B.6 Relevant Sanitary Authority

There will be no discharges to the local authority sewer from the development.

B.7 Relevant Health Board Region

Information relating to the relevant Health Board is included in the main application form.

B.8 Site Notice, Newspaper Advertisement and Planning Authority Notice

A site notice, containing the following text was erected on 06th May 2010, the location of which is shown on Figure B.8.1.

APPLICATION TO THE ENVIRONMENTAL PROTECTION AGENCY FOR A LICENCE

Endesa Ireland Limited, 3 Grand Canal Plaza, 5th Floor, Grand Canal Street Upper, Dublin 4, intends to apply to the Environmental Protection Agency for a review of the existing Integrated Pollution Prevention and Control (IPPC) Licence (Registration Number P0606-02) for Great Island Power Plant, Co. Wexford.

The Class of Activity, under the First Schedule of the Protection of the EPA Acts 1992-2007, is as follows:

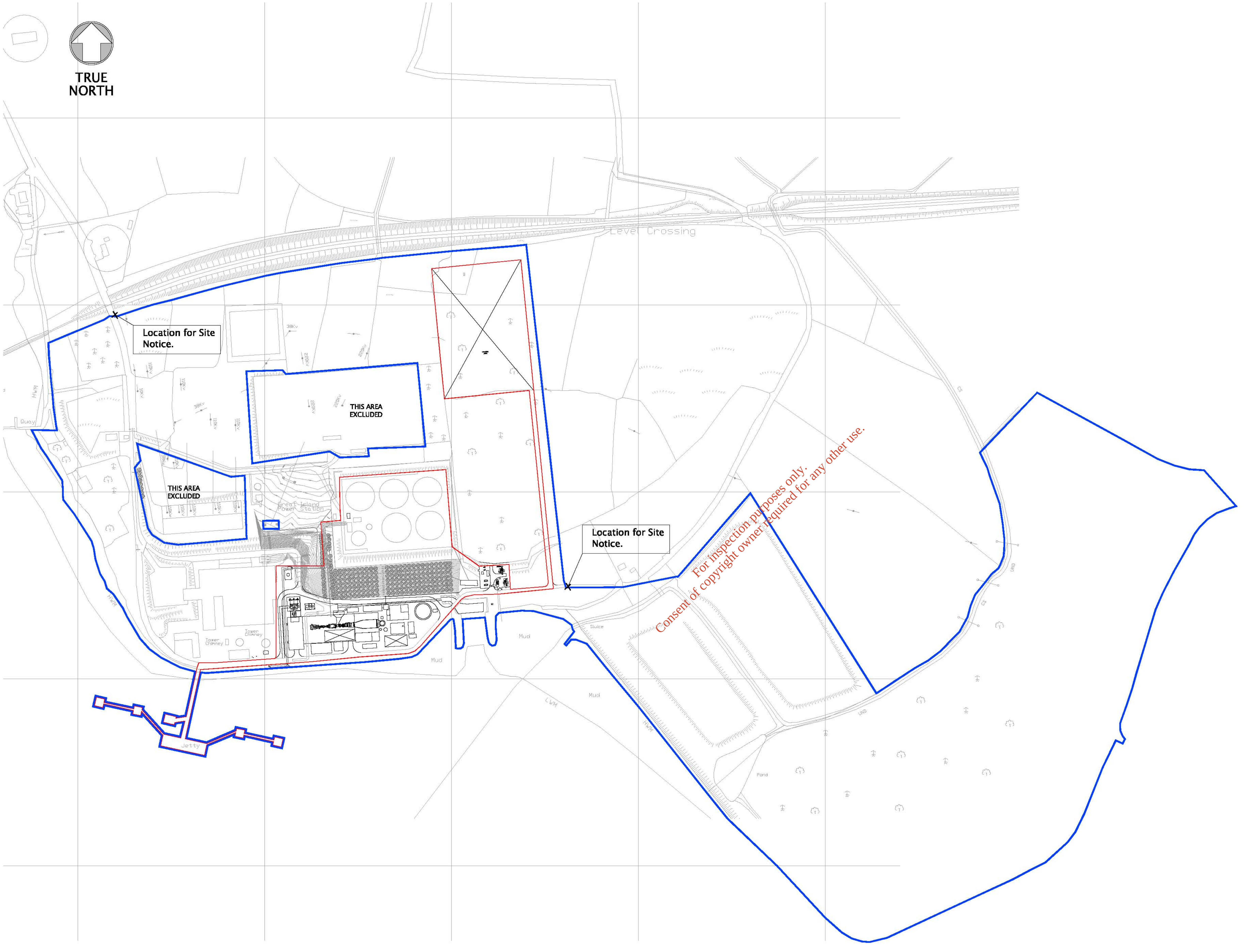
Class 2.1: The operation of combustion installations with a rated thermal input equal to or greater than 50 MW

The application relates to a proposed 430 MW Combined Cycle Gas Turbine Power Plant at Great Island, Co. Wexford – National Grid Reference E 268 907, N 114 574.

The application is accompanied by an Environmental Impact Statement (EIS), which was previously submitted to the planning authority as part of the planning application. The EIS, and any further information relating to the effects on the environment of the emissions from the activity, which may be furnished to the Agency in the course of the Agency's consideration of the application, will be available at the headquarters of the Agency. Copies of the EIS were previously submitted to An Bord Pleanála and Wexford County Council as part of the planning application.

A copy of the application for the licence may be inspected at, or obtained from, the headquarters of the Agency, at Johnstown Castle Estate, Co. Wexford, as soon as is practicable after the receipt by the Agency of the application for the licence.

Notification of the intention to apply for an IPPC licence has been provided to An Bord Pleanala and Wexford County Council. Copies of these notices, in addition to local and national newspaper notices are provided hereunder.



Notes

1. ORDNANCE SURVEY IRELAND LICENCE NO. EN0034509
© ORDNANCE SURVEY IRELAND/GOVERNMENT OF IRELAND
2. ALL CO-ORDINATES SHOWN RELATE TO IRISH NATIONAL GRID CO-ORDINATES.
3. ALL SITE LEVELS REFER TO MEAN SEA LEVEL VERTICAL DATUM AT POOLBEG.
4. GENERAL SITE LEVEL IS +7.00M O.D.

Legend:

Site Boundary

Property Boundary

0 125m 250m

1:2500

Rev	Date	Drawn	Description	Ch'k'd	App'd
P1	07/05/10	CC	Issued for IPPCL	DC	DMc

Mott MacDonald

Mott MacDonald Ireland Ltd.
South Block, Rockfield,
Dundrum, Dublin 16,
Ireland
Tel +353 (1) 291 6700
Fax +353 (1) 291 6747
Web www.mottmac.com

Client

endesa ireland

Endesa Ireland Ltd.
5th Floor,
3 Grand Canal Plaza,
Grand Canal Street Upper,
Dublin 4,
Ireland
Tel +353 (1) 552 8300
Fax +353 (1) 552 8301

Title

Combined Cycle Gas Turbine
Great Island, Co. Wexford

Site Notice

Designed	D. McRandal	Eng.Chk.	D. Carr
Drawn	C. Cunningham	Coordination	D. McRandal
Dwg.Chk.	C. Cunningham	Approved	D. McRandal

Scale 1:2500 | Project 257554 | CAD file Figure B.8.1 | Status APR

Drawing No Figure B.8.1 | Rev P1

endesa ireland

Kieran Somers,
An Bord Pleanála,
64 Marlborough Street,
Dublin 1.

