The protected areas where there is the greatest potential for impact by drainage from the terminal site are briefly described here.

Sruwaddacon Bay SPA

The drains in the north eastern parts of the terminal site feed into small streams, which in turn drain into Sruwaddacon Bay and the drains in the eastern parts of the site drain into small streams, which in turn drain into the Glenamoy River which flows into Sruwaddacon Bay approximately 1.5km due north of the most northerly part of the terminal site.

Sruwaddacon Bay is a shallow tidal inlet off Broadhaven Bay (candidate SAC 472) and is of special importance for its wintering wildfowl populations, which feed on the intertidal sand/mud flats. The bay forms an integral part of the Glenamoy River salmonid fishery.

Carrowmore Lake cSAC

The drains on the terminal footprint and those on land immediately to the west of the terminal footprint flow into the Bellanaboy River and its tributaries, which then flow into Carrowmore Lake. The lake itself is located to the south west of the terminal site and is fed by a number of streams from the surrounding locality. Carrowmore Lake is a large (960ha), shallow lake, with a maximum depth of approximately 2.5m and a generally stony bottom. The lake water is almost neutral in terms of acidity (i.e. pH) and generally rather nutrient-poor.

9.2.3 Surface Water

Catchment Area

The surface water divide between the catchment of the Bellanaboy River (Carrowmore Lake) and the Glenamoy River (Sruwaddacon Bay) runs approximately along the eastern boundary of the terminal plant footprint. Therefore runoff from the terminal footprint itself flows to the Bellanaboy and its tributaries and so into Carrowmore Lake. Runoff from the eastern area of the land holding where the temporary construction facility is proposed to be sited flows into the Glenamoy River and so into Sruwaddacon Bay.

The catchment area of the site is small. The ground slopes away from the SW, NE and SE boundaries of the terminal site.

Shallow land-drains currently control much of the surface drainage of the terminal site. These shallow drains are frequently dry. The drains crossing the site are led into deeper drainage ditches to the SW and NE of the site. Most water from the site flows into the S and SW boundary ditch. These ditches are up to 1.8m deep and 1m wide.

The water in the ditches is slow moving and deep (up to 1m depth of water). The maximum base flow recorded during the study in the main drain coming from the site was approx 2 litres per second. This measurement was after a rain free period; following rain the discharge is expected to be greater.

Terminal Site

Flow measurements have been taken between June 2001 and March 2003 in a number of the major drains on the site. These measurements showed that base flows in the existing perimeter ditches alongside the SW boundary of the terminal site are in the region of 0.1 to 1 litre per second. The surface gradient and surface-drains over the terminal footprint fall towards the SW and so surface flow is in this direction, into the perimeter drain on that side (there is little base flow in the perimeter drain to the NE of the terminal site).

As the SW perimeter ditch drains towards the SW and the R314 road, the flow steadily increases. However, at a location very near to the SW corner of the terminal site, all the water in this ditch discharges to a large sinkhole in the peat. All the water disappears into the ground hence here is no surface-water flow out of this hole. The outflow of this groundwater is into drain D16 that runs alongside the R314. The sinkhole presently takes almost all of the surface drainage from the terminal site. Following periods of heavy flow it is considered likely that the sinkhole, which is about 2-3 m deep, would fill up and overflow and allow water to continue to flow down the ditch towards the R314.

9.2.4 Water Quality – Rivers and Drains

Baseline river chemical/physical water quality data was collected in order to determine the potential impacts of the proposed terminal. This included monthly surface water grab sample analysis at thirteen sites, with water quality being continuously logged at seven of these (ten of the sites are shown in Figure 7.3, while the other three were drains 16, 22 and 62, shown in Figure 9.1) over a year sampling period from June 2001 to May 2002. Table 9.2 presents the site names locations and activities carried out.

Other sites were subjected to spot sampling.

In order to compare results obtained with regulatory values, average water quality results from the 12-month sampling period were analysed in accordance and with reference to the following legislation:

- EC Quality of Salmonid Waters Regulations of 1988 (S.I. No. 293, 1988);
- Water Quality Standards for Phosphorus Regulations, 1998 (S.I. No. 258 of 1998); and
- EC Drinking Water Regulation 2000 (S.I. No. 439 of 2000).

Samples were analysed using United Kingdom Accreditation Service (UKAS) accredited test methods for the following parameters:

- colour;
- nitrate;
- nitrite;
- phosphate;
- suspended solids; and
- ammoniacal-nitrogen.

Field readings of the following physio-chemical parameters were also recorded:

- pH;
- temperature;
- dissolved oxygen; and
- conductivity.

Figure 9.1 Upgrading of Land Drains

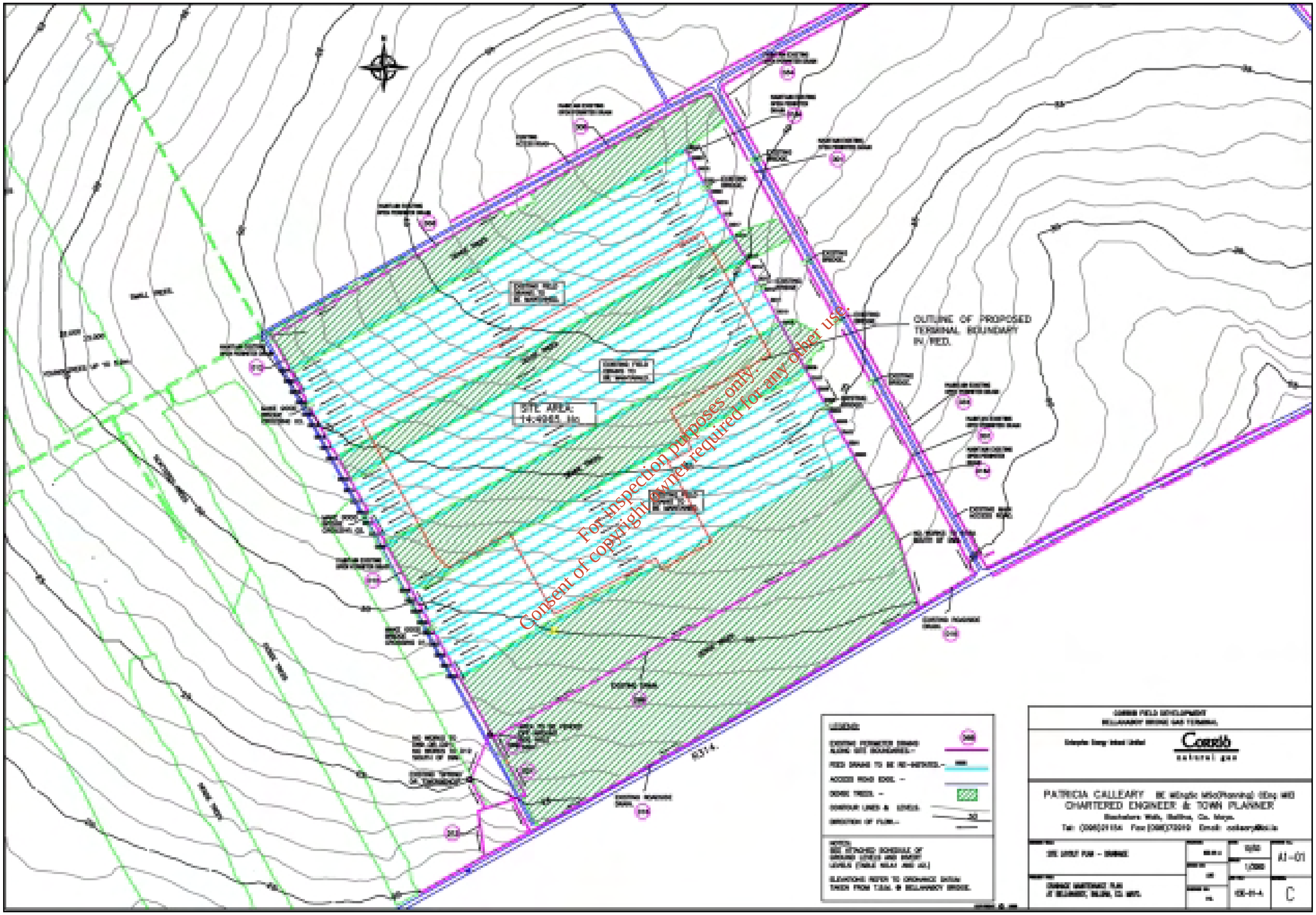


Table 9.2 – River Sampling Locations and Survey Types at Each Location

Location Ref.	Location Name	Monthly water analysis	Data Logging
Site 1	Lake outlet	Yes	No
Site 2	Glencullen River	Yes	No
Site 3	Glenturk River	Yes	No
Site 4	Bellanaboy Bridge	Yes	Yes
Site 5	Muingingaun River	Yes	Yes
Site 6	SW Culvert – Drain	Yes	Yes
Site 7	Aghoos River	Yes	Yes
Site 8	SE Drain	Yes	Yes
Site 9	Private residence	Yes	Yes
Site 10	Glenamoy Bridge	Yes	Yes
Drain 16	Drain 16	Yes	Yes
Drain 22	Drain 22	Yes	Yes
Drain 62	Drain 62	Yes	Yes

EC Quality of Salmonid Waters Regulations of 1988 (S.I. No. 293, 1988)

EC Quality of Salmonid Waters Regulations assessments need to be based on data from twelve months sampling. Several of the sites sampled during the survey period (Table 9.2) were added to or removed from the list during that period, therefore twelve months data is not available for all of the sites. Only those with twelve consecutive monthly samples are discussed in relation to the Salmonid Water Regulations.

At least one sample from all locations taken between 1st November and 31st April exceeded the regulation limit of 10°C for that period. No readings exceeding the 21°C limit applicable to the other months were recorded.

The lower limit pH value of 6 was exceeded by at least one sample at all sampling locations during the period with the exception of sites 1 and 2. No samples exceeding the upper pH limit of 9 were recorded throughout the monitoring programme.

At least one reading of O_2 concentration was below the lower 6mg/l limit from all except three sites (4, 5 and 7) during the sampling period. Only the Muingingaun River had O_2 concentrations greater than 9 mg/l on more than 50% of sampling occasions (the Salmonid Water Regulation Limits recommend that at least 50% of readings are greater than 9mg/l), though 9mg/l or more was achieved at all sites at least once during the sampling period.

Annual average suspended solids levels from all sites were less than the regulatory level of 25mg/l. For nitrite no sites achieved the annual regulatory level of 95% of all samples having a concentration of less than 0.05mg/l (all sites had only 83% of samples less than this figure).

The ammonium regulatory standard was met by sites 1, 2 and 3 (95% of samples contain <1mg/l NH_4). Either one or two of the twelve samples collected from each of the other sites were greater than 1mg/l, which do not meet the standard.

EC Drinking Water Regulation 2000 (S.I. No. 439 of 2000)

In accordance with the EC Drinking Water Regulations, conductivity, nitrite and nitrate values at all the sites were within regulation limits. There were a number of samples exceeding Total Ammonium and the lower limit of pH 6.5.

Water Quality Standards for Phosphorus Regulations, 1998 (S.I. No. 258 of 1998)

Phosphate results based on the Water Quality Standards for Phosphorus Regulations indicate a quality rating, which is indicative of pollution status. The majority of the sites have a Q value of Q4 – Q5, which corresponds to “unpolluted”.

Water Quality Carrowmore Lake

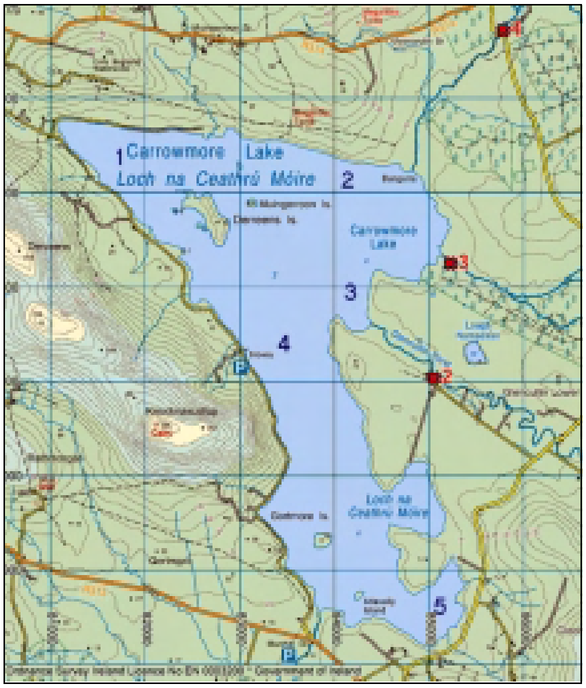
Baseline water quality data was collected and analysed to provide details of the physio-chemical properties and trophic status of Carrowmore Lake. Samples were taken from five locations around the lake (Figure 9.2):

Sample Station 1: Pump House;
Sample Station 2: Bellanaboy Inlet;
Sample Station 3: Glencullen Inlet;
Sample Station 4: Centre Point; and
Sample Station 5: SE Bay.

Samples were taken monthly from the surface of the lake. It has been assumed that due to the shallowness of the lake, the water column is homogenous and that surface samples are representative of the water column. Samples were analysed for:

- nutrients (Total Phosphorus and Total Nitrogen);
- chlorophyll a and b; and
- suspended solids.

Figure 9.2 Water Quality Sampling locations in Carrowmore Lake



The trophic level of Lake Carrowmore may be classified as Mesotrophic/Eutrophic. This is based upon the classification proposed by the Organisation for Economic and Cultural Development (O.E.C.D) using total phosphorus and chlorophyll results. The uncertainty lies in the inability to measure low-level total phosphorus samples to relevant accredited standards.

Concentrations of suspended solids were less than 25mg/l for all sampling locations over the annual monitoring period (with the exception of site 4, where one reading was 25mg/l. This indicates compliance with the EC Quality of Salmonid Waters Regulations of 1988 (suspended solids levels of <25mg/l).