30th April 2010

Dear Mr Somers,

Application to the Environmental Protection Agency for a Licence Review

Endesa Ireland Limited, 3 Grand Canal Plaza, 5th Floor, Grand Canal Street Upper, Dublin 4, intends to apply to the Environmental Protection Agency for a review of the existing Integrated Pollution Prevention and Control (IPPC) Licence (Registration Number P0606-02) for Great Island Power Plant, Co. Wexford.

The Class of Activity, under the First Schedule of the EPA Acts 1992-2007, is as follows:

Class 2.1: The operation of combustion installations with a rated thermal input equal to or greater than 50 MW

The application relates to a 430 MW Combined Cycle Gas Turbine Power Plant at Great Island, Co. Wexford – National Grid Reference E 268 907, N 114 574.

The application is accompanied by an Environmental Impact Statement (EIS), which was previously submitted to the planning authority as part of the planning application. The EIS, and any further information relating to the effects on the environment of the emissions from the activity, which may be furnished to the Agency in the course of the Agency's consideration of the application, will be available at the headquarters of the Agency. Copies of the EIS were previously submitted to An Bord Pleanála and Wexford County Council as part of the planning application.

A copy of the application for the licence may be inspected at, or obtained from, the headquarters of the Agency, at Johnstown Castle Estate, Co. Wexford, as soon as is practicable after the receipt by the Agency of the Application for the licence.

Endesa Ireland Ltd. 3 Grand Canal Plaza, 5th Floor, Grand Canal Street Upper, Dublin 4, Ireland Registered Office
Tel: +353 (0)1 522 8300 Fax: +353 (0)1 522 8301 Email: info@endesaireland.ie

It is anticipated that the IPPC licence application will be submitted to the Environmental Protection Agency on Friday May 7th, 2010. Notice of the application will be published in the Waterford News and Star on Tuesday May 4th, the New Ross Echo on Wednesday May 5th and The Irish Times on Tuesday May 4th. A site notice will be erected at the entrance to the facility on Thursday May 6th.

A copy of the application for the licence may be inspected at, or obtained from, the headquarters of the Agency, at Johnstown Castle Estate, Co. Wexford, as soon as is practicable after the receipt by the Agency of the Application for the licence.

Yours Sincerely,

Peter Gavican
Endesa Ireland Limited

endesa ireland

Eamonn Hore,
Director of Services,
Wexford County Council,
County Hall,
Spawell Road,
Wexford.

30th April 2010

Dear Mr Hore,

Application to the Environmental Protection Agency for a Licence Review

Endesa Ireland Limited, 3 Grand Canal Plaza, 5th Floor, Grand Canal Street Upper, Dublin 4, intends to apply to the Environmental Protection Agency for a review of the existing Integrated Pollution Prevention and Control (IPPC) Licence (Registration Number P0606-02) for Great Island Power Plant, Co. Wexford.

The Class of Activity, under the First Schedule of the EPA Acts 1992-2007, is as follows:

Class 2.1: The operation of combustion installations with a rated thermal input equal to or greater than 50 MW

The application relates to a 430 MW Combined Cycle Gas Turbine Power Plant at Great Island, Co. Wexford – National Grid Reference E 268 907, N 114 574.

The application is accompanied by an Environmental Impact Statement (EIS), which was previously submitted to the planning authority as part of the planning application. The EIS, and any further information relating to the effects on the environment of the emissions from the activity, which may be furnished to the Agency in the course of the Agency's consideration of the application, will be available at the headquarters of the Agency. Copies of the EIS were previously submitted to An Bord Pleanála and Wexford County Council as part of the planning application.

A copy of the application for the licence may be inspected at, or obtained from, the headquarters of the Agency, at Johnstown Castle Estate, Co. Wexford, as soon as is practicable after the receipt by the Agency of the Application for the licence.

Endesa Ireland Ltd. 3 Grand Canal Plaza, 5th Floor, Grand Canal Street Upper, Dublin 4, Ireland (Registered Office)
Tel +353 (0)1 522 8300 Fax +353 (0)1 522 8301 Email info@endesaireland.ie

It is anticipated that the IPPC licence application will be submitted to the Environmental Protection Agency on Friday May 7th, 2010. Notice of the application will be published in the Waterford News and Star on Tuesday May 4th, the New Ross Echo on Wednesday May 5th and The Irish Times on Tuesday May 4th. A site notice will be erected at the entrance to the facility on Thursday May 6th.

A copy of the application for the licence may be inspected at, or obtained from, the headquarters of the Agency, at Johnstown Castle Estate, Co. Wexford, as soon as is practicable after the receipt by the Agency of the Application for the licence.

Yours Sincerely,

Peter Gavican
Endesa Ireland Limited

Radio

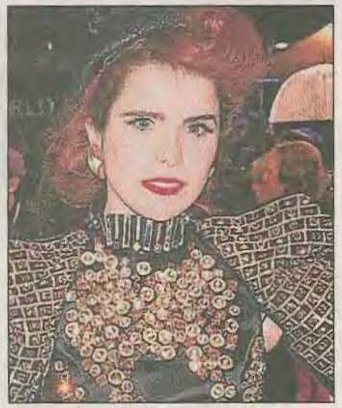
RTÉ Radio 1
FM: 88.2-90.0; 95.2 mHz, LW: 252 kHz. News on the hour. **5.30am** Risin' Time. **7.00** Morning Ireland. **9.00** The Tubridy Show. **10.00** Today with Pat Kenny. Followed by The Angelus. **12.00** The Ronan Collins Show. **1.00** News. **1.45** Liveline. **3.00** Mooney. **4.30** Drive-time. With Mary Wilson. **7.00** Sport at 7. Sporting news, comment and analysis, presented by Darragh Maloney. **7.30** Arena. A look at the latest news from the world of arts and entertainment, presented by Seán Rocks. **8.30** The John Creedon Show. A blend of contemporary, Irish and international music for the evening. **9.50** Nuacht. **10.00** The Late Debate. **11.00** News; Sport News. **11.15** The Book on One. *Fear and Loathing in Dublin*, by Aodhan Madden. **11.25** Late Date. A musical end to the day presented by Alf McCarthy. **2.00** Through the Night; The Tubridy Show. **2.30** Today with Pat Kenny. **3.30** Liveline. **4.00** Arts Tonight.

RTÉ 2FM
FM: 90.4-92.2; 97.0 mHz. **6.00am** The Colm and Jim-Jim Breakfast Show. **9.00** The Gerry Ryan Show. **12.00** Rick O'Shea. **3.00** Larry Gogan's Golden Hour. **4.00** The Will Leahy Show. **7.00** Dave Fanning. **9.00** Dan Hegarty. **11.00** Damian Farrelly. **1.00** 2fm Replay.

A concert to mark the 200th anniversary of the birth of Chopin by Garrick Ohlsson – one of the leading interpreters of the composer

Performance on 3, BBC R3, 7pm; and RTÉ Lyric FM, 8.30pm

RTÉ Lyric FM
FM: 96-99 mHz. **6.30am** Liz Nolan's Daybreak. Liz Nolan with music, news, weather and traffic, *Opera Cereal* featuring *The Mikado* by Gilbert and Sullivan, and *Bookmarks in Brief* on Maria Callas. **9.30** Paul Herriott In Tempo. 10.00am CD of the Week: *In the*



Paloma Faith sings some retro-soul from her debut album plus some classics from her idols such as Billie Holiday and Ella Fitzgerald, *Paloma Faith with the Guy Barker Orchestra*, BBC R2, 8pm

The Guy Barker Orchestra. **10.00** Miles Plugs In. **11.00** Angel of Harlem: The Billie Holiday Story. **12.00** Janice Long. **2.00** Tim Smith. **5.00** Sarah Kennedy.

BBC Radio 3
FM: 90.2-92.4 mHz. **7.00am** Breakfast. **10.00** Classical Collection. **12.00** Composer of the Week: Monteverdi to Rossini – Italian Opera. **1.00** Radio 3 Lunchtime Concert. **2.00** Afternoon on 3. **5.00** In Tune. **7.00** Performance on 3. Ian Skelly presents Garrick Ohlsson (piano) in Chopin: *Impromptu in F sharp, Op 36; Fantasy in F minor, Op 49; 2 Nocturnes, Op 27; Scherzo in C sharp minor, Op 39; Preludes, Op 28.* **9.15** Night Waves. **10.00** As noon. **11.00** The Essay. **11.15** Late Junction. **1.00** Through the Night.

BBC Radio 4
FM: 92.4-94.6 mHz, LW: 198 kHz. News on the hour. **6.00am** Today. **9.00** Morecambe and Wise: The Garage Tapes. **9.45** Book of the Week: *Blood Knots*. By Luke Jennings. **10.00** Woman's Hour. **10.45** An Unsuitable Attachment. **11.00** Saving Species. **11.30** Pistols at Dawn.

LEGAL NOTICES

ADVERTISEMENT FOR INCUMBRANCERS

2004 No. 532 SP

BETWEEN :

THE GOVERNOR AND COMPANY OF THE BANK OF IRELAND

Plaintiff

- and -

JAMES L. (OTHERWISE LEO) O'DONNELL

Defendant

Pursuant to an Order of The High Court made in the above-mentioned suit all persons claiming to be incumbrancers affecting the interest of the Defendant in the lands comprised in Folio 6639 of the Register of Freeholders County of Waterford situate in the Townland of Lyre East in the Barony of Coshmore and Coshbride and the County of Waterford are to enter their claims at the Examiner's Office, 2nd Floor, Courts Service Building, Phoenix House, 15-24 Phoenix Street North, Smithfield, Dublin 7 on or before the 4th day of June 2010 at 11.00 a.m. and to prove such claims by Affidavit on or before the same day or in default thereof they will be peremptorily excluded from the benefit of the said Order. Every such incumbrancer holding any security is required to produce the same at the Examiner's Office on the 16th day of June 2010 at 11.00 o'clock in the forenoon being the time appointed for adjudicating on the claims.

Dated the 20th day of April 2010

Signed: T.KINIRONS
ASSISTANT EXAMINER

HARRISON O'DOWD
Solicitors for the Plaintiff,
35 Molesworth Street,
Dublin 2

and

98 Henry Street,
Limerick.

Record No. 2010/203/COS

THE HIGH COURT

In the matter of Discount Electrical Company Limited

And in the matter of the Company's Acts 1963-1990

Mr. Justice

Notice is hereby given that a Petition for the Winding Up of the above named company by the High Court was on the 30th day of March 2010 presented to the High Court by Kitchen Accessories Limited of Gowan Group House, Herbert Avenue, Merrion Road, Dublin 4, a creditor of the said company, and that the said Petition came before Mr. Justice Murphy on the 26th April 2010 when it was adjourned for hearing before the High Court on the 17th of May 2010 and that any creditor or contributory of the said company who wishes to support or oppose the making of an order on the said Petition may appear at the time of the hearing by himself or his Counsel for that purpose and a copy of the Petition will be furnished to any creditor or contributory of the said company who requires it by the undersigned on payment of the regulated charge for the same.

Signed: St John Solicitors
14 City Gate, Lower Bridge Street, Dublin 8
Solicitors for the Petitioner

NOTE — Any person who intends to appear at the hearing of the said Petition must serve on or send by post to the above-named Petitioner or his solicitor, notice in writing of his intention to do so. The Notice must state the name and address of the person or if a firm the name and address of the firm and must be signed by the person or firm, or his or their solicitor (if any) and must be served or, if posted, must be sent by post in sufficient time to reach the above-named solicitor or Petitioner not later than five o'clock in the afternoon of the 16th day of May 2010.

APPLICATION TO THE ENVIRONMENTAL PROTECTION AGENCY FOR A LICENCE

Endesa Ireland Limited, 3 Grand Canal Plaza, 5th Floor, Grand Canal Street Upper, Dublin 4, intends to apply to the Environmental Protection Agency for a review of the existing Integrated Pollution Prevention and Control (IPPC) Licence (Registration Number P0606-02) for Great Island Power Plant, Co. Wexford.

The Class of Activity, under the First Schedule of the EPA Acts 1992 - 2007, is as follows:

Class 2.1: The operation of combustion installations with a rated thermal input equal to or greater than 50 MW

The application relates to a 430 MW Combined Cycle Gas Turbine Power Plant at Great Island, Co. Wexford - National Grid Reference E 268 907, N 114 574.

The application is accompanied by an Environmental Impact Statement (EIS), which was previously submitted to the planning authority as part of the planning application. The EIS, and any further information relating to the effects on the environment of the emissions from the activity, which may be furnished to the Agency in the course of the Agency's consideration of the application, will be available at the headquarters of the Agency. Copies of the EIS were previously submitted to An Bord Pleanála and Wexford County Council as part of the planning application.

A copy of the application for the licence may be inspected at, or obtained from, the headquarters of the Agency, at Johnstown Castle Estate, Co. Wexford, as soon as is practicable after the receipt by the Agency of the Application for the licence.

MOTORS FOR SALE

AUDI

RENT A CAR

DEATHS

BRADLEY (née **McCarthy**) (Monument Road, Menlo and formerly Woodquay, Galway) — May 1, 2010, Peggy dearly beloved wife of Bob and much loved mother of Brenda, Tara, Gillian, Carli, Robert and Peter; sadly missed by her loving husband, daughters and sons, sister Katherine, brothers Jerry and Pat, grandchildren, extended family and friends. Reposing at home today (Tuesday) from 5 p.m. to 7 p.m. Removal tomorrow Wednesday to arrive at St. James Church, Bushypark at 10.30 a.m. Requiem Mass at 11 a.m. Private Cremation to follow. House private Wednesday morning. Family flowers only, donations in memory of Peggy to the Galway Hospice.
"Forever Mam"

CLEARY (née **McCarthy**) **Grainne** (Avoca Hall, Avoca Avenue, Blackrock) — April 30, 2010 (peacefully), at home; she will be sadly missed by her four adoring sons Conor, Thomas, John and Kevin, her daughters-in-law Caroline, Muriel and Triona, her eleven loving grandchildren, extended family, Tom (Snr) and friends. Rest in peace. Removal this (Tuesday) evening, May 4, from Carnegie's Funeral Home, The Crescent, Monkstown to Church of St. Therese, Mount Merrion arriving 6 o'c. Funeral tomorrow (Wednesday) May 5, after 10 o'c. Mass to Mt. Jerome Crematorium.

CURLEY Sr., Dolorosa (LSU) — May 3rd, 2010, (peacefully) at Mont Vista, Retreat Road, Athlone (formerly of Derrylissane, Menlough, Ballinasloe, Co. Galway). Deeply regretted by her loving family, Sister-in-law Bridget, nephews and nieces, community sisters, staff, relatives and friends RIP. Evening prays will be celebrated in the Mont Vista Oratory today (Tuesday) at 6.30 o'c. Funeral Mass tomorrow (Wednesday) at 12 o'c with burial afterwards in Our Ladies Bower Cemetery.