9.2.5 Protection of Natural Flows and Hydrology

Natural run-off from the terminal site eventually feeds into designated conservation areas. Any substantial alterations to the flow regime in local watercourses may impact upon the ecosystem functioning of these areas, which include Carrowmore Lake SAC/SPA and Sruwaddacon Bay SPA.

9.3 Characteristics of the Proposed Development

The proposed planning development area covers approximately 160 ha. Within this, the terminal (and its associated buildings and car parking) will occupy 13 ha. The remainder will be used as compensation habitat and forestry screening.

9.3.1 During Construction

Approximately 650,000m^3 of peat rock and mineral soils will be excavated. The peat, once excavated, will be transported off site to a cutaway peatland at Srahmore, near Bangor Erris, owned and operated by Bord na Mona. The mineral soils will be used as bulk fill beneath site roads and the temporary construction facility.

The secondary / emergency access road will be upgraded, by peat improvement technique, followed by placing fill and geotextile membrane, along the line of the existing forest track, which gives access from the Pollatomish Road.

Peat/Soil improvement is a technique used to increase the strength of soft materials such as peat and silt. A binder such as lime or cement is mixed with the in-situ peat. When the binder sets, the resultant mixture has a far higher strength than the original peat. There are various techniques for introducing the binder to the peat. For the terminal, it is proposed to use 'dry deep mixing'. In this technique an augur drills a hole, into which compressed air and dry cement is injected. Columns of stabilised material are created that overlap to form a cellular pattern.

The construction methodologies and sequences are described in Section 3. There will be considerable activity involving plant and equipment and disturbance of the ground during the construction phase.

9.3.2 During Operation

The peat below the first 10-20cm tends to be fully saturated. When rain falls on this surface the majority of it tends to runoff. Once the peat has been removed and replaced by a mixture of paved area and unpaved ground in the terminal footprint, the situation will change. The rain that falls on the paved area will run off to the open drain system or clean rainwater system. The rain falling on the unpaved area will percolate into the ground and find its way to the terminal perimeter groundwater drain.

The terminal activities will involve the processing, handling and storage of hydrocarbons and other materials. Materials will be transported around the site and loaded and unloaded. The operation of equipment and vehicles will form part of the activity.

9.4 Potential Impact of the Proposed Development

9.4.1 During Construction

Because of the presence of a near-surface water table in the peat and the saturated (or near saturated) condition of the underlying mineral soils and bedrock, groundwater would be expected to flow into any excavation that extends more than a few metres below the ground surface. In addition existing drains in the terminal footprint will be intersected by the excavations, which could cause surface water to collect in the excavation. These effects could result in changes to the runoff into surrounding water courses.

Changes to the volume and/or characteristics of the rainwater runoff from the terminal footprint and surrounding area during the construction phase could have a negative impact on the surrounding watercourses. The pattern of runoff could change with some existing drains and streams receiving significantly more or less flow than they receive currently.

Watercourses receiving a greater volume of runoff may be subject to erosion or scour with resultant increase in the silt burden. Localised flooding could also result. Conversely reduced flow may result in stagnation in previously free flowing streams.

The construction activities will expose the cut surface of the peat, soil and bedrock. Rainfall runoff may wash peat and silt into the surrounding watercourses, with consequent effects as described in Section 7.

There is the potential for lime/cement binder to leach into the surface/ground water. This could increase the alkalinity of the surface/ground water locally due to run off from the work.

The construction works could increase the risk of spills of fuel or lubricants or other materials entering the soil, groundwater and water courses.

Pumping to dewater excavations could potentially affect local wells and a spill or leak could cause contamination.

9.4.2 During Operation

During operation of the terminal, there could be spills or leaks of process materials which could have a negative impact on surrounding water courses.

Local wells could potentially be affected by permanent changes to the groundwater regime or could become contaminated by a spill or leak.

9.4.3 Worst Case Scenario

Spills or leaks in the terminal, or from tankers taking materials to the terminal could damage the ecology of nearby watercourses, water bodies and designated conservation areas. This could reduce or eliminate invertebrate and vertebrates (fish) and lead to loss of feeding habitat for predators. Recovery would be expected, but could take considerable time.

9.5 Mitigation Measures

The hydrology and hydrogeology of the site has been considered in some detail. The measures in place to minimize the impact of the terminal on the hydrology and drainage have been designed in sympathy with the local aqueous environment - rainfall, surface water runoff and hydrology and hydrogeology. The runoff from the terminal site will be managed in order to minimise the impact and not significantly alter the flow.

9.5.1 Construction Phase

A series of drains will be installed, during the construction phase, to collect rainwater runoff and groundwater in order to maintain the excavations free from water. Both temporary and permanent drains will be used. Localised pumping may also be required. These are described in Section 3.

The drains will discharge to the settlement ponds, which will be one of the first facilities to be constructed. There will be two sets of ponds. One set comprising a pair of ponds will be located in the south western corner of the site. They will deal with runoff from the terminal footprint. A third pond will be located on the south eastern edge of the temporary construction facility to deal with runoff arising there.

The ponds have been designed to allow peat and silt to settle out. Water collected in the ponds following a high rainfall event will be released slowly and in a controlled manner, thus minimising erosion damage that could result in the receiving watercourses. The outlet from the ponds will be monitored, as described in Section 9.7 below.

In respect of the peat improvement the following mitigation methods are suggested:

- injection occurs in the peat underground; this is not a surface spreading and mixing technique;
- minimise amount of run-off from the stabilisation work area by covering area with impermeable covers;
- use on-site containment measures to prevent run-off from reaching off-site by use of a

perimeter ditch which is a moat type structure i.e. no outlet drain;

- re-use run-off for on-site water usage, with possible pre-treatment (as above). As the peat is generally wet any wind blown binders will land only once and bind with the wet surface material
- monitor alkalinity of surface run-off in site drainage, catch reservoir and post-treatment discharge;
- cover recently mixed and curing area with waterproof covers during periods of rainfall and overnight once curing has started;
- monitor dust, for airborne lime powder, downwind of stabilisation work area; and
- reduce airborne lime dust using skirts around blending rotating equipment.

During the construction phase the contractor will be required to have a management plan in place, which will minimise the risks of spills and leaks, and other potential causes of contamination, from construction activities.

The silt ponds will be operated and maintained in accordance with a defined procedure that will form part of the planned environmental management system for the site, both during construction and in the operational phase.

9.5.2 Operational Phase

The measures which will be in place to minimise the risks to surface water and ground water during the operational phase will include:

- strict site procedures controlling the handling of liquids (incorporated into the site Environmental Management Plan, Section 20, and including emergency response to spills or leaks);
- specially designed liquid handling systems; and
- the incorporation of containment into the design of liquid handling areas and associated drainage systems.

As described in Section 2, a series of drainage systems and other mitigation measures will be installed in the terminal to minimize the impacts on the hydrology.

Drainage Systems

The drainage systems to be installed on site will comprise:

- closed drains, for process fluids;
- open drains, into which any rainwater run-off which could potentially become contaminated is directed, The runoff collected in the open drains is treated prior to discharge to the sea outfall;
- laboratory drainage system;
- clean surface water drain;
- terminal perimeter surface water drain;
- terminal perimeter ground water drain; and
- sewage system.

The drainage systems have been designed to ensure that rainwater, which could become contaminated by process activities, is segregated, treated and discharged to the sea outfall. Only clean rainwater and ground water is discharged via the silt ponds to the surrounding watercourses. Process fluids will be in totally contained systems. All areas, where oil or chemicals could spill or leak, will be bunded and sealed from the underlying ground and will not have the potential to contaminate surface or ground water. Enclosed drains will collect the contaminated water from these areas and feed it to the treatment system.

A firewater retention pond will be provided to which the open drain system will be diverted in the event of a fire.

9.6 Predicted Impact of the Proposed Development

The most noticeable feature would be the possible decrease in baseflow in the watercourse immediately downstream of the terminal. It is anticipated that any such impact will be negligible by the time this watercourse reaches its confluence with the Bellanaboy River.

Velocities of the runoff water leaving the silt ponds will be controlled as described earlier in this Section. It is therefore considered that the potential scouring impact on local watercourses will be managed and that there will be no impact providing the silt pond system is managed as designed.

Siltation of local watercourses is not expected to occur as a result of this development. The silt pond design and the contingency measures incorporated will prevent siltation events form occurring.

In the case of wells, the pathway through the ground is restricted due to the tight nature of the fractures in the rock as evidenced by the hydrogeological investigation and rock core properties.

If a well source was located in the glacio-lacustrine or till deposits and/or the weathered rock, there may be a minor impact local to the site. Away from the site impacts are unlikely due to the disjointed nature (poor connectivity) of the local groundwater pathways and the low conductivity of the formations.

The potential locations of any local wells have been determined and the only working well was located on the east of the water divide. As discussed in Section 8 the ground water quality is very poor and without treatment is not categorised as being suitable for either human or animal consumption.

9.6.1 During Construction

Flows

The surface water management system as designed will ensure that base flows in the local water courses are maintained close to existing conditions.

Quality

The water flowing offsite will have passed through the silt pond system and therefore will not be carrying silt particles in quantities any greater than the waters currently flowing off the site. It is probable that the water quality will improve as a result of the construction drainage system. As discussed in Section 3 any accidental spills of diesel or other liquids will be contained and removed and thus will not enter the surface water drains. If part of a spill were to escape the fluids would become mixed with the surface water and hence would flow to the silt ponds where the contaminated water could be retained and either pumped back for treatment on site or pumped out into a tanker for delivery to an appropriate treatment plant.

Phosphate is not expected to impact the local watercourses as a result of the development because the peat excavation process (Section 3) and the associated water management have been designed to mitigate such impacts.

The contamination of well water or surface water in the local area by chemical or oil spills on site is not expected to occur as a result of this development. Other potential sources of impact to local well supply such as loss of volume due to changes in the local hydrogeological regime resulting from the excavation of the site are considered to be very unlikely due to the low permeability of the bedrock.

The likely impacts to the ecosystem are therefore expected to be negligible.

9.6.2 During Operation

It is very unlikely that observable impacts will occur due to the runoff form the site. The provision of high levels of treatment will serve to markedly reduce the concentrations of silt in any drainage waters. In addition, because the runoff will not be crossing peat once the terminal has been constructed, this will lead to further reductions in the concentrations of silt.

Organic discharges may result from the contaminated rainwater runoff from the terminal site. This water cannot enter the surface water system and will thus not impact the local water courses. The treatment of this discharge is discussed in Section 10.

Physical Impacts

The discharge will not impact the flows of the local water courses, the speed of the water leaving the silt ponds being regulated to match the receiving water courses.

9.7 Monitoring

The mitigation measures will be monitored at appropriate intervals during the initial years of operation of the terminal facility to ensure successful implementation.

9.7.1 Local Water Courses

Pre- and post-construction monitoring will be carried out to substantiate conclusions concerning the environmental impacts.

The field monitoring to be undertaken will encompass a number of aspects selected to provide a robust picture of the water quality in specific reservoirs. The details of this will be agreed with the North West Regional Fisheries Board prior to construction commencing and are likely to encompass similar protocols and philosophies to the baseline monitoring already carried out.

It is proposed to monitor both surface water and groundwater prior to, during, and post construction. Monitoring will consist of examination of:

- groundwater levels and water quality in the peat and the bedrock prior to and during excavation at the terminal footprint;
- groundwater levels and water quality in the peat and bedrock surrounding the terminal footprint during operation of the terminal; and
- biological and chemical water quality, surface flow and levels in watercourses downstream of the terminal site and the peat deposition area from pre-construction (baseline conditions) through operation.

Details of the baseline monitoring scope and parameters are presented in Appendix 7.2.

The scope of testing of the surface and groundwater during construction and operation will be agreed with the regulatory authorities. This is likely to include:

- temperature;

- turbidity;
- dissolved oxygen;
- electrical conductivity;
- pH;
- phosphate;
- nitrate;
- suspended solids; and
- BTEX.

9.8 Reinstatement and Residual Impacts

Following the end of the life of the terminal, the facilities decommissioning plan will ensure where possible some compensation for the lost groundwater storage in the peat is put in place by landscaping of the restored site. However, the final restoration could never replace the situation that existed before the development took place and there may be a slight long-term residual impact on base flow to the local watercourses.

A slight increase in groundwater vulnerability as a result of the peat removal may also be a residual impact. The decommissioning plan for the site will take account of this and ensure that no sources of residual contamination which could cause a residual impact remain.

Appendix 10.1

Dispersion Modelling Study
Broadhaven Bay

10 Effluent

10.1 Introduction

This section addresses issues related to the discharge of treated effluent arising from the proposed terminal development. There will be two main types of effluent. The first arises from the liquids associated with the gas in the offshore reservoir (the produced water), which are transported ashore in the pipeline. The second derives from rainwater draining from process areas within the terminal where it may have become contaminated. These and other more minor sources are discussed below.

10.2 Study Methodology

The consideration of the management of effluent has drawn on the Offshore EIS (Corrib Field Development [Offshore Field to Terminal] EIS, October 2001) and various baseline marine studies, surveys and modelling activities commissioned by Shell. In addition, a number of key references have been consulted to source information on the characteristics of the receiving environment that may be affected by effluents from the terminal.

10.2.1 The Offshore EIS

An assessment has been made of the site for the proposed terminal development with respect to the likely impacts from the construction and operation of a produced water treatment system and associated effluent pipeline. In the offshore EIS this assessment included the potential and predicted impacts from the construction of the effluent pipeline, including mitigation measures to reduce these impacts. The Offshore EIS was submitted in support of the various licence applications to the Department of (then) Marine and Natural Resources in 2001.

10.2.2 Baseline Marine Studies and Surveys

Shell commissioned current, sediment and faunal sampling along the pipeline route including in the vicinity of the proposed wastewater discharge location. These studies consisted of the placement of current meters and the physical sampling and photography of sediments. These sediments were analysed for their chemical and physical characteristics, and the macro-invertebrate fauna within the samples were also identified.

10.3 Receiving Environment

The environment with the potential to be affected by effluent from the terminal could include local surface and ground waters as well as the marine environment that will receive the discharges after treatment. The potential impacts to surface and ground water are discussed further in Section 9. As the drainage water from process areas is contained and treated in a piped system before discharge to sea, this will prevent impacts on surface or ground waters, and so consideration of the receiving environment is limited to the coastal waters, beyond Broadhaven Bay, that will receive treated effluent streams from the terminal.

10.3.1 Designated Areas in the Wider Locality

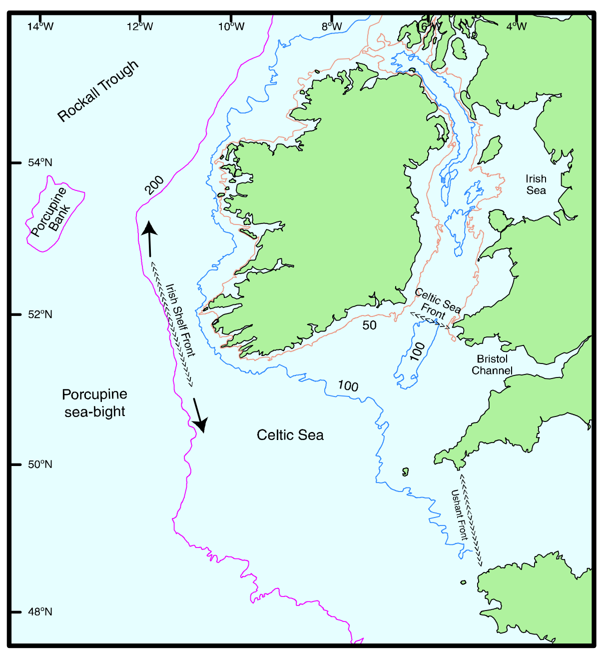
A number of designated areas are found some distance from the site. Potential direct and indirect effects of the terminal development are considered in this EIS where appropriate. Further discussions can also be found in the Offshore EIS.

Designated conservation areas in the wider locality are listed in Sections 6 and 7. Full site synopses are provided in Appendix 6.3.

10.3.2 Hydrodynamic Model of Broadhaven Bay

In order to assess the tidal current conditions within Broadhaven Bay, Kirk McClure Morton were commissioned to create a hydrodynamic model of the area.

Figure 10.1: Bathymetry of the Irish Coast



This indicates that in the offshore area, i.e. beyond Erris Head and Kid Island, the flood tidal stream tends to set to the north east, while the ebb runs in a generally south westerly direction. The south west going flow is predicted to begin at approximately 2 hours after high water Broadhaven and runs for circa 6½ hours. Similarly, the flood commences at approximately 9 hours after local high water and runs for around 6 hours. Peak speeds during both the flood and ebb tides are similar at approximately 0.5 m/s, see Figure 10.3.

Within outer Broadhaven Bay, i.e., the open water area bounded to the north by a line between Erris Head and Kid Island, but excluding the various inlets, the tidal flow regime is significantly weaker than offshore.

The model predictions indicate a noticeable reduction in the magnitude of the tidal currents moving southwards through this area. The relatively high tidal flows past Erris Head and Kid Island give rise to the formation of eddies or gyres during both the flood and ebb tide. This is in line with the indication on the Admiralty Chart of the occurrence of tidal overfalls in these areas.

10.3.3 Seawater Chemistry

The natural environment is dynamic and generates inputs of chemicals as a result of natural geological processes such as volcanic activity, mudslides and earthquakes and other natural processes such as forest fires, flash floods and extreme tide or wind events. In addition, anthropogenic inputs have increased over the last 100 years or so.

The Corrib development, which falls within OSPAR Region III, covers a range of seawater environments from open Atlantic Ocean to nearshore tidal bays. Scientists from the Marine Institute have contributed to the OSPAR Quality Status Report 2000 for the Celtic Seas. The input was presented in a report (Ireland's Marine and Coastal Areas and Adjacent Seas: An Environmental Assessment; Boelens et al, 1999). This comprehensive document covers the area designated as OSPAR Region III.

Data sets on marine chemistry have been studied. The west coast of Ireland in general, and more specifically, the areas affected by the Corrib development, are not well documented, as very few studies have been carried out in these areas.

Other data sets studied include that from the Monterey Bay Aquarium Research Institute (MBARI) Chemical Sensor Programme. In Figure 10.2 data from the MBARI programme show typical concentrations in the sea for the twelve key metals that are likely to be present in treated effluents from the terminal.

10.3.4 Sources of Inputs to Seawaters

Rivers

Background levels of metals that reflect natural geochemical weathering of soils are ever-present in Irish rivers. Elevated levels of metals occur in rivers that drain contaminated land. Using data from river catchments, the Marine Institute (Boelens *et al*., 1999) estimated the input of metals into the Irish coastal waters for a number of years between 1990 and 1996 (See Table 10.1).

In addition to the above metals, there are also nutrients entering the sea from rivers, including most notably nitrogen and phosphorus. Nitrogen inputs are perceived as being potentially damaging to coastal waters due to the limiting role of nitrate in marine primary production (stimulation of species which restrict primary production) in many areas (Boelens et al., 1999). In Irish waters nitrate concentrations are generally lower than those found elsewhere in Europe. It could be assumed that, due to a decline in arable farming over the last 10 years in Ireland, there would be a net fall of riverine nitrate loads. In reality, the observed increase over this time period (Table 9.7) can partly be attributed to continuing increases in the use of nitrogen-based fertilizers. Other known sources of nitrates include rivers that receive sewage discharges and general farm run-off.

It is universally acknowledged that phosphorus is the main limiting nutrient for algal growth in freshwater, under most conditions. However, the limiting role of phosphorous in marine waters is less certain. Small changes in phosphorus levels can potentially lead to shifts in the trophic status of particular marine areas (McGarrigle, 1993). Phosphorus in rivers arises from the natural background weathering of soils, the decay of plants and inputs due to human activities, e.g., sewage plants and intensive agriculture. Although phosphorus has a generally low mobility in soils, there is a general increase in the input of phosphates in proportion to increasing soil reserves, which is evident in many catchments, due to declining water quality. Consequently, this is likely to increase marine inputs of phosphorus, particularly outside the growing season. Estimated phosphorus inputs to the marine environment from the principal rivers discharging into the Irish marine environment over the period 1990 – 1996 are provided in Table 9.7 Offshore (Field to Terminal) EIS.

Table 10.1 Estimated Annual Loads (tonnes) of Four Metals Over 1990-1996 for the Principal Rivers Discharging into the Atlantic

Metal	1990	1992	1993	1994	1995	1996
Cu	33.6	59.7	36.2	67.6	62.5	19.3
Zn	235.8	498	165.4	183.4	418.5	138.4
Pb	26.5	23.4	4.5	14.5	16.9	7.6
Cd	1.14	0.45	0.37	0.54	0.46	0.77

Table 10.2 Estimated Annual Loads of Total Nitrogen and Total Phosphorus Over the Period 1990 – 1996 for the Principal Rivers Discharging into Irish Marine Areas

Marine area	1990 Kt[1]	1991 Kt	1992 Kt	1993 Kt	1994 Kt	1995 Kt	1996 Kt
Nitrogen							
Celtic Sea	35.77	37.80	24.05	38.63	46.51	41.61	50.30
Atlantic Ocean	35.86	30.56	27.45	27.79	32.96	27.29	35.90
Phosphorus							
Celtic Sea	1.127	0.868	1.085	1.730	2.526	1.191	2.220
Atlantic Ocean	1.153	0.993	1.057	1078	1.461	1.300	1.240

[1] kilotonnes

Atmosphere

Metals and other compounds also enter the sea from the atmosphere. The atmospheric transport of metals is considerably quicker than in water, resulting in long-lived compounds being rapidly transported around the globe. For Ireland, the prevailing wind direction is westerly and so atmospheric input is generally low. When the winds swing to an easterly direction, inputs can increase dramatically, due to their passage over continental Europe. These easterly winds are also generally dry winds, and so wash-out is less than with the wetter westerly winds. Valentia and Turlough Hill are both subject to this atmospheric deposition during dry and wet weather conditions (EMEP/CCC-Report 2/2000). These data can be extrapolated using atmospheric models to give depositional load estimates over the Irish Coastal area (See Table 10.2).

Nutrient deposition from the atmosphere is highly dependent on the wind direction. The wet westerly winds tend to have lower concentrations of nutrients compared to the dry easterly winds. Using ammoniacal compounds as an example, concentrations measured on the west coast of Ireland were up to four times less than those on the east coast (McGettigan & O'Donnell, 1995). Most atmospheric nitrogen compounds are attributable to anthropogenic sources, and so a declining concentration from east to west is again experienced under most conditions.

Table 10.3: Total Annual Inputs of Various Metals from the Atmosphere and Precipitation.

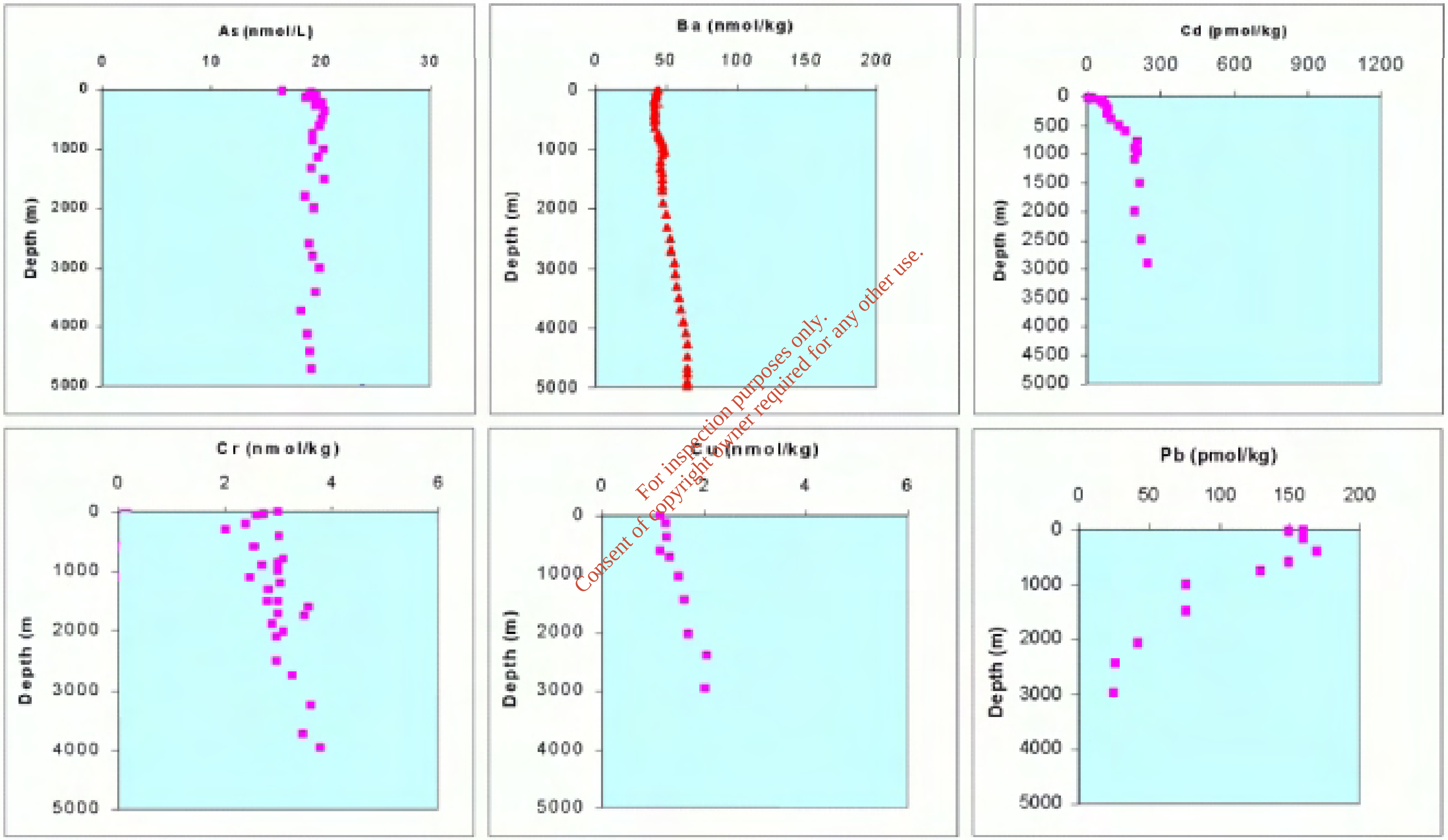
Metal	Precipitation (g/km2) Turlough Hill	Precipitation (g/km2) Valentia Observatory	Total input (tonnes/yr) to OSPAR area III from atmosphere
Arsenic	481	446	
Cadmium	154	214	1.4
Chromium	481	446	7.3
Copper	1192	5258	10.8
Lead	1691	1301	152
Mercury*	115	107	~
Nickel	1057	891	47.5
Zinc	5055	95068	82.8