DOHERTY (née **Goodwin**) (Our Lady's Manor, Dalkey, late of Cluny Grove, Killiney and formerly of Tralee, Co. Kerry) — May 1, 2010 (peacefully) at St. Columcille's Hospital, Peggy dearly loved wife of the late Neil, much loved mother of Elaine, mother-in-law of Vincent (Nolan), adored grandmother of David, Gavin, Emma and Ben, loving sister of Eddie and the late P.M. Goodwin; will be very sadly missed by her family, relatives and friends. Funeral today (Tuesday) after 10 o'c. Mass in The Church of Our Lady of Good Counsel, Churchview Road,

JOBS & NOTIC

APPLICATION TO THE ENVIRONMENTAL PROTECTION AGENCY FOR A LICENCE

Endesa Ireland Limited, 3 Grand Canal Plaza, 5th Floor, Grand Canal Street Upper, Dublin 4, intends to apply to the Environmental Protection Agency for a review of the existing Integrated Pollution Prevention and Control (IPPC) Licence (Registration Number P0606-02) for Great Island Power Plant, Co. Wexford.

The Class of Activity, under the First Schedule of the EPA Acts 1992 - 2007, is as follows:

Class 2.1: The operation of combustion installations with a rated thermal input equal to or greater than 50 MW

The application relates to a 430 MW Combined Cycle Gas Turbine Power Plant at Great Island, Co. Wexford – National Grid Reference E 268 907, N 114 574.

The application is accompanied by an Environmental Impact Statement (EIS), which was previously submitted to the planning authority as part of the planning application. The EIS, and any further information relating to the effects on the environment of the emissions from the activity, which may be furnished to the Agency in the course of the Agency's consideration of the application, will be available at the headquarters of the Agency. Copies of the EIS were previously submitted to An Bord Pleanála and Wexford County Council as part of the planning application.

A copy of the application for the licence may be inspected at, or obtained from, the headquarters of the Agency, at Johnstown Castle Estate, Co. Wexford, as soon as is practicable after the receipt by the Agency of the Application for the licence.

PROPOSALS FOR AFFORESTATION IN ENVIRONMENTALLY SENSITIVE AREAS

The following application has been received:

Contract Number:	CN53641	CN53601
County:	WATERFORD	WATERFORD
District Electoral Division:	STRADBALLY	GRANGE
Townland:	NEWTOWN	NEWTOWN
Area (hectares):	11.63	2.52

Submissions from the public may be made, in writing, within 21 days of the publication of this notice. A copy of the application and map of the site are available from Approvals Section, Forest Service, Department of Agriculture, Fisheries and Food, Johnstown Castle Estate, Co. Wexford.

LoCall: 1890 200 223

email: info@agriculture.gov.ie
www.agriculture.gov.ie

Department of Agriculture, Fisheries and Food
An Roinn Talmhaíochta, Iascaigh agus Bia

PLANNING NOTICES

WATERFORD COUNTY COUNCIL

We, Brian Greene and Debbie Grant, of Knockaturnory, Kilmacthomas, Co. Waterford, intend to apply for a retention permission for development at this site at Knockaturnory, Kilmacthomas, Co. Waterford. The development will consist of the retention of the dormer bungalow, septic tank and percolation area, entrance, access road and associated works erected on this site at Knockaturnory, Kilmacthomas, Co. Waterford. Permission was granted on the site under planning file 05/1179, the retention application covers changes in the site layout and to the house plan from that previously granted.

The planning application may be inspected or purchased at a fee not exceeding the reasonable cost of making a copy at the offices of the planning authority, Civic Offices, Dungarvan, Co. Waterford, during normal opening hours, i.e., 10am to 1pm and 2pm to 4pm Monday to Friday (excluding bank holidays). A submission or observation in relation to the application may be made in writing to the planning authority on payment of a fee of €20 within the period of 5 weeks beginning on the date of receipt by the planning authority of this application. Signed: Brian Greene and Debbie Grant.

WATERFORD COUNTY COUNCIL

We, Tony and Averil Shanahan, hereby wish to give notice of our intention to apply to Waterford Co. Council for planning permission to construct a matching extension consisting of conservatory and F/F bedroom to the rear of our existing cottage and replace existing flat roof with pitched roof at Westtown, Tramore, Co. Waterford. The planning application may be inspected, or purchased at a fee not exceeding the reasonable cost of making a copy, at the offices of the Planning Authority, Civic Offices, Dungarvan, Co. Waterford, during its public opening hours and that a submission or observation in relation to the application may be made to the authority in writing on payment of the prescribed fee (€20) within the period of 5 weeks beginning on the date of receipt by the authority of the application.

publicnotices

APPLICATION TO THE ENVIRONMENTAL PROTECTION AGENCY FOR A LICENCE

Endesa Ireland Limited, 3 Grand Canal Plaza, 5th Floor, Grand Canal Street Upper, Dublin 4, intends to apply to the Environmental Protection Agency for a review of the existing Integrated Pollution Prevention and Control (IPPC) Licence (Registration Number P0606-02) for Great Island Power Plant, Co. Wexford.

The Class of Activity, under the First Schedule of the EPA Acts 1992 - 2007, is as follows:

Class 2.1: The operation of combustion installations with a rated thermal input equal to or greater than 50 MW

The application relates to a 430 MW Combined Cycle Gas Turbine Power Plant at Great Island, Co. Wexford – National Grid Reference E 268 907, N 114 574.

The application is accompanied by an Environmental Impact Statement (EIS), which was previously submitted to the planning authority as part of the planning application. The EIS, and any further information relating to the effects on the environment of the emissions from the activity, which may be furnished to the Agency in the course of the Agency's consideration of the application, will be available at the headquarters of the Agency. Copies of the EIS were previously submitted to An Bord Pleanála and Wexford County Council as part of the planning application.

A copy of the application for the licence may be inspected at, or obtained from, the headquarters of the Agency at Johnstown Castle Estate, Co. Wexford, as soon as is practicable after the receipt by the Agency of the Application for the licence.

THE DISTRICT COURT

DISTRICT COURT AREA OF WEXFORD DISTRICT NO 23 IN THE MATTER OF THE AUCTIONEERS & HOUSE AGENTS ACT, 1947-67

NOTICE OF APPLICATION TO THE DISTRICT COURT FOR A CERTIFICATE OF QUALIFICATION TO HOLD AN AUCTIONEERS LICENCE

TAKE NOTICE that an application will be made to the District Court at Wexford on 14th June 2010 at 10.30 a.m. on behalf of Adrian Haythornthwaite trading as Sherry Fitzgerald Haythornthwaite having his office at 1, Westgate, Wexford pursuant to the above Acts, for a Certificate of Qualification to hold an Auctioneer's Licence.

Dated the 27th April 2010

SIGNED:
Ensor O'Connor,
Solicitors,
4, Court Street,
Enniscorthy.

THE DISTRICT COURT

DISTRICT COURT AREA OF ENNISCORTHY DISTRICT NO 23 IN THE MATTER OF THE AUCTIONEERS & HOUSE AGENTS ACT, 1947-67

NOTICE OF APPLICATION TO THE DISTRICT COURT FOR A CERTIFICATE OF QUALIFICATION TO HOLD AN AUCTIONEERS LICENCE

TAKE NOTICE That an application will be made to the District Court at Enniscorthy on 16th June at 10.30 a.m. on behalf of McGuinness Lambert Limited having its registered office at Portsmouth House, Templeshannon Quay, Enniscorthy, County Wexford and trading under the name of Property Partners McGuinness Lambert having it's office at Portsmouth House, Templeshannon Quay, Enniscorthy, County Wexford pursuant to the above Acts, for a Certificate of Qualification to hold an Auctioneer's Licence.

Dated the 27th April 2010

SIGNED:

THE DISTRICT COURT

DISTRICT COURT AREA OF ENNISCORTHY DISTRICT NO 23 IN THE MATTER OF THE AUCTIONEERS & HOUSE AGENTS ACT, 1947-67

NOTICE OF APPLICATION TO THE DISTRICT COURT FOR A CERTIFICATE OF QUALIFICATION TO HOLD AN AUCTIONEERS LICENCE

TAKE NOTICE That an application will be made to Enniscorthy District Court on 16th June 2010 at 10.30 a.m. on behalf of Michael Jordan of Kilcullen, Enniscorthy, County Wexford trading under the name of Michael Jordan having his office at Kilcullen, Enniscorthy, County Wexford pursuant to the above Acts, for a Certificate of Qualification to hold an Auctioneer's Licence.

Dated the 27th day of April 2010

SIGNED:
Ensor O'Connor,
Solicitors,

THE DISTRICT COURT

DISTRICT COURT AREA OF ENNISCORTHY DISTRICT NO 23 IN THE MATTER OF THE AUCTIONEERS & HOUSE AGENTS ACT, 1947-67

NOTICE OF APPLICATION TO THE DISTRICT COURT FOR A CERTIFICATE OF QUALIFICATION TO HOLD AN AUCTIONEERS LICENCE

AIDAN LEACY TRADING AS PHOENIX ESTATES

TAKE NOTICE That an application will be made to the District Court at Enniscorthy on 16th June 2010 at 10.30 a.m. on behalf of Aidan Leacy of Dunganstown, New Ross, County Wexford carrying on business under the name of Phoenix Estates having it's principal office at 32, Slaney Street, Enniscorthy, County Wexford pursuant to the above Acts, for a Certificate of Qualification to hold an Auctioneer's Licence.

Dated the 27th day of April 2010

SIGNED:

AN CHUIRT DUICHE THE DISTRICT COURT

DISTRICT COURT AREA OF GOREY DISTRICT NO. 23

IN THE MATTER OF THE AUCTIONEERS & HOUSE AGENTS ACT, 1947-67

NOTICE OF APPLICATION TO THE DISTRICT COURT FOR A CERTIFICATE OF QUALIFICATION TO HOLD AN AUCTIONEERS LICENCE

TAKE NOTICE that an application will be made to the District Court at Gorey at 10.30 a.m. on the 10th June 2010 on behalf of **BEN KAVANAGH AUCTIONEERS LIMITED** having it's registered office at Kilmurray, Gorey in the County of Wexford trading at Kilmurray, Gorey, County Wexford pursuant to the above Acts, for a Certificate of Qualification to hold an Auctioneer's Licence.

Dated the 27th April 2010

Signed:
Ensor O'Connor

B.9 Seveso II Regulations

The facility is considered to be a lower tier Seveso site in accordance with the *European Communities (Control of Major Accident Hazards Involving Dangerous Substances Regulations 2006 (SI No 74 of 2006)* due to the quantity of distillate oil proposed to be stored on site (approximately 11,000 m^3).

A copy of the Quantitative Risk Assessment (QRA) report, submitted to the Health and Safety Authority (HSA) as part of the planning application is included over leaf.

Our Ref: 26.PA0016

Your Ref: 25755400009N

An Bord Pleanála

64 Sráid Maoilbhríde,
Baile Átha Cliath 1.

Tel: (01) 858 8100
LoCall: 1890 275 175
Fax: (01) 872 2684
Web.http//www.pleanala.ie
email:bord@pleanala.ie

64 Marlborough Street,
Dublin 1.

Mott MacDonald Ireland
South Block
Rockfield
Dundrum
Dublin 16

26th January 2010

Re: Construction Of A 430 MW Natural Gas Fired Combined Cycle Gas Turbine (CCGT) Power Plant At Great Island, Co. Wexford.

Dear Sir/Madam,

Enclosed for your information is a copy of a submission received by the Board in relation to the above mentioned proposed development.

If you have any queries in relation to the matter please contact the undersigned officer of the Board.

Please quote the above mentioned An Bord Pleanála reference number in any correspondence or telephone contact with the Board.

Yours faithfully,

Kieran Somers
Executive Officer
Encls.

PA08.LTR

HEALTH AND SAFETY AUTHORITY

Cork Regional Office, 3rd Floor, 1A, South Mall, Cork

Kieran Somers

An Bord Pleanala

64 Marlborough St

Dublin 1

Our Ref: 17288

25th January, 2010

Re: Proposed Strategic Infrastructure Development [ref. 26.PA0016] by Endessa Ireland Ltd., at Great Island, Co Wexford, & your letter of the 11th December 2009

Dear Kieran,

The approach of the Authority to Land-use Planning is set out in the document 'Policy & Approach of the Health and Safety Authority to COMAH Risk-based land-use Planning (07 September 2009)'. It is available from our website at

http://www.hsa.ie/eng/Sectors/Control_of_Major_Accident_Hazards/Land_Use_Planning/.

The document should be consulted to fully understand the advice given in this letter.

In that context, and the Health and Safety Authority remit, in respect of this specific application the following points are relevant:

1. The application is covered by Regulation 27(1) of SI 74 of 2006
2. The development constitutes a new establishment (Reg. 27(1)(a))
3. On the basis of the information supplied, the Authority has determined that the siting criteria for new establishments have been met (see page 5, section 1.2 of above referenced Policy & Approach document). Accordingly the Authority **DOES NOT ADVISE AGAINST** the granting of planning permission in the context of major accident hazards.

4. Your attention is brought to the final sentence of section 1.2 of the Policy & Approach document: *The Authority will bring to the attention of the Planning Authority the need to consult with the local authority emergency services on any potential impact on local access/egress arrangements in the context of public behaviour in the event of an emergency and access for emergency services.*
5. Although our LUP advice is risk-based, it is the policy of the Authority to advise planning bodies of the consequences of worst case major accidents, so that they may take account of this information in their decision making. Although the risks are considered sufficiently low, there is the possibility of a major accident to the marine environment from a catastrophic failure of a storage tank. Even less likely is the possibility of a fire in the bund resulting from serious tank failure.
6. The advice given is only applicable to the specific circumstances of this proposal at this period of time. The assessment submitted, which formed the basis of the Authority's advice, specifies the particular dangerous substances and storage quantities that will be stored in the various tanks at this location. Changes to those substances or their location could alter that advice. You are asked to consider this in relation to any conditions you may wish to impose should you decide to grant planning permission.

If you have any queries please contact the undersigned.

Yours sincerely

Patrick Conneely

Inspector, Process Industries Unit

Encl: Note on the Approach of the HSA to the Provision of Land-use Planning Advice

HEALTH AND SAFETY AUTHORITY

Note on the Approach of the HSA to the Provision of Land-use Planning advice.

The Authority, acting as the Central Competent Authority under the EC (Control of Major Accident Hazards involving Dangerous Substances) Regulations, 2006 (SI 74 of 2006), gives technical advice to the planning authority when requested, under regulation 27(1) in relation to

(a) the siting of new establishments,

(b) modifications to an existing establishment to which Article 10 of the Directive applies, or

(c) proposed development in the vicinity of an existing establishment

The advice given is for the purposes of assessing new development only. A full explanation of the Authority's Land use Planning advice system can be found at http://www.hsa.ie/eng/Sectors/Control_of_Major_Accident_Hazards/Land_Use_Planning/.