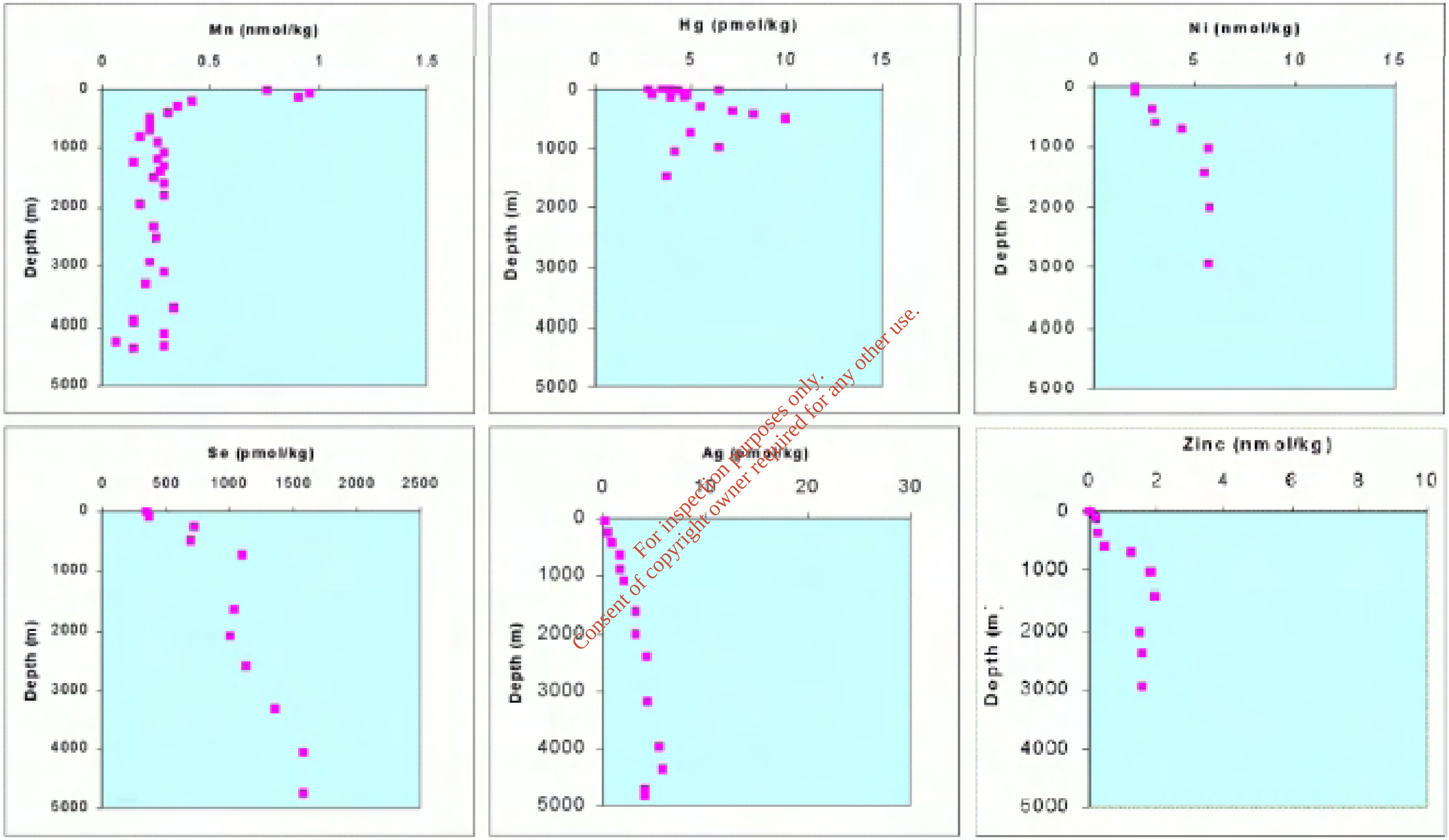
* measurements of Mercury in precipitation at Turlough Hill and Valentia may not be reliable due to the high detection limits in the method of detection (EMEP/CCC, 2000)

Atmospheric phosphorus deposition is thought to be responsible for the absence of oligotrophic lakes in the north of Ireland, and as a result, could present a large source of phosphorus to the sea. Some atmospheric phosphorus is derived from marine sources and so it is difficult to estimate any net contribution to marine phosphorus concentrations from the atmosphere.

Figure 10.2: Depth Profiles of Background Concentrations of Various Metals in the Atlantic Ocean

Source: Monterey Bay Aquarium Research Institute (www.mbari.org).




Mn (nmol/kg)
0
0.5
1
1.5
Depth (m)
0
1000
2000
3000
4000
5000
Hg (pmol/kg)
0
5
10
15
Depth (m)
0
1000
2000
3000
4000
5000
Ni (nmol/kg)
0
5
10
15
Depth (m
0
1000
2000
3000
4000
5000
Se (pmol/kg)
0
500
1000
1500
2000
2500
Depth (m)
0
1000
2000
3000
4000
5000
Ag (pmol/kg)
0
10
20
30
Depth (m)
0
1000
2000
3000
4000
5000
Zinc (nmol/kg)
0
2
4
6
8
10
Depth (m
0
1000
2000
3000
4000
5000

Estimates of atmospheric deposition of various nutrients are provided in Table 10.4.

Table 10.4 Approximate Annual Atmospheric Inputs of Various Nutrients into the Atlantic Zone West of Ireland

Nutrient	Input
Ammoniacal compounds	0.25 gNH_4-N/m^2/yr
Oxidised Nitrogen (Nitrate & Nitrite)	0.2 gNO_3-N/m^2/yr
Total Nitrogen	0.175 gN/m^2/yr
Phosphorus	20 mgP/m^2/yr
Data taken from Boelens *et al*. (1999)	

Other inputs from the atmosphere include trace organic chemicals, such as petroleum hydrocarbons (PHCs) and polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), pesticides and dioxins. These compounds are all deposited into the ocean from the atmosphere. Estimates for the west coast of Ireland are given Table 10.5.

Table 10.5 Estimates of the Annual Input of Organic Contaminants into the Atlantic Zone West of Ireland

Contaminant	Input
PHCs	0.8 to 1.3 mg/m^2/y
PAHs	0.35 mg/m^2/y
PCBs	1.8 µg/m^2/y
Pesticides	0.9 mg/m^2/y
Dioxins	2.1 ng/m^2/y
Data taken from Boelens *et al*. (1999)	

Dumping

There has been no dumping of sewage offshore Ireland since 1994. The dumping sites used are well away from the coast of north-west Mayo, and outside the area of influence for the area.

Mariculture

Marine finfish and shellfish farming in Ireland has expanded considerably over the past 30 years. The expansion has been most pronounced on the western seaboard and to a lesser extent on the southern coast (Boelens *et al* 1999). The cultivation processes involve pellet feeding and the use of chemotherapeutics. These activities introduce contaminants into coastal waters in the form of nutrients and other trace organic compounds.

10.3.5 Marine contaminants

Petroleum Hydrocarbons

From data presented in Boelens *et al* (1999), the most significant losses of oil into the sea are operational losses rather than accidents. These authors also note that since the enactment of the MARPOL regulations (MARPOL 73/78 enacted through the Sea Pollution Act, 1991), there has been a substantial reduction in oil inputs to marine environments in most categories. No specific data are available for operational losses of oil from shipping in Irish waters. Nevertheless, given the volume of traffic in the whole of Region III (150,000 merchant vessel transits and 13,000 tanker transits per year), it is considered that these inputs are likely to be significant (Boelens *et al*., 1999).

Metals

Inputs from rivers, the atmosphere, disposal operations and mariculture, all contribute to background concentrations of key metals. These background levels of metals increase significantly towards the coastlines, as shown in Table 10.6.

Table 10.6 Background Concentrations for Five Key Metals in the Ocean, Offshore and Estuarine Environments (OSPAR, 2000 Region III QSR)

Metal	Ocean	Offshore	Estuarine
	Concentration in µg/litre unless otherwise stated		
cadmium	0.05	0.01 – 0.03	0.03 – 0.1
copper	0.5	~	0.31
lead	0.03	~	0.12
mercury	0.1-0.4	0.2 – 0.5 (ng/l)	~
zinc	5	0.5	40

Seawater samples were taken from Broadhaven Bay in 2000 and 2001. These samples were analysed for the range of metals that might occur in the produced water. The results of these analyses are provided in Table 10.7.

The measured concentrations in Broadhaven Bay tie in well with published data. Selenium and manganese are found in higher concentrations than most other trace metals in seawater. One reason is because they form oxyanions upon contact with water. These oxyanions are readily soluble in water. Other transition metals tend to form insoluble colloids (very fine grained solids) in solution, and therefore exhibit lower concentrations in marine waters. Manganese, lead and zinc concentration increases with proximity to the shore, suggesting a significant input to the coastal zone (e.g. by river runoff or diffusion from bottom sediments).

Table 10.7 Measured Background Metal Concentrations (mg/l) in Broadhaven Bay

Metal	2000	2001
antimony	~	0.001
arsenic	0.008	0.006
barium	<0.01	0.00761
cadmium	<0.0001	<0.00004
chromium	0.001	0.003
cobalt	~	0.001
copper	0.011	0.018
calcium	401	~
iron	0.01	~
lead	<0.001	0.000864
magnesium	1280	~
manganese	0.014	0.056
mercury	<0.0001	0.000041
molybdenum	~	0.007
nickel	0.005	0.005
silver	<0.001	<0.001
strontium	6.66	~
tin	~	<0.001
vanadium	~	<0.001
zinc	0.005	0.032

10.4 Characteristics of the Proposed Development

This section is limited to a description of the wastewaters that are expected to arise during operation of the terminal. The manner in which their impacts will be reduced is presented in Section 2.5.

10.4.1 Surface Water

Rainfall onto non-process (un-paved) areas will be directed to a drainage system and then will flow to the settlement ponds. This water will be free of any pollutants.

The maximum hourly rainfall (100 year storm = 31 mm per hour) has been used for sizing the drainage system. The integrity of the system has also been checked for an extreme rainfall event of 45 mm per hour. Rainwater, as discharged, is expected to contain a maximum of approximately 30ppm suspended solids.

10.4.2 Firewater

Water used for fire fighting in process areas could become contaminated with combustion products and foam. This water will be collected in the open drain system. In the event of a fire the open drain system will divert to the used firewater retention pond to ensure appropriate containment of the used firewater.

10.4.3 Oily Water Characteristics

Rainfall falling on process areas may become contaminated as a result of fuel spills, lubricant oil drips or leaks from the process plant. The rainwater will be collected in the 'Open Drain System', which is described further in Section 2.

The maximum hourly rainfall, coupled with the process drainage area, has been used to design the drainage system to ensure that it can handle all of the potentially contaminated water that will be generated during rainfall events. Table 10.8 provides the design concentrations for water draining from process areas prior to treatment.

Table 10.8 Design Composition of Water from Process Areas

Parameter	Prior to treatment
	Max hourly average (mg/l)
pH	7
Suspended Solids	<300
Dissolved Solids	<100
Oil Content	5 to 1000

10.4.4 Produced Water – Characteristics

As part of the recovery of natural gas from the reservoir some fluids will also arise in the form of water of condensation and formation water which comes from the rock reservoir in which the gas occurs. The condensed water often contains traces of organic compounds and some metals. The formation water, should it occur will contain natural salts and minerals which have leached from the rock in which the water has been resident over geological time. The actual composition will vary from location to location (well to well) and over time. Indications of the likely constituents have been determined from industry experience and from the testing of water recovered from the exploration wells.

The water that will be produced from the Corrib Field may be divided into two types – 'water of condensation' and 'formation water'.

Water of Condensation.

The hydrocarbon gas in the reservoir contains a certain amount of water in gaseous phase. This water in gaseous phase condenses out during the production process as the temperature and pressure of the hydrocarbon gas decrease. This water is known as water of condensation. It occurs from first production and arrives in the gas stream. The volume of water of condensation produced is directly proportional to the gas production rate.

Formation Water.

Formation water is present in liquid form within the reservoir, both in the gas column and in the aquifer. As the field is produced and the reservoir pressure declines, formation water within the aquifer may encroach into the gas bearing part of the structure.

The combined produced water will contain naturally-occurring dissolved salts and metals, and small quantities of condensate and dosing chemicals (methanol, corrosion inhibitor, scale inhibitor) that will require recovery from the effluent water stream. A summary of all key constituents with the required EQS limits is provided the mitigation section (Table 10.11) and detailed in the following sub-sections.

The aim of the characterisation of the produced water effluent stream is to identify and quantify the occurrence of any undesirable substance or quality of the wastewater. As is often the case in gas fields, Shell have had difficulty in obtaining samples of the formation water and condensed water, since the rock comprising the formation does not contain much free water. Only when the reservoir pressure drops, later in field life, is it likely that any free water in the formation will escape with the gas stream.

The containment and treatment of Produced Water is described further in Section 2

The produced water composition has been analysed and is described in Table 10.9. This is considered to present a conservative view of the produced water composition and provides a robust basis for the design of water treatment facilities.

The nature of natural gas production is such that it is considered prudent to design facilities for a typical range of inlet concentrations and that this be evaluated on an ongoing basis.

In Table 10.9 a design basis water composition has been derived as a worst case, i.e. using the greatest concentration for each component from each of the inlet streams. This ‘design case’ composition ensures that the treatment plant can cope with all possible constituents of the produced water.

Within Table 10.9, a second composition, referred to as ‘worst operational’, is provided, based on a conservative mix of water of condensation and formation water. This composition is provided to allow a qualitative comparison with the design basis, such that a judgement can be made on the significance of any further test data.

In the offshore production system, certain dosing chemicals are added to the wellstream (methanol, corrosion inhibitor, scale inhibitor). The reasons for use of these chemicals are presented in Section 2. Some will be partly removed with the condensate, but it is assumed that these chemicals will mainly be in the water phase, mixed with the produced water.. The water treatment process will treat the produced water to ensure removal of these chemicals to an acceptable level prior to discharge.

pH

The range in pH values reflects the possible range predicted, taking into consideration the possible variations in composition of produced water over the life of the field. This is done to ensure that the produced water treatment plant design is sufficiently robust to handle varying input concentrations.

Dissolved Solids

The majority of dissolved solids are those normally occurring in seawater or brine salts such as chlorides, with some sulphates and bicarbonates of sodium, potassium, calcium and magnesium. There is no requirement to treat or remove these salts from the produced water.

Suspended Solids

Gross solids arriving at the onshore terminal will settle in the slugcatcher or inlet filters. Solids in the aqueous phase passing through the slugcatcher or filters will collect in the raw methanol storage tank from which they will be removed.

Iron hydroxide, calcium sulphate and carbonate are expected as the waters mix, before any treatment takes place in the onshore terminal. Precipitated solids may build up in the methanol regeneration re-boiler with limited quantities carrying over to the water treatment system. Provision of scale inhibition is included within the methanol recovery system.

Condensate

Carry-over from separation is anticipated to be of the order of 2 - 5% condensate into the aqueous phase, the majority of this and the BTEX (see below) will be removed in the flash drum and coalescer upstream of the methanol still.

Recovery of methanol in the methanol still will vaporise any components more volatile than water, leaving the aqueous stream mostly free of hydrocarbons with those remaining being sparingly soluble.