Your attention is drawn to Article 12 of the EU Directive 96/82/EC (as amended by Directive 2003/105/EC):

'Member States shall ensure that their land-use and/or other relevant policies and the procedures for implementing those policies take account of the need, in the long term, to maintain appropriate distances between establishments covered by this Directive and residential areas,buildings and areas of public use, major transport routes as far as possible, recreational areas and areas of particular natural sensitivity or interest, and, in the case of existing establishments, of the need for additional technical measures in accordance with Article 5 so as not to increase the risks to people.'

and to the Major Accident Hazard Bureau/ Joint Research Centre of the European Commission guidance[1] in this area:

[1] Land-use Planning Guidelines in the context of Directives 96/82/EC and 105/2003/EC (Seveso II) JRC 2008, ISBN 978-92-79-09182-7

From the text of the Directives the following conclusions may be drawn with regards to the overall land use (or spatial) planning system:

- The requirement of Article 12 is a specific one within the general objectives of planning.
- The requirement may be fulfilled by means of planning and/or technical solutions.
- It is a mandatory requirement, which means it cannot be "overruled" by other factors of consideration.
- It applies only for cases of future development (new sites, modifications or new developments in the vicinity) → Article 12 therefore does not apply retrospectively.

In giving its advice the Authority does not deal with routine emissions. It is the understanding of the Authority that such emissions will be subject to EPA or Local Authority scrutiny and control.

The operator of an establishment covered by S.I. 74 of 2006 is also required to take all necessary measures -

(a) to prevent major accidents occurring, and

(b) to limit the consequences of any such major accidents for man and the environment.

Quantitative Risk Assessment – Land Use Planning Report CCGT Power Plant Great Island

Client: Endesa Ireland Limited

November 2009

Delivering sustainable solutions in a more competitive world

ERM

Endesa Ireland Limited

Quantitative Risk Assessment – Land Use Planning Report CCGT Power Plant Great Island

November 2009

0100952

Prepared by: Tony Clark and Gareth Roberts

For and on behalf of
Environmental Resources Management

Approved by: Kevin Kinsella

Signed: 

Position: Partner

Date: 19th November 2009

CONTENTS

1 INTRODUCTION

1.1 PROJECT BACKGROUND

Endesa Ireland Limited (Endesa) plans to construct and operate a gas fired power station on the site of the existing Great Island heavy fuel oil (HFO) power station on the confluence of the River Suir and River Barrow in County Wexford, Ireland.

The Irish health and safety regulator, the Health and Safety Authority (HSA), requests that operators applying for planning permission for new major hazard facilities submit a quantitative risk assessment (QRA) report with their planning application. The QRA report assists the HSA in coming to an informed view on the safety implications of the proposed facility with respect to land use planning in the vicinity of the establishment. In addition to safety risks, the HSA must also make a judgement on the risk of major accidents to the environment (MATTEs).

In order to provide a comprehensive set of risk results, the above ground installation (AGI) associated with the connection between the power plant and the incoming pipeline (provided by Bord Gais) have also been addressed in the study.

The general QRA methodology used for this study is consistent with the approach used by the HSA [1]. In addition, guidance documents produced by the UK Health and Safety Executive have also been used as the basis for the methodology [2].

In order to make the necessary comparisons with risk criteria (see *Section 5*), the scope of the QRA was to generate the following risk outputs:

- Individual risk of fatality contours;
- The individual risk of fatality at the nearest residential property; and,
- The societal risk of fatality for the workforce and people off-site in the vicinity of the installation.

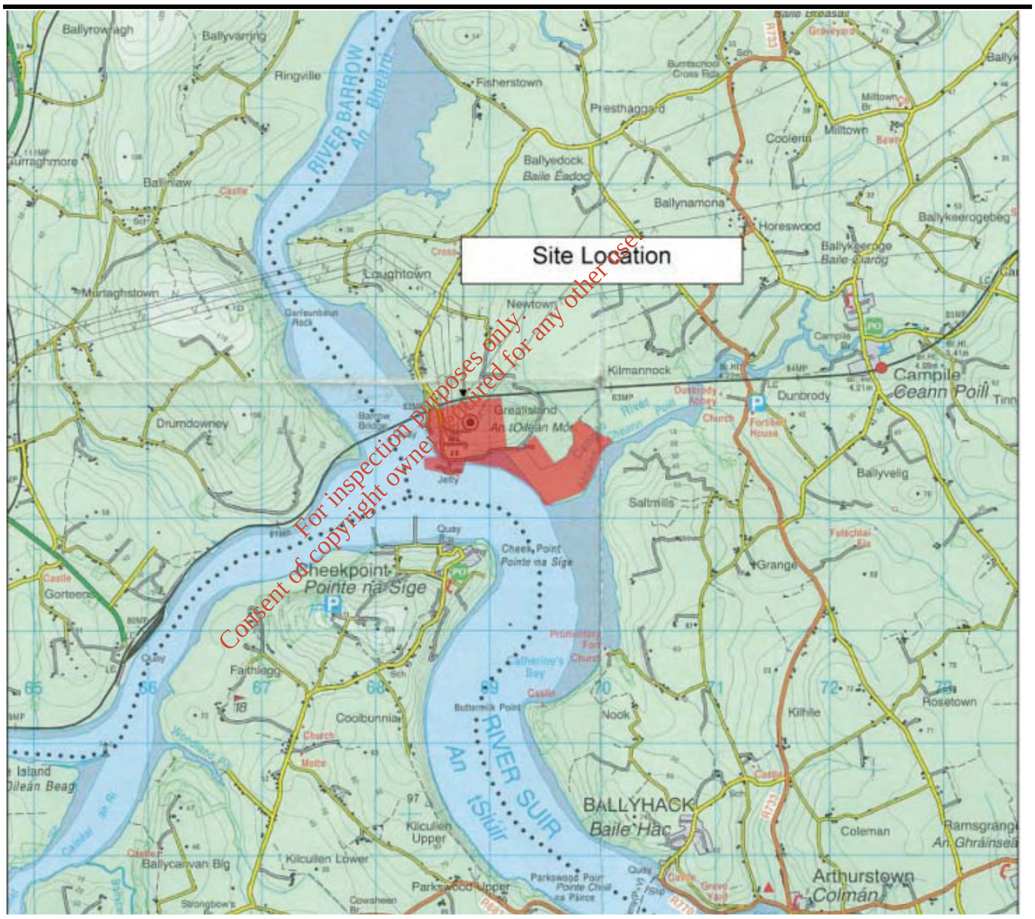
1.2 LOCATION AND SURROUNDINGS

The Great Island site is an existing power generating plant located on a 68 hectare site at the confluence of the River Suir and River Barrow, on the shores of Waterford Harbour. The nearest area of settlement is at Cheekpoint on the opposite side of the estuary, in County Waterford, which is approximately 1 km from the site of the proposed power plant. The nearest house is 100m from the main gate. There is also a hamlet in Newtown, which is 200m from the northern site boundary, which comprises 8 to 10 houses. The village of Campile is located approximately seven kilometres away (*see Figure 1.1*).

The surrounding area is predominantly agricultural. A railway track and some agricultural lands are located to the north of the site. To the south is the River Suir estuary. More agricultural lands are located to the east. The River Barrow flows along the western boundary of the site.