Table 10.9 Produced Water Composition

All values in mg/1		Inlet Concentration: Condensed water from well 18/25-1	Formation water from well '27/5-1	Proposed Design Criteria from Enterprise	Design Basis	Worst Operational Level	Required Levels: EQS	Background	Remarks
Na	mg/1	1480	23050		23050	6736			
K	mg/1	58	3196		3196	823			
Ca	mg/1	1390	2059		2059	1553		401	
Mg	mg/1	155	737		737	297		1280	
Ba	mg/1	0.22	<0.4		0.4	0.26	0.5	0.01	95% compliance
Sr	mg/1	2.1	46.1		46.1	12.82		6.66	
Fe dissolved	mg/1	185	1		185	185			
Fe total	mg/1	215	76.8	20	215	215	1	0.01	Limits relative to dissolved iron
Cl	mg/1	4610	41200		41200	13525			
SO4	mg/1	340	4093		4093	1254			
HCO3	mg/1	195	127		195	195			
CO3	mg/1	0	0		0	0			
CH	mg/1	0	0		0	0			
NO3 as N	mg/1		-				50		
Bo	mg/1	2.1	4		4	2.56	2	0.01	
Al	mg/1	<0.2	<1.3		1.3	0.47	0.2		95% compliance
Si	mg/1	2.8	4.6		4.6	3.24			
P	mg/1	0.11	<1		1	0.33			
Li	mg/1	0.15	2.3		2.3	0.67			
CR 6+	mg/1		-						
Cr Total	mg/1	0.005	<0.1	0.5	0.5	0.028	0.100	0.001	
Mn	mg/1	3.1	2.7		3.1	3.1	0.300	0.14	
N	mg/1	0.26	15.7	1	15.7	4.02	0.100	0.005	Annual mean
Cu	mg/1	0.44	<0.01		0.44	0.44	0.050	0.011	
Zn	mg/1	25	<0.01	10	25	25	0.100	0.005	
As	mg/1	0.019	<0.1	0.5	0.5	0.039	0.050	0.006	
se	mg/1	0.02	<0.1		0.1	0.039	0.020	0.042	
Ag	mg/1	0.05	<0.1		0.1	0.062	0.010	<0.001	
Cd	mg/1	0.005	<0.01	0.05	0.05	0.006	0.005	0.0001	Total
Hq	mg/1	0.0085	3	0.05	1	0.737	0.0001	<0.0001	
Pb	mg/1	0.05	<0.05	0.5	0.5	0.05	0.001	<0.001	
pH @ 20 °C	mg/1	4.8	7.4		7.4	4.8	6		Not more than 0.2 points from natural level in 95% of samples
	mg/1					5.4	9		
Resistivity	mg/1	1.145	0.0992		1.145	1.145			
SG @ 60 °F	mg/1	1.019	1.0532		1.0532	1.027			
TDS	mg/1	8420	76000		76000	24886			
H_2S	mg/1	0	0		0	0			
Oil,Fat,Grease(free)	mg/1	5	5	15	15	5	0.3		To protect aquatic life, not more than 0.3 mg/l for mineral oils
TOC Dissolved	mg/1	67		200	200	67			
Methanol	mg/1	50	50	150	150	50			Included with TOC
mrl oil Intcpts	mg/1								None expected included with TOC
mrl oil bioplant	mg/1								None expected included with TOC
Suspended Soils	mg/1	320			320				Visually neutral
Phenol	mg/1	5	5	10	10	5	0.0005		
Ammonia Total	mg/1	5	5	5	5	5	0.3		Amine residuals as ammonia
BTEX	mg/1	0.1	0.1	25	25	0.1	0.01		
Sn	mg/1						0.01		
Cyanide	mg/1						0.01		None expected
Organoalogens	mg/1								No freon refrigerant
BOD	mg/1								
COD	mg/1	274		500	500				
PAH	mg/1			1	1		0.0002		
Organic Acids	mg/1			30	30				
NPD	mg/1			0.5	0.5				

Notes:
The condensed water sample is probably contaminated with brine.
The formation water is taken from the Avonmore formation (approximately 20km from the Corrib formation)

Benzene, Toluene, Ethylbenzene, and Xylene (BTEX)

The majority of aromatics in the form of benzene, toluene, ethylbenzene and xylene (BTEX) which may be present in the produced water are expected to behave similarly to condensate in the methanol still and hence leave the aqueous phase mostly free of aromatics.

Heavy Metals

Heavy metals are naturally present in the produced water. These will be removed to the IPPC licence limits in the produced water treatment plant prior to discharge .

Radioactive Materials

If present, radioactive materials will generally precipitate as solids in the process equipment at the terminal. From industry experience, radioactive concentrations within the water phase have been shown to depend on the concentration of radon gas in the reservoir fluids (gas). The concentration from two available gas samples from the Corrib reservoir varied as follows:

- one sample (26.9 Bq/m³) is an order of magnitude lower than comparable gas plants where radioactive solids are present; and ·
- the second (155-190 Bq/m³) is similar to other gas plants where management procedures are in place for handling and disposal of radioactive solids.

At these levels it is not expected to be harmful.
In general, whilst solids are unlikely to exceed the permitted upper limits for radioactivity in solid waste (10 Bq/g), the variation in levels of Radon measured in the gas would suggest that further analysis is undertaken. It is known that the methanol still operation will tend to concentrate any solids that collect in the reboiler and bottom of the still. If such solids occur, occupational safety controls will be implemented for maintenance personnel involved in internal inspection of the relevant equipment.

10.4.5 Additional Processing Chemicals

Additional fluids are introduced at the subsea wellhead facilities to control the properties of the produced gas and liquids i.e. hydrates, corrosion and scale. The onshore processing plant will add further dosing chemicals. This section addresses these chemicals, whether injected in the subsea wellhead, or used at the terminal.

Corrosion Inhibitor

Several kinds of inhibitors, or pH stabilisers, can be used to inhibit the corrosion of natural gas pipelines. Most inhibitors used are long chain nitrogenous compounds which include aliphatic fatty acid derivative (amines, amides and diamines), acetic, oleic, acid phosphate salts and amphoteric compounds. The inhibitors are likely to remain in the aqueous phase, and the water treatment system is designed to remove these to the IPPC licence limits.

Scale Inhibitor

Chemical inhibitors are added in the methanol recovery system to minimise scale. The chemicals may be inorganic polyphosphates or organic phosphate esters and phosphates. The inhibitors will be in the aqueous phase and will be separated from it in the water treatment system.

Well Intervention Fluids

These may include completion or packer brine fluids, mud acids (HCl/HF) and stimulation fluids. Intervention fluids are not expected in normal production but could cause temporary high solids loadings and settling out or blockage in the system.

Anti-Foam

Silicon based additives may be used occasionally for foam breaking in the condensate separation or hydrate inhibitor regeneration systems.

Heating Medium

There should not normally be any heating medium present in the water treatment feed. The heating medium is a glycol-water based system and leakage of the heating medium will appear in the aqueous effluents. Pinhole leaks are the most likely source and as little as a litre an hour of glycol could contribute 100-200 mg per litre of COD prior to water treatment.

Mineral / Lubrication Oils

Oil leakage from operating equipment may contaminate the aqueous phase if it occurs downstream of the aqueous separation. Oil contamination is unlikely as leakage is from the system, rather than to it.

Descaling Fluid

Dilute hydrochloric acid (5% HCL) is used for removing scale build up in areas like the methanol stills. Small quantities could remain in equipment after descaling operations.

Degreasing Fluids

Degreasing may be required for cleanout of condensate handling equipment and lubricated machinery in general. Small quantities could remain in equipment after maintenance operations.

10.4.6 Chemical Drains

Dosing, injection and cleaning chemicals will be stored in small quantities. Any spillage will be contained locally in bunds and/or drip trays for re-use or disposal. Chemicals will be bought in IBC containers.

If any water treatment chemicals require neutralisation, a local sump is provided to receive drainage from any low pH/high pH systems via dedicated drains.

A chemical drain is provided to collect spent chemicals from the on-site laboratory with a local sump for offsite disposal.

10.4.7 Sanitary Waste

This is the wastewater from toilets and washrooms in the terminal. This will be treated with a commercial 'Puraflo' waste treatment system (see Section 2).

10.4.8 Waste Water Flowrates

Produced Water

Reservoir simulations carried out for the Corrib field predict that formation water will be produced in very low quantities.

Table 10.10 provides a year by year tabulation of the predicted produced water inflows into the terminal. Condensed and formation water flow rates represent the most likely water production profile from the reservoir.

Table 10.10 Produced Water Flow Rates

Year	Condensed Water (m^3/hr)	Formation Water (m^3/hr)	Total Produced Water (m^3/hr)
1	3.2	0	3.2
2	3.3	0	3.3
3	3.2	0	3.2
4	2.6	0	2.6
5	2.1	0	2.1
6	1.7	0	1.7
7	1.4	0	1.4
8	1.2	0	1.2
9	1.0	0	1.0
10	0.9	0	0.9
11	0.8	0	0.8
12	0.7	0.1	0.8
13	0.7	0.1	0.8
14	0.6	0.2	0.8
15	0.6	0.2	0.8
16	0.5	0	0.5
17	0.4	0	0.4
18	0.4	0	0.4
19	0.3	0	0.3
20	0.3	0	0.3
21	0.2	0	0.2

Open Drain Catchment

The typical surface water runoff rate from paved process areas (13000 m^2) is estimated at ca. 2.1 m^3/hr based on a maximum annual rainfall of 1447.8mm. The maximum daily surface water runoff rate from paved process areas is estimated at 881 m^3/day (36.7 m^3/hour) based on a maximum daily rainfall of 67.8mm (20 year 24-hour Maximum). The open drain system has been designed to meet the 100 yr., 1 hour, 31mm/hr. criteria. As discussed in Sections 2 and 9.

Clean Surface Water Drainage

Drainage from uncontaminated areas will be discharged to the settlement ponds. A maximum flow of 3600 m^3/hr is predicted, based on one-hour 100-year storm rainfall conditions.

10.5 Potential Impact of the Proposed Development

10.5.1 During Construction

The treated water discharge pipeline, which will be laid to a point north of Erris Head outside of Broadhaven Bay, will be installed at the same time, and in the same trench, as the gas pipeline. A detailed discussion of these impacts can be found in the Offshore (Field to Terminal) EIS.

10.5.2 During Operation

Potential impacts of the treated water discharge on aquatic biota are discussed in Section 7.

In the absence of any treatment system to deal with the constituents of the produced water, there would be the potential for some of these metals to accumulate in the sediment and in the waters, with a further consequence that bioaccumulation may occur.

In the worst case, in the absence of the mitigation measures, pollution incidents could damage the marine ecology of nearby watercourses, water bodies and designated conservation areas. This could reduce or eliminate invertebrate and vertebrates (fish) and lead to loss of feeding habitat for predators. Recovery would be expected, but could take considerable time.

10.6 Mitigation Measures

This section describes the design and other measures proposed to manage the impacts associated with effluents arising from terminal operations. It focuses on the Environmental Quality Standard values that will need to be achieved to reduce the impacts to a point that is as low as reasonably practicable.

10.6.1 Regulations and Environmental Quality Standards

Effluent discharges to the environment will be via long sea outfall and to a road drainage ditch to the south west of the site.

Environmental Quality Standards (EQS) for a number of substances have been determined by the EPA. There are different standards which apply to different waters. For the terminal development, values for open water have been selected. EU Directive 76/464/EEC defines the EQS on the basis of the toxicity, persistence and bioaccumulation of a substance released into the environment. *The EQS values reflect the maximum level in the water body that may be present without affecting biological communities in their functional processes or otherwise giving rise to unacceptable adverse effects on the ecosystem or accumulation of substances that are harmful to the biota* (EPA, 1997).

In Europe, the Scientific Advisory Committee on Toxicity and Ecotoxicity of Chemicals has proved to be a valuable source of expertise on EQS levels and the EPA has used this body to assist in the setting of proposed aquatic EQS values. Also consulted was the Office of Water in the United States Environmental Protection Agency (USEPA).

Monitoring of water characteristics for comparison against EQSs are usually taken some distance from a discharge source, the discharge then having been diluted by the surrounding waters.

The EPA generally requires discharges to meet an ELV (emission limit value) at the discharge point. This limit is informed by the characteristics of the receiving water and is set so as to ultimately achieve the EQS. Thus it is usually higher than the EQS. There is no requirement under current legislation to meet EQS levels at the point of discharge.

Nevertheless, the design philosophy for the water treatment facilities at the terminal is that the discharge will be at or below the EQSs (EPA, 1997a) at the end of the pipeline. Discharges at this level will guarantee that there will be no harm to the receiving environment.

For the purposes of this EIS in considering the impact on the environment from the discharges of water into receiving waters, the EQS values determined by the EPA and the philosophy outlined above have been used.

10.6.2 Water Management – Routine Operations

The site drainage systems are described in detail in Section 2.

Treatment of wastewater during routine operations consists of the recovery of methanol from the aqueous stream of the wellstream fluids (produced water) in a still (see Section 2.5.) and subsequent further treatment of the water prior to discharge to the marine environment through a 12.7km long marine outfall. In addition, separate treatment is provided for drainage from paved process areas intercepted in the open drains system.

Water Treatment Systems

The treatment systems are described in Sections 2.5.

The effluent from each treatment system will be tested. If the effluent fails to meet the required standard it will be returned to the system for further treatment. Thus out-of-specification effluent will not be pumped to the discharge point.

Table 10.11 presents the anticipated characteristics of the treated produced water effluent.

Table 10.11 Composition of Treated Produced Water (EQS levels)

Parameter	As discharged* Max. concentration (mg/l) EQS
pH	6 - 9
COD[1]	400
Suspended Solids	visually neutral
Total Dissolved Solids	To be determined *
Total Ammonia	0.3
Oil, Fat, Grease	0.3
Total Organic Carbon (TOC) including Methanol[1]	100
Phenol	0.0005
Benzene, Toluene, Ethyl-Benzene, Xylene (BTEX)	0.01
Polyaromatic Hydrocarbons	0.0002
Barium	0.5
Iron (Dissolved)	1
Iron (Total)	1
Boron	2
Aluminium	0.2
Chromium	0.1
Manganese	0.3
Nickel	0.1
Copper	0.05
Zinc	0.1
Arsenic	0.05
Selenium	0.02
Silver	0.01
Cadmium	0.005
Mercury	0.0001
Lead	0.005

* Dissolved solids will consist primarily of salts (chlorides, sulphates. bicarbonates of bicarbonates of sodium, potassium, calcium and magnesium). The treatment system is not designed to specifically remove these elements as they are naturally occurring at high concentrations in seawater.
[1] COD and TOC are predicted concentrations; there are no EQS levels currently

Table 10.12 presents the anticipated characteristics of the treated open drain water effluent

Table 10.12 Composition of Treated Drainage Water from Process Areas

Parameter	As discharged	
	Max. hourly average (mg/l)	Max. daily average (mg/l)
pH	6 - 9	6 - 9
Suspended Solids	Visually neutral	Visually neutral
Dissolved Solids	Negligib le	Negligible
Oil Content	0.3	0.3

Sea Outfall

If the quality of treated effluent in the Produced Water Sump fails to meet the required EQS limit values, it will be pumped to the raw methanol storage tanks for recycling through the Produced Water Treatment System. If the quality of the water in the sump meets the required EQS values, it will be pumped to the Treated Water Sumps where it will be combined with the treated Surface Water stream. The combined treated streams (produced water and surface water) will then be pumped to the sea outfall.

10.7 Predicted Impact of the Proposed Development

10.7.1 Impacts in the Marine Environment

Water Quality Modelling

In order to assess the consequences of both existing and proposed discharges to the marine environment, Shell commissioned a dispersion modelling study of Broadhaven Bay by Kirk McClure Morton. A two dimensional depth integrated hydrodynamic model of Broadhaven Bay has been developed (Section 10.3.2) and verified by comparing model predictions to recorded data and anecdotal information. The correlation achieved between the model predictions and field observations of tidal currents and heights is considered sufficient to give confidence that the model is predicting the correct tidal exchange between the various inlets and outer Broadhaven Bay (see Appendix 10 at the end of this section). Within the main body of Broadhaven Bay a slack tidal regime is predicted which is in accordance with available records and observations (See Figure 10.3).

The pollutant dispersion model, PLUME-RW, simulates the movement of pollutant plumes discharged, for example, from sea outfalls or storm water overflows, using a random walk representation of turbulent diffusion. Pollutant discharges are represented by the release of discrete particles, which move in three dimensions under the influence of mean tidal currents, based on TELEMAC-2D simulations and under the influence of wind.

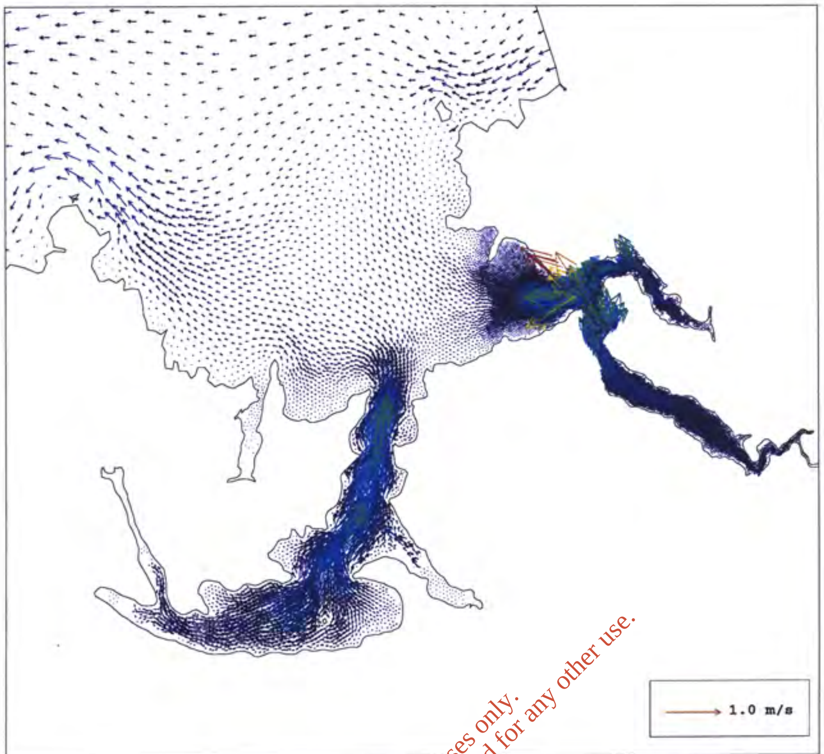
A series of dispersion models using PLUME-RW have been developed and simulations of typical wet and dry weather effluent discharges generated for a range of possible outfall positions within Broadhaven Bay. Information on the projected flow rates and concentrations of various constituents in the final effluent has been obtained from the Water Treatment Strategy for the terminal prepared by Kvaerner. Due to the high level of effluent treatment proposed (equal to or better than the EQS before discharge), the investigation has been restricted to investigating elements for which existing background levels are available. The results of the model simulations have, therefore, been presented in terms of the percentage increase in the concentration of each constituent above the existing background level.

In order to assess the predicted impact of these discharges, reference was made to the water quality modelling which used as an input the predicted annual contaminant loading from the water treatment plant given in Table 10.13 and the waste water flow rates given in Table 10.10. The modelling provided an estimate of the likely impacts on the waters of Broadhaven Bay, due to the discharge of wastewater from the water treatment plant in the terminal.

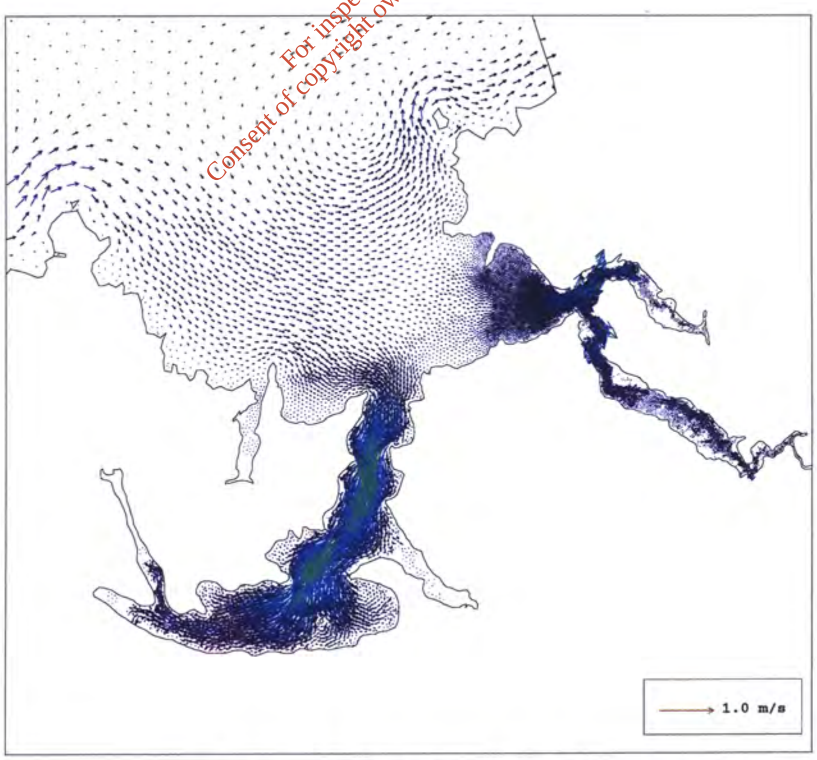
Table 10.13 Maximum Annual Metal Contaminant Loading of the Waste Water in Year 2

Contaminant	Annual discharge Kg/year
Barium	14.4200
Boron	57.6700
Phosphorus	28.8400
Chromium	2.8800
Manganese	8.6500
Nickel	2.8800
Copper	1.4400
Zinc	2.8800
Arsenic	1.4400
Selenium	0.5800
Silver	0.2900
Cadmium	0.1400
Mercury	0.0029
Lead	0.1400

Figure 10.3 Predicted Tidal Currents 3 Hours / 9 Hours After High Water



Predicted Tidal Currents @ 3 hours after HW



Predicted Tidal Currents @ 9 hours after HW

For the purpose of this study, two extreme conditions were selected for simulation in the dispersion model corresponding to the effluent discharge during periods of dry weather and the peak wet weather discharge. Representative wet and dry weather loading rates were established by assuming that the daily loading was discharged over a total 16 or 2 hours respectively.

The resulting 'worst case' discharge rates were:

- dry weather: 82.3 m^3/hr for 2 hours per day or 165 m^3 in a day; and
- storm conditions: 82.3 m^3/hr for 16 hours per day or 1317 m^3 in a day, assumed to be equivalent to 54.8 m^3/hr over the full day due to pump cycling, i.e. the pump would not be run continuously over a 16 hour period since the peak rate of inflow is only 55.6 m^3/hr.

Since the rainwater component of the discharge does not contribute to the pollutant loadings assessed in this study, these two scenarios are sufficient to assess the environmental impact of all possible alternative dry weather discharges that might be proposed. For example, the impact of using a low pumping rate to give a continuous discharge from the outfall during dry weather will be identical to the impact predicted for the wet weather discharge, since the actual pollutant loading rate is the same. Consequently, the impact of any other discharge time between 2 and 24 hours will produce an impact that lies somewhere between that predicted for the dry and wet weather simulations included in this study.

Twelve plume simulation runs were carried out in order to assess the impact of the proposed effluent discharge and determine the optimum position for the final effluent discharge.

In summary, the simulation runs covered outfall locations at the 10m, 20m, 30m and 40m bathymetric contours, where it intersects the gas pipeline. Each run covered both a spring and a neap tidal cycle and also a wet and a dry weather scenario. At the 40 m location four additional runs were carried out to look at wind effects on the discharge. Wind directions modelled were northerly, north-westerly, westerly and south-westerly.

This study indicated that an outfall extending to the 40m contour in Broadhaven Bay would be sufficient to prevent a significant increase in background concentrations of metallic. Subsequent to the submission of the various applications and discussions with various interested parties it was decided to investigate the impact of discharging the effluent at a point outside the boundary of the Broadhaven Bay (Candidate) Special Area of Conservation.

The principal objectives of the additional study were therefore:

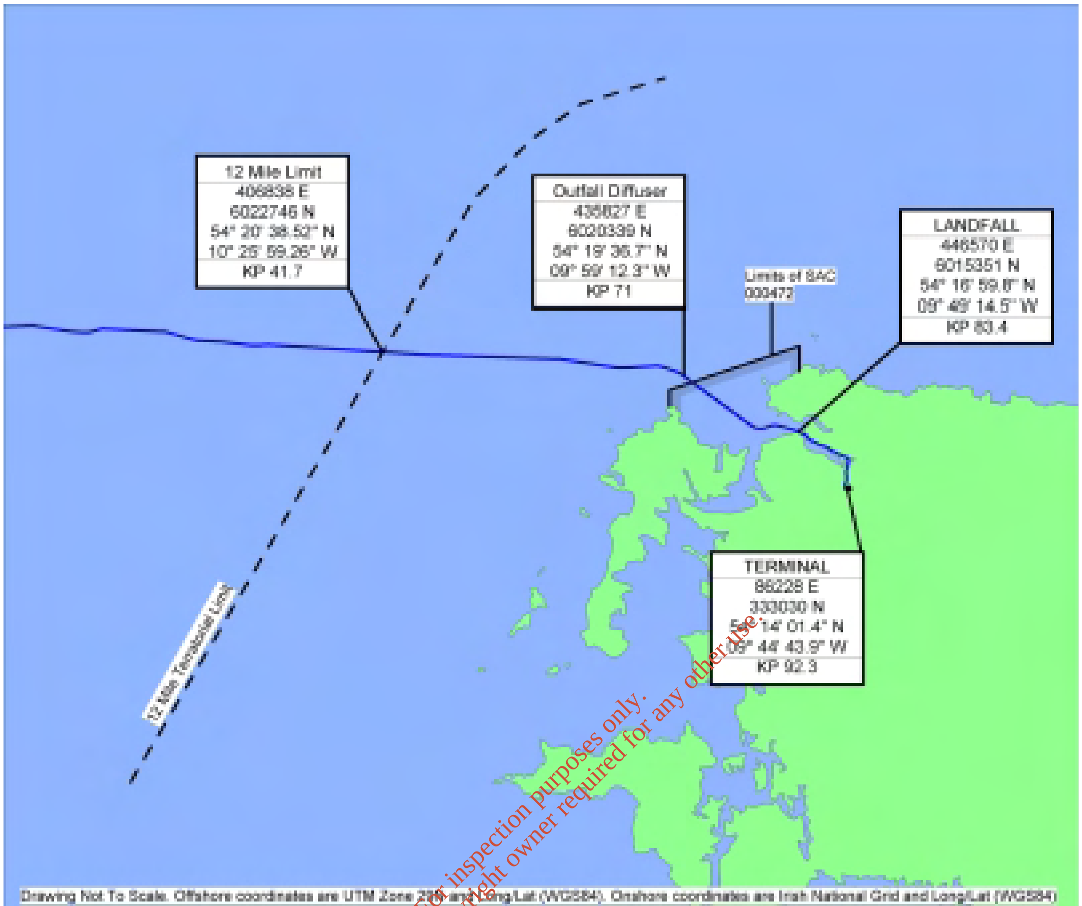
- To utilise the hydrodynamic model of Broadhaven Bay developed during the original study to provide simulated tidal flow conditions for input to the dispersion models;
- To establish a series of dispersion models to simulate the advection, dispersion and fate of a range of constituents in the effluent discharged from a potential outfall position outside Broadhaven Bay; and
- To establish the impact of the discharge on existing background concentrations of metallic elements within Broadhaven Bay and the SAC.

The additional model simulations are presented in full within Kirk McLure Morton's Dispersion Modelling Addendum report, Appendix 10. Following completion of this modelling study, Enterprise Energy Ireland advised that the diffuser is to be located at KP 71.0, approximately on the 64m contour, outside Broadhaven Bay. This adjustment is not expected to significantly alter the predictions for the 60m depth.