The River Barrow and the River Suir, as well as the neighbouring estuary, are designated as Special Areas of Conservation (SAC) under the European Directive on the Conservation of Natural Habitats and Wild Flora and Fauna (92/43/EEC), otherwise known as the Habitats Directive.

Figure 1.1 Site Location



Reproduced under OSI Licence No. 0006608

The power generation buildings and infrastructure ("Station Grounds") comprise a series of tiered benches cut into the bedrock, which step down towards the River Suir estuary (*see Figure 1.1*). A former waste disposal area with two rectangular shaped cells is located to the east of the Station Grounds. It is not intended to construct in the aforementioned waste disposal area, which will remain intact throughout the construction and operational phases. There is a heavily vegetated undeveloped area known as the Wetlands beyond the former waste disposal area.

1.3 *OUTLINE OF THE PROPOSED DEVELOPMENT*

1.3.1 *Overview*

The existing plant comprises three generation units with a total electricity generation capacity of 240 MW, (two 60 MW units and one 120 MW unit). Heavy Fuel Oil (HFO) is the main fuel and distillate oil is used for start-up. The HFO is shipped to the site and stored in an oil tank farm. Distillate oil, also stored on site, is tankered to site by road.

Great Island Power Plant currently operates on Heavy Fuel Oil (HFO) with a maximum electrical export capacity of 216 MW. All of these units are at the end of their life span.

Endesa proposes to construct a new Combined Cycle Gas Turbine (CCGT) power plant at Great Island. The new CCGT power plant will use the best available technology to generate approximately 430 MW of electricity at an efficiency of circa 58%. The new CCGT plant will operate on natural gas with a back-up supply of distillate oil. It is anticipated that the introduction of the new technology will bring substantial improvement in relation to effects on the environment.

It is intended that the new CCGT power plant will be commissioned in 2012. The new CCGT will be constructed while the existing units are still in service whilst maintaining the highest safety standards. The existing oil fired power plant will continue to operate until the new plant is operational. Once the CCGT plant becomes operational the existing units will be decommissioned.

1.3.2 *Combined Cycle Power Plant*

Endesa intends to develop a circa 430 MW Combined Cycle Gas Turbine (CCGT) power plant at Great Island, County Wexford.

The proposed process of operation is summarised in the following paragraphs and illustrated in *Figure 1.2*.

A 'Combined Cycle' plant combines the technologies of gas turbines and steam turbines in order to produce electricity more efficiently than can be produced using either of these technologies separately.

The gas turbine consists of a compressor section, a combustion chamber and a turbine section. Air is drawn in through an intake filter, compressed and fed into the combustion chamber where fuel is injected and ignited. The resulting hot combustion gases pass through the turbine which rotates the shaft that drives the electrical generator to produce electrical energy.

The high temperature exhaust gases exiting the gas turbine will pass through a Heat Recovery Steam Generator (HRSG) which is used to produce steam from high purity water. Any hot gases remaining from the process will be emitted to atmosphere via an exhaust gas stack.

The steam generated in the HRSG is passed through a steam turbine which converts the thermal energy in the hot steam to mechanical energy which is then used to drive an electrical generator which produces electrical energy. The exhaust steam from the steam turbine will be condensed back to water by cooling it with seawater in a condenser. This condensed water will then be fed back into the HRSG so that the process can start again.

The CCGT power plant proposed for Great Island will be arranged in a "single-shaft" arrangement which means that the gas turbine and steam turbine will be installed in a straight line with a common electrical generator located between each turbine.

The new power plant will use the most up to date technology and it is intended that it will operate as a 'base-load' plant with an efficiency of approximately 58%.

The plant will be designed to operate primarily on natural gas supplied from the Bord Gáis Networks' grid. A new natural gas pipeline will be required to bring natural gas to the power plant and this will be constructed and operated by Bord Gáis Networks/Gaslink.

The power plant will also include back up storage of distillate oil which will allow the plant to operate for five days in case of an unlikely interruption to the gas supply. This is in accordance with the Commission for Energy Regulation (CER) requirements presented in CER Decision Paper *CER/09/001, Secondary Fuel Obligations on Licensed Generation Capacity in the Republic of Ireland, January 2009*.

The electrical power generated will be exported from the power plant via the existing 220 kV substation located at the Great Island site.

Cooling water (CW) will be required for the new power plant to absorb heat from the steam turbine condenser and other heat exchangers associated with the proposed CCGT power plant. It is intended to continue to abstract seawater from the River Suir for this purpose, in accordance with current operations, utilising the existing water intake, supply and outfall systems. A seawater CW system has been continuously in operation at the site since the late 1960's. It is anticipated that the existing CW system will continue to be used so that no new construction in the River Suir environment will be required. It is also anticipated that, when fully commissioned, the volume of aqueous discharges from the proposed CCGT plant will be considerably less than the existing licensed discharges. Consequently, the discharge flow rate, and subsequent area of heat dissipation in the receiving waters, are predicted to be significantly less. In addition, it is anticipated that the volume of cooling water required to operate, at full capacity, for the proposed CCGT will be significantly less than that required for the existing units.

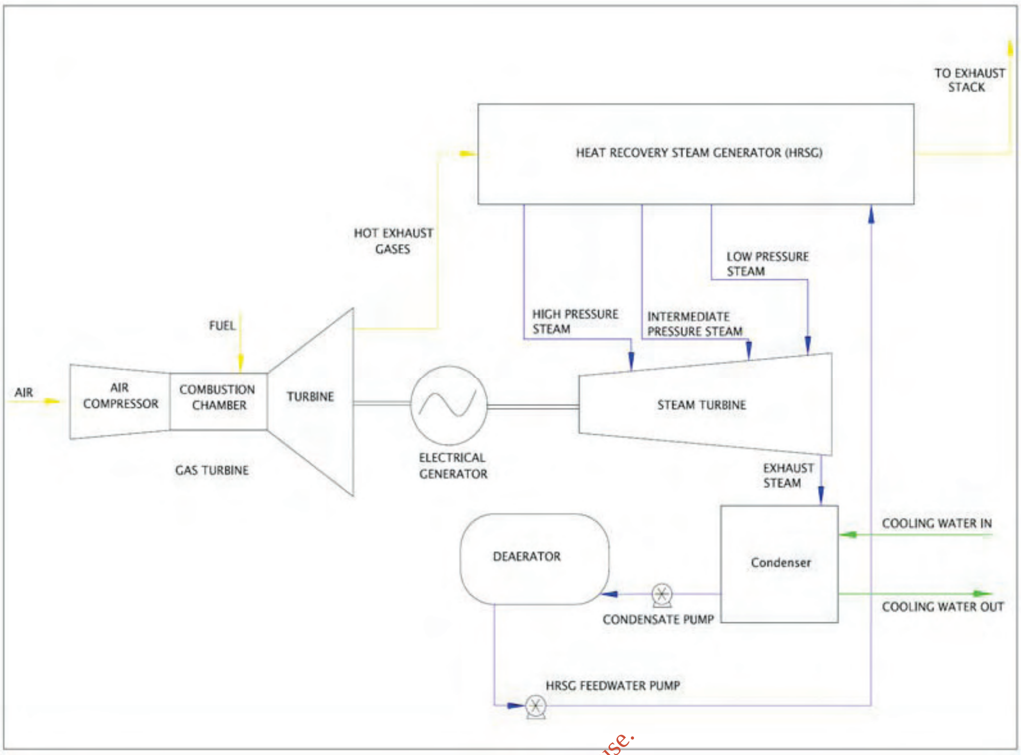
As well as the main power train items (Gas Turbine, Steam Turbine, HRSG and Generator) there will be a number of auxiliary systems required to operate the plant including:

- Water treatment plant
- Water storage facilities
- Distillate oil system and storage facilities
- Fuel gas system / Above Ground Installation (AGI)
- Fire protection system
- Compressed air system
- HRSG chemical dosing system
- Exhaust Stack
- Auxiliary boiler (if required)
- Transformers
- Electrical switchgear
- Electrical cabling
- Drainage system
- Foul water treatment system
- Building structures to house the main power train items
- Workshop / stores building
- Internal roads and parking

It is intended to utilise as much of the existing power plant infrastructure as possible including:

- Fuel storage tanks
- Cooling Water pumphouse, inlet and outfall
- Administration / Control Building
- Workshop and Stores
- Fire pumphouse building
- Surface water drains
- Roads and fencing
- 220 KV station
- Raw Water/Fire Water Storage

Figure 1.2 Single Shaft CCGT Cycle Flow Schematic



1.3.3 *Incoming Gas Pipeline*

The incoming gas pipeline to the Great Island site will be owned and operated by Bord Gáis and will be connected to the site boundary AGI, which will also be Bord Gáis' responsibility. The gas supplied to the AGI will normally be at a pressure of 40 barg, but can be as high as 70 barg. The pipeline diameter is yet to be confirmed, but is expected to be 150mm. The gas pressure will on occasion fall below this value, but will not be less than a guaranteed value of 19 barg. The operating pressure of the gas at the outlet from the AGI will be selected to suit the requirements of the gas turbine, but will not be more than 50 barg.

At times when the incoming gas pressure to the AGI is below the pressure required by the gas turbine, the gas will be compressed to the required pressure by compressors located near the gas turbine, before being routed to the combustion chamber of the gas turbine system.

1.3.4 *Above Ground Installation (AGI) and Gas Lines*

The AGI will consist of the final section of the supply pipework, tariff metering, pressure control and a suitable valved connection for the pipeline which will convey gas to the new power plant. Bord Gáis will supply, install, erect and commission the AGI that will be positioned to the north-east of the power plant.

The proposed pipeline connecting the AGI to the gas compressor will be up to 10" (250 mm) in diameter and will be routed east-west from the AGI to the gas compressor. The gas will then be compressed, if required, to 50 barg and routed to the combustion chamber of the gas turbine system.

1.3.5 *Distillate Storage and Containment*

Distillate oil will be the standby fuel for the gas turbine in addition to fuel for the emergency generator set. It is proposed that the middle tank to the north of the storage area will be completely refurbished for the storage of the distillate oil. The inventory of distillate present on site will be 11,000m^3, which is the minimum legal requirement.

1.4 *SEVESO IMPLICATIONS*

The Great Island facility will be a lower tier Seveso site because of the inventory of distillate that will be present. Distillate is a generic name used to describe a complex mixture of hydrocarbons, mainly paraffinic, naphthenic and aromatic in the range C10-C28. Other commonly used names are diesel and gas oil and are listed under petroleum products with respect to the Seveso Directive. The threshold quantity of petroleum products for a lower tier establishment is 2,500 tonnes and 25,000 for top tier.

The requirements for lower tier establishments are summarised as follows (as defined in the HSA's (2007) *A Short Guide to the European Communities (Control of Major Accident Hazards Involving Dangerous Substances) Regulations, 2006. S.I. No. 74 of 2006*):

- notification to the HSA and the local planning authority;
- discharging certain general duties;
- preparation and implementation of a major accident prevention policy;
- action in the event of a major accident; and
- maintaining a register of notifiable incidents.

Figure 1.3 Location of Existing Great Island Power Plant

Figure 1.4 *Existing Facility Layout*

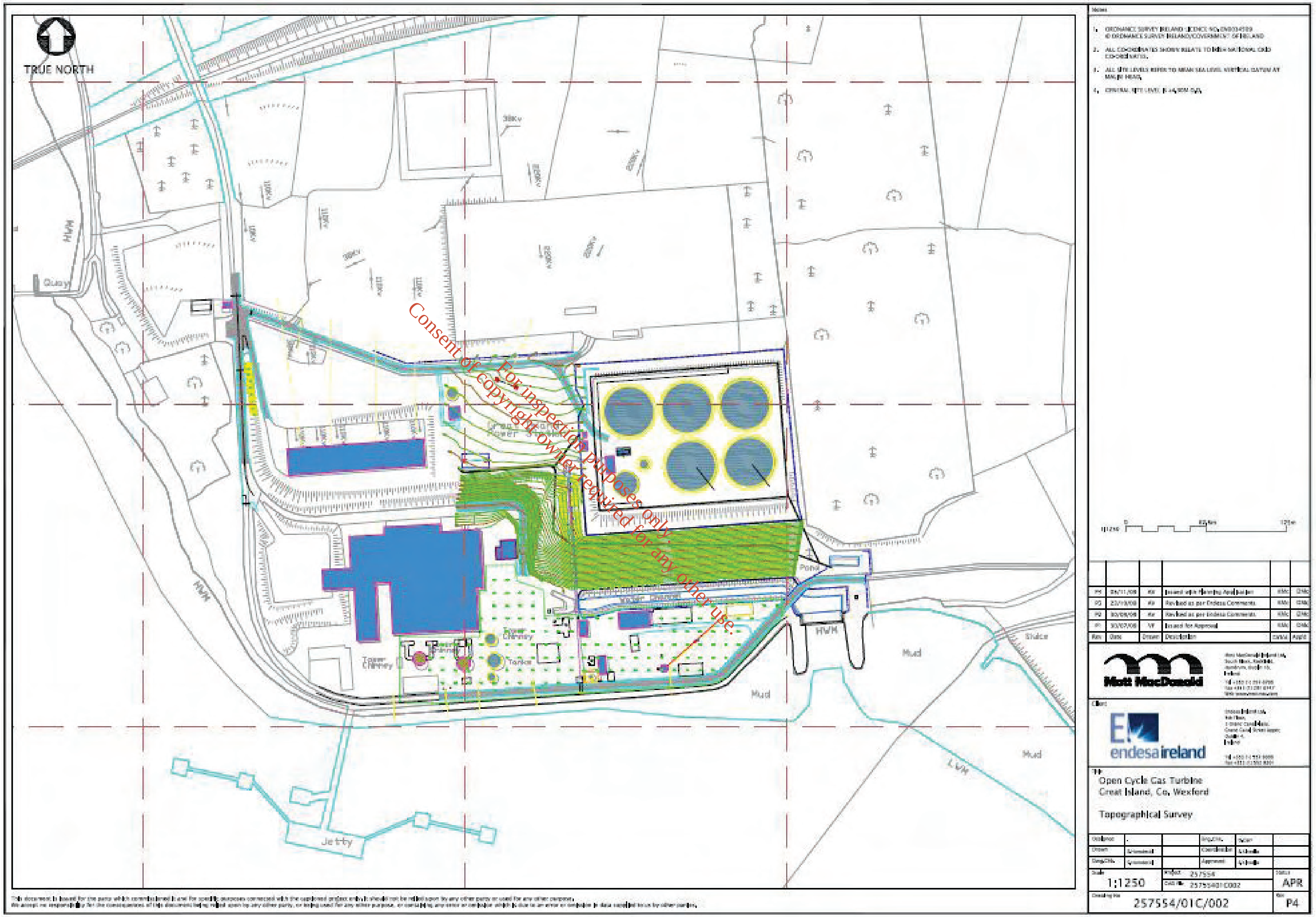