Examination of the data presented in Table 2 of Kirk McLure Morton's report (Appendix 10) indicates that increasing the available water depth at the point of discharge reduces the maximum concentration of each constituent of the effluent predicted to occur within the receiving waters. However, the incremental difference reduces with increasing water depth to the point where moving from a water depth of 30m to 40m does not materially alter the magnitude of the predicted impact. Thus it was concluded in the original study that extending the outfall into deeper water within the Bay i.e. beyond the 40m contour would not yield any significant benefit in terms of water quality. This is borne out by the results of the dispersion model simulations for the 60m water depth which generally do not indicate a significant reduction in impact when compared to the equivalent data for the 40m water depth.

However, as a result of the marine licensing activities for the Corrib Field Development the outfall has been moved by the Minister for Communications, Marine and Natural Resources to a point outside of the bay. The outfall location is approximately 2km north of Erris Head, 12.7km along the pipeline route from the landfall in 68.5m water depth (Figure10.4).

Figure 10.4 Location of outfall diffuser



Metals

It is anticipated that several metals will be present in trace quantities in the water discharged into a coastal discharge location. Samples of the receiving water have been taken to determine the background concentrations of these metals. Table 10.14 provides anticipated metal concentrations in the discharge, along with summer background concentrations of the metals in Broadhaven Bay. The background levels should be considered only as indicative (within an order of magnitude), as they are likely to vary throughout the year.

Table 10.14 Concentrations of Metals in Broadhaven Bay and the Terminal Discharge

Metal	Concentration in Wastewaters (µg/litre)	Concentration in Broadhaven Bay (µg/litre)
Arsenic	50	8
Barium	500	<10
Cadmium	5	<0.1
Chromium	100	1.0
Copper	50	11
Lead	5	<1.0
Manganese	300	14
Mercury	0.1	<0.1
Nickel	100	5
Selenium	20	42
Silver	10	<1.0
Zinc	100	5

Given the low concentrations of metals in the treated wastewater, the rapid dilution of the terminal discharge and knowledge of trace metal cycling, it is predicted that no observable impacts will occur due to the discharge of treated wastewater effluents from the Corrib field development.

Studies on produced water fate and effects on the marine environment have concluded that "In general the concentrations of most metals in natural marine food webs show either no relation or even an inverse relation to trophic levels, indicating that food chain biomagnification does not occur" (E & P Forum, 1994).

Methanol, Oil and Grease and Total Organic Carbon

It is anticipated that a small quantity of methanol will be discharged with the produced water. Methanol will, on the whole, be recycled in the terminal. More information on methanol discharge and recycling is provided in Section 2. There may also be extremely small traces of well fluids and inhibitor chemicals remaining in the methanol when it is discharged.

Methanol is classified by the Oslo and Paris Commission (OSPAR) as a substance that poses little or no risk to the environment (PLONOR). This is effectively the most benign classification for any chemical used and discharged in the oil and gas industry.

The oil and grease discharges relate to material that is washed off industrial plant by rain, or accidentally spilled onto impermeable surfaces within the terminal and washed into the contaminated drain system. The amount of discharge estimated relates to the specified treatment capability of the terminal plant, which will reduce the level of oil and grease in water to EQS level. Normally the discharge of oil and grease will be insignificant.

Organic discharges may result from the contaminated rainwater runoff from the terminal site. The treatment of this discharge is discussed in Section 2. It is estimated that the annual discharge of total organic carbon (TOC) from treated rainwater run-off and produced water will be up to 5 tonnes. The TOC discharge is expected to rapidly dilute in the marine environment. The final fate of the organic contaminants is likely to be attachment to particulate material, which sinks to the seabed, where the organic molecules will be degraded by micro-organisms. The lighter fractions of the organics will evaporate. The levels of organic material being discharged to the Atlantic Ocean are extremely unlikely to present any effects to the local flora and fauna.

Physical Impacts

The discharge varies in quantity. The speed of the water being discharged from the pipeline in wet weather conditions may sweep any small organisms away that happen to be in the water column in the vicinity when water is being discharged. However, the type of animal that is swept away (e.g. plankton) is likely to be swept around by the tidal currents and waves in the sea during normal conditions. Larger faunal species are expected to avoid the area directly above the end of the pipe during the period of discharge. The physical influence of the discharge stream will decrease quickly and organisms that are a few metres away may not experience any abnormal effects.

10.8 Monitoring

The mitigation measures will be monitored as part of the IPPC licensing conditions. Good practice also requires that impacts on adjoining areas, especially designated conservation areas, be monitored for impacts. This work will be undertaken in consultation with DCMNR as required by the terms of the plan of development approval for the Corrib field development and the associated Foreshore Licence.

Pre, during and post-project monitoring will be carried out to substantiate conclusions with respect to the environmental impacts. This is desirable even though the data that are presently available suggest that the effects of the treated wastewater discharge are likely to be very minor (and may not even be observable). A programme of such monitoring is subject to the licence approvals referenced above, and will be subject to approval by the Minister for Communications, Marine and Natural Resources.

Monitoring will be required of the quality of the treated wastewater. This monitoring will be a condition of the IPPC licence.

Discharge limits for liquid effluents are subject to prior agreement of consent levels with the Environment Protection Agency (EPA). Regular flow proportional sampling will be undertaken along with spot measurement in the discharge of the produced water and oily water treatment facilities to ensure levels are achieved and maintained. Monitoring of the process effluents will be made for the following:

- flowrate;
- pH;
- Temperature; and
- TOC (surrogate for COD/BOD).

Frequent flow proportional sampling for total oil will be provided as currently no reliable on-line technology is available due to the level of salts. Samples will also be monitored for appropriate other parameter such as those below over relevant time periods, typically daily, weekly, monthly or annually depending on circumstances:

- oil in water;
- ammoniacal and total nitrogen;
- suspended solids;
- phenols;
- sulphides; and

- metals (typically Cd, Hg, Cr, Ni, Zn, Cu and As).

In addition to the regular monitoring carried out by the operator to demonstrate compliance with the release limits set, a fuller analysis will be carried out covering a broad spectrum of substances to establish that all relevant substances have been taken into account when setting the release limits.
The monitoring programme will be subject to an IPPC licence agreement.

10.9 Reinstatement and Residual Impacts

The decommissioning plan for the site will have provision for the management of contaminated water during site reinstatement and restoration.

In terms of the marine environment, due to the very low concentrations of naturally occurring elements in the discharge waters after treatment, it is not expected that there will be any measurable residual impact.

Appendix 10.1

Dispersion Modelling Study
Broadhaven Bay

Enterprise Energy Ireland Ltd
Corrib Field Development Project

Dispersion Modelling Study
Broadhaven Bay

Addendum Report

May 2002

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CORRIB FIELD DEVELOPMENT PROJECT

DISPERSION MODELLING STUDY – BROADHAVEN BAY

ADDENDUM REPORT

Report Status:	Final Report
Date:	May 2002
Reference:	Kirk McClure Morton, 2002. Corrib Field Development Project, Dispersion Modelling Study – Broadhaven Bay. A report for Enterprise Energy Ireland Ltd.
Report number:	RW1212a
Contract number:	KMM 5222.00
Commissioned by:	Enterprise Energy Ireland Ltd., Corrib Project Team, Park House, Frascati Road, Blackrock, Co. Dublin, Ireland.

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CONTENTS

1.0 INTRODUCTION

Enterprise Energy Ireland Ltd. has commissioned a series of studies with the ultimate aim of developing the Corrib natural gas field, which lies off the western seaboard of County Mayo, Ireland. Due to the exposed location of the Corrib gas field, on-site pre-processing of the raw gas is not considered to be feasible. Consequently, all processing to meet sales gas specifications will be carried out at a new onshore reception terminal to be built at Bellanaboy Bridge in County Mayo.

Within the proposed reception terminal any liquids contained within the gas stream will be extracted, produced water separated out, and passed through a comprehensive treatment process. The aim of the proposed treatment process is to reduce concentrations of metallic elements in the effluent to or below the EQS level prior to discharge. Before discharge, the treated produced water will be combined with treated rainwater and any firewater runoff. This second wastewater stream will also have been treated to EQS levels in a separate treatment process. The preferred method for the disposal of the resulting treated effluent is by direct discharge to the receiving waters of Broadhaven Bay and the western seaboard of Ireland.

The onshore development is presently the subject of a planning application and Foreshore Licence application for which a study of the dispersion of metallic elements contained in the effluent discharge was required to determine the likely environmental impact on Broadhaven Bay. Kirk McClure Morton was therefore commissioned by Enterprise Energy Ireland Ltd to study dispersion within Broadhaven Bay using computational modelling techniques and prepare a report as supporting information for the aforementioned applications.

This study indicated that an outfall extending to the 40m contour in Broadhaven Bay would be sufficient to prevent a significant increase in background concentrations of metallic elements occurring as detailed in Reference 1. Subsequent to the submission of the various application and discussions with various interested parties it was decided to investigate the impact of discharging the effluent at a point outside the boundary of the Broadhaven Bay Special Area of Conservation. It is this latter element of the dispersion study that is the subject of this addendum report.

The principal objectives of Kirk McClure Morton's additional study were therefore:

- to utilise the hydrodynamic model of Broadhaven Bay developed during the original study to provide simulated tidal flow conditions for input to the dispersion models;

- to establish a series of dispersion models to simulate the advection, dispersion and fate of a range of constituents in the effluent discharged from a potential outfall position outside Broadhaven Bay;

- to establish the impact of the discharge on existing background concentrations of metallic elements within Broadhaven Bay and the SAC.

The additional model simulations have been completed and the potential impact for receiving water quality of extending the outfall to a point on the 60m contour line is discussed in subsequent sections of this document. Following completion of this modelling study, Enterprise Energy Ireland advised that the diffuser is to be located at KP 71.0, approximately on the 64m contour, outside Broadhaven Bay. This adjustment is not expected to significantly alter the predictions for the 60m depth, as discussed within.

2.0 HYDRODYNAMIC MODELLING

Kirk McClure Morton's hydrodynamic model of Broadhaven Bay and a portion of the adjoining Atlantic seaboard of County Mayo was developed using the TELEMAC-2D suite of computational modelling software developed by LNH in Paris and distributed in the UK and Ireland by H.R. Wallingford Ltd. This model solves the two-dimensional depth-integrated shallow water equations, which represent the flow in rivers, estuaries and seas using a finite element technique, permitting the use of very flexible unstructured triangular grids to represent the model domain. Full details of the model implementation and the correlation with field observations are presented in Section 2 of the main dispersion modelling report, Reference 1.

The tidal flow regime predicted by the hydrodynamic model was compared with observations and notes contained in sailing directions, the Admiralty coast pilot and current and level information collected specifically for this purpose. Generally the predicted tidal current regime was found to be broadly in line with the observations presented in the Irish Coast Pilot, Reference 2.

Similarly the correlation between the model predictions and field observations of tidal levels and currents was judged sufficient to give confidence that the model was predicting the correct tidal exchange between the various inlets and outer Broadhaven Bay. Hence the model predictions were considered to be representative of tidal movements within the Bay.

3.0 WATER QUALITY MODELLING

3.1 General

Computational models for the assessments of effluent dispersion in the marine environment comprise a suite of post processing packages associated with the hydrodynamic model. These models are designed to examine the consequences of both existing and proposed discharges to the water environment. For this study the effluent dispersal model, PLUME-RW, was utilised to model the release of treated effluent from the proposed gas reception terminal at Bellanaboy Bridge into the receiving waters off the County Mayo coastline.

Details of the dispersion model implementation and the assumptions made regarding dispersion characteristics are presented in Section 3 of Reference 1. The accuracy of the various assumptions was confirmed by simulating a selection of the dye release experiments undertaken as part of the main study and the results obtained were sufficient to conclude that the dispersion model was capable of accurately predicting the mean advection of the dye patches. Thus confirming the applicability of the diffusion coefficients etc. used in the dispersion model simulations to the receiving waters of Broadhaven Bay.

3.2 Dispersion Model Simulations

A series of dispersion model simulations were carried out in order to identify the potential impact of discharging the proposed dry weather loading from the Bellanaboy Bridge Terminal on receiving water quality in Broadhaven Bay during this additional study. The predicted dry weather discharge was selected for investigation since this had previously been shown to be the most onerous loading condition. A possible outfall position on the route of the proposed gas transmission pipeline but outside the boundary of the SAC in approximately 60m of water was selected for investigation during this study. The influence of wind generated surface currents was included in the analysis of this outfall position to illustrate any potential variation in impact during different climatic conditions. This analysis has been restricted to reviewing the impact during neap tidal conditions as the model results presented in the main report indicated this to be the most adverse tidal state.

The following plume simulation runs were carried out in order to assess the impact of the proposed effluent discharge and determine the likely impact on receiving water quality in Broadhaven Bay.

Run 15 Dry weather discharge from an outfall extending to the 60m contour off Broadhaven Bay during neap tidal cycles and calm weather.

Run 16 Dry weather discharge from an outfall extending to the 60m contour off Broadhaven Bay during neap tidal cycles and northerly winds.

Run 17 Dry weather discharge from an outfall extending to the 60m contour off Broadhaven Bay during neap tidal cycles and northwesterly winds.

Run 18 Dry weather discharge from an outfall extending to the 60m contour off Broadhaven Bay during neap tidal cycles and northeasterly winds.

Run 19 Dry weather discharge from an outfall extending to the 60m contour off Broadhaven Bay during neap tidal cycles and westerly winds.

An envelope of the maximum concentration of each constituent of the final effluent attained at every point in the model grid has been plotted for each model run. These envelopes represent the highest concentration reached in every cell in the model although this may have been present for only a short period during the tidal cycle. The envelope therefore marks the outer limit of the plume's influence and the excursion of the effluent plume at any given time during the tidal cycle will lie entirely within the area covered by the plume envelope.

Contours equivalent to an increase of 0.5, 1.0 and 1.5 percent over the existing background concentrations of each of the constituents within Broadhaven Bay have been drawn to illustrate the potential impact of the effluent discharge on water quality.

60m OUTFALL OPTION

Run 15 Dry weather discharge from an outfall extending to the 60m contour off Broadhaven Bay during neap tidal cycles and calm weather conditions.

This series of model runs was intended to determine the impact on water quality in Broadhaven Bay of discharging treated effluent from the Gas Reception Terminal outside the designated SAC during dry weather conditions.

The following assumptions were made for these computer runs:

1. The effluent was discharged at a rate of 82.3 m^3/hour for one hour commencing at one hour after each high water i.e. 2 hours per day.

2. Treated produced water in the effluent stream was discharged at a concentration equivalent to the EQS for each constituent of the effluent.

3. No temporal decay was applied i.e. concentrations are only reduced by the processes of natural dispersion.

4. Calm weather conditions prevailed during each of the model runs.

5. The effluent was discharged over a series of neap tides from an outfall extending to the 60m contour off Broadhaven Bay in order to allow a stable distribution of effluent concentrations to develop.

6. The effluent mixed vertically throughout the water column, i.e. no stratification occurred.

The furthest excursions of the resulting effluent plumes in Broadhaven Bay are shown in Runs 15a and b.

Run 15a

Year 2, Dry Weather Discharge, Neap Tides, 60m Outfall

Year 2, Dry Weather Discharge, Neap Tides, 60m Outfall

Run 15b

60m OUTFALL OPTION

Run 16 Dry weather discharge from an outfall extending to the 60m contour off Broadhaven Bay during neap tidal cycles and northerly winds.

This series of model runs was intended to determine the impact of northerly winds on the dispersion of effluent from the proposed Gas Reception Terminal and the resulting impact on water quality within Broadhaven Bay during dry weather conditions.

The following assumptions were made for these computer runs:

1. The effluent was discharged at a rate of 82.3 m^3/hour for one hour commencing at one hour after each high water i.e. 2 hours per day.

2. Treated produced water in the effluent stream was discharged at a concentration equivalent to the EQS for each constituent of the effluent.

3. No temporal decay was applied i.e. concentrations are only reduced by the processes of natural dispersion.

4. A 5.5m/s northerly wind prevailed during each of the model runs.

5. The effluent was discharged over a series of neap tides from an outfall extending to the 60m contour off Broadhaven Bay in order to allow a stable distribution of effluent concentrations to develop.

6. The effluent mixed vertically throughout the water column, i.e. no stratification occurred.

The furthest excursions of the resulting effluent plumes in Broadhaven Bay are shown in Runs 16a and b.

Run 16a

Year 2, Dry Weather Discharge, Neap Tides, 60m Outfall, Northerly Wind

Year 2, Dry Weather Discharge, Neap Tides, 60m Outfall, Northerly Wind

Run 16b

60m OUTFALL OPTION

Run 17 **Dry weather discharge from an outfall extending to the 60m contour off Broadhaven Bay during neap tidal cycles and north westerly winds.**

This series of model runs was intended to determine the impact of north westerly winds on the dispersion of effluent from the proposed Gas Reception Terminal and the resulting impact on water quality within Broadhaven Bay during dry weather conditions.

The following assumptions were made for these computer runs:

1. The effluent was discharged at a rate of 82.3 m^3/hour for one hour commencing at one hour after each high water i.e. 2 hours per day.

2. Treated produced water in the effluent stream was discharged at a concentration equivalent to the EQS for each constituent of the effluent.

3. No temporal decay was applied i.e. concentrations are only reduced by the processes of natural dispersion.

4. A 5.5m/s north westerly wind prevailed during each of the model runs.

5. The effluent was discharged over a series of neap tides from an outfall extending to the 60m contour off Broadhaven Bay in order to allow a stable distribution of effluent concentrations to develop.

6. The effluent mixed vertically throughout the water column, i.e. no stratification occurred.

The furthest excursions of the resulting effluent plumes in Broadhaven Bay are shown in Runs 17a and b.

Year 2, Dry Weather Discharge, Neap Tides, 60m Outfall, North Westerly Wind

Run 17a

Year 2, Dry Weather Discharge, Neap Tides, 60m Outfall, North Westerly Wind

Run 17b

60m OUTFALL OPTION

Run 18 Dry weather discharge from an outfall extending to the 60m contour off Broadhaven Bay during neap tidal cycles and north easterly winds.

This series of model runs was intended to determine the impact of north easterly winds on the dispersion of effluent from the proposed Gas Reception Terminal and the resulting impact on water quality within Broadhaven Bay during dry weather conditions.

The following assumptions were made for these computer runs:

1. The effluent was discharged at a rate of 82.3 m^3/hour for one hour commencing at one hour after each high water i.e. 2 hours per day.

2. Treated produced water in the effluent stream was discharged at a concentration equivalent to the EQS for each constituent of the effluent.

3. No temporal decay was applied i.e. concentrations are only reduced by the processes of natural dispersion.

4. A 5.5m/s north easterly wind prevailed during each of the model runs.

5. The effluent was discharged over a series of neap tides from an outfall extending to the 60m contour off Broadhaven Bay in order to allow a stable distribution of effluent concentrations to develop.

6. The effluent mixed vertically throughout the water column, i.e. no stratification occurred.

The furthest excursions of the resulting effluent plumes in Broadhaven Bay are shown in Runs 18a and b.

Year 2, Dry Weather Discharge, Neap Tides, 60m Outfall, North Easterly Wind

Run 18a

Run 18b

Year 2, Dry Weather Discharge, Neap Tides, 60m Outfall, North Easterly Wind

60m OUTFALL OPTION

Run 19 **Dry weather discharge from an outfall extending to the 60m contour off Broadhaven Bay during neap tidal cycles and westerly winds.**

This series of model runs was intended to determine the impact of westerly winds on the dispersion of effluent from the proposed Gas Reception Terminal and the resulting impact on water quality within Broadhaven Bay during dry weather conditions.

The following assumptions were made for these computer runs:

1. The effluent was discharged at a rate of 82.3 m^3/hour for one hour commencing at one hour after each high water i.e. 2 hours per day.

2. Treated produced water in the effluent stream was discharged at a concentration equivalent to the EQS for each constituent of the effluent.

3. No temporal decay was applied i.e. concentrations are only reduced by the processes of natural dispersion.

4. A 5.5m/s westerly wind prevailed during each of the model runs.

5. The effluent was discharged over a series of neap tides from an outfall extending to the 60m contour off Broadhaven Bay in order to allow a stable distribution of effluent concentrations to develop.

6. The effluent mixed vertically throughout the water column, i.e. no stratification occurred.

The furthest excursions of the resulting effluent plumes in Broadhaven Bay are shown in Runs 19a and b.

Year 2, Dry Weather Discharge, Neap Tides, 60m Outfall, Westerly Wind

Run 19a

Year 2, Dry Weather Discharge, Neap Tides, 60m Outfall, Westerly Wind

Run 19b

4.0 CONCLUSIONS OF THE STUDY

The implications for receiving water quality in Broadhaven Bay of discharging effluent from the proposed onshore gas reception terminal at Bellanaboy Bridge via a new outfall outside the bay have been assessed using computational modelling techniques. The following conclusions have been drawn with the aid of the computerised dispersion model simulation runs:

Hydrodynamic and water quality models of Broadhaven Bay and its approaches have been set-up and verified against data recorded specifically for this project and other published data. The hydrodynamic models have been proven to be capable of simulating the tidal flow regime within the Bay and the various passages leading to the inner parts of Broadhaven Bay and the Sruwaddacon.

A series of effluent dispersion simulations have been completed for an outfall position outside the Bay using neap tidal predictions and a range of weather conditions. The results of the dispersion modelling have been compared to recorded background concentrations of various metallic elements within Broadhaven Bay in order to assess the significance of the predicted impact.

Dispersion modelling was completed for an outfall extending to the 60m contour outside Broadhaven Bay at IGR 070969,343698. Subsequent to the completion of the dispersion modelling Enterprise Energy Ireland Ltd advised that the diffuser is to be located at KP 71.0, approximately on the 64m contour outside the Bay. However, the slight increase in water depth and movement of the outfall are not expected to significantly alter the predictions of the model from those presented for the 60m water depth. Only the dry weather discharge was modelled using neap tidal conditions as these were known to be the worst case combination as a result of the extensive modelling undertaken during the main study.

The maximum percentage increase in background concentration of the various metallic elements during calm weather conditions is presented in Table 1.

Table 1 Predicted Impact of Effluent Discharge (60m Outfall)

Constituent		Maximum Increase
Chromium	Cr	1.2%
Manganese	Mn	0.3%
Nickel	Ni	0.3%
Copper	Cu	<0.1%
Zinc	Zn	0.3%
Arsenic	As	0.1%
Selenium	Se	<0.1%
Silver	Ag	0.3%
Cadmium	Cd	0.7%
Mercury	Hg	<0.1%
Lead	Pb	0.1%
Barium	Ba	0.7%

The results of the modelling presented in Table 1 indicate that the effluent plume resulting from the intermittent dry weather discharge is not predicted to increase background concentrations by more than 1.2% during neap tides. Predicted increases of greater than 0.5% of the existing background concentrations are restricted within approximately 500m of the point of discharge.

The results of the dispersion model simulations for this longer outfall option are compared with corresponding results for the various outfall positions investigated in the main study in Table 2 below.

Table 2 Comparison of the Impact of the Potential Effluent Discharges

Constituent		Water Depth at Discharge Point				
		10m	20m	30m	40m	60m
Chromium	Cr	6.6%	3.8%	2.1%	2.2%	1.2%
Manganese	Mn	1.4%	0.8%	0.5%	0.5%	0.3%
Nickel	Ni	1.4%	0.8%	0.4%	0.4%	0.3%
Copper	Cu	0.3%	0.2%	0.1%	0.1%	<0.1%
Zinc	Zn	1.4%	0.8%	0.4%	0.4%	0.3%
Arsenic	As	0.4%	0.3%	0.1%	0.1%	0.1%
Selenium	Se	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
Silver	Ag	1.4%	0.8%	0.4%	0.4%	0.3%
Cadmium	Cd	3.3%	1.9%	1.1%	1.1%	0.7%
Mercury	Hg	0.2%	0.1%	<0.1%	<0.1%	<0.1%
Lead	Pb	0.4%	0.2%	0.1%	0.1%	0.1%
Barium	Ba	3.3%	1.9%	1.1%	1.1%	0.7%

Examination of the data presented in Table 2 indicates that increasing the available water depth at the point of discharge reduces the maximum concentration of each constituent of the effluent predicted to occur within the receiving waters. However the incremental difference reduces with increasing water depth to the point where moving from a water depth of 30m to 40m does not materially alter the magnitude of the predicted impact. Thus it was concluded in the original study that extending the outfall into deeper water within the Bay i.e. beyond the 40m contour would not yield any significant benefit in terms of water quality. This is borne out by the results of the dispersion model simulations for the 60m water depth which generally do not indicate a significant reduction in impact when compared to the equivalent data for the 40m water depth.

The impact of wind derived currents on the dispersion of effluent from the deep water outfall position outside Broadhaven Bay was also investigated using the dispersion model. Again this exercise was restricted to an investigation of the impact on the dispersion of the dry weather discharge during periods of neap tides as this had previously been shown to be the worst case scenario. Model simulations for a light to moderate breeze from four wind directions ranging from north east through north to west were completed.

The dispersion modelling does not indicate any occasion when the wind induced currents cause effluent to be advected into Broadhaven Bay in sufficient quantity to increase the concentrations of metallic elements by more than 0.5% above background. The effect of the wind induced currents is to reduce the magnitude of the peak concentrations close to the outfall. This can be explained in terms of the increased advection and dispersion of effluent within the Bay caused by wind induced currents particularly during the periods when the tidal flow is slack. The proposed 60m outfall position is also sufficiently far offshore to prevent the impact at the shoreline in Broadhaven Bay from exceeding 0.1% of the existing background levels. The actual effect of the wind induced currents on the maximum concentrations of metallic elements is summarised in Table 3 below.

Table 3 Impact of Wind on Effluent Dispersion

Constituent		Wind Direction				
		Calm	North East	North	North West	West
Chromium	Cr	1.2%	0.5%	0.5%	0.6%	0.7%
Manganese	Mn	0.3%	0.1%	0.1%	0.2%	0.2%
Nickel	Ni	0.3%	0.1%	0.1%	0.2%	0.2%
Copper	Cu	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
Zinc	Zn	0.3%	0.1%	0.1%	0.2%	0.2%
Arsenic	As	0.1%	<0.1%	<0.1%	<0.1%	<0.1%
Selenium	Se	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
Silver	Ag	0.3%	0.1%	0.1%	0.2%	0.2%
Cadmium	Cd	0.7%	0.2%	0.3%	0.3%	0.4%
Mercury	Hg	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
Lead	Pb	0.1%	<0.1%	<0.1%	<0.1%	<0.1%
Barium	Ba	0.7%	0.3%	0.3%	0.3%	0.4%

The modelling results indicate that for effluent treated to at least the EQS standard before discharge, the provision of an outfall extending to the 60m contour outside Broadhaven Bay will not result in a significant adverse impact on water quality within the Bay. In all cases investigated any impact in excess of 0.5% of the existing background lies outside Broadhaven Bay with the worst case showing an increase of 1.2% in Chromium levels above the existing background. In many cases no increase in excess of 0.5% of the existing background concentration is predicted to occur even within the offshore waters.

Subsequent to the completion of this modelling study Enterprise Energy Ireland advised that the diffuser is to be located at KP 71.0, approximately on the 64m contour outside Broadhaven Bay. This revised position is approximately 220m further offshore than the position investigated for this addendum report. Given the minimal differences in impact associated with moving the discharge from the 40m contour to the 60m contour it is considered very unlikely that this further movement would have any significant impact on the results of the dispersion modelling.

5.0 REFERENCES

1. Kirk McClure Morton, 2001. Corrib Field Development Project, Dispersion Modelling Study – Broadhaven Bay. A report for Enterprise Energy Ireland Ltd.

2. UK Hydrographic Office. Irish Coast Pilot.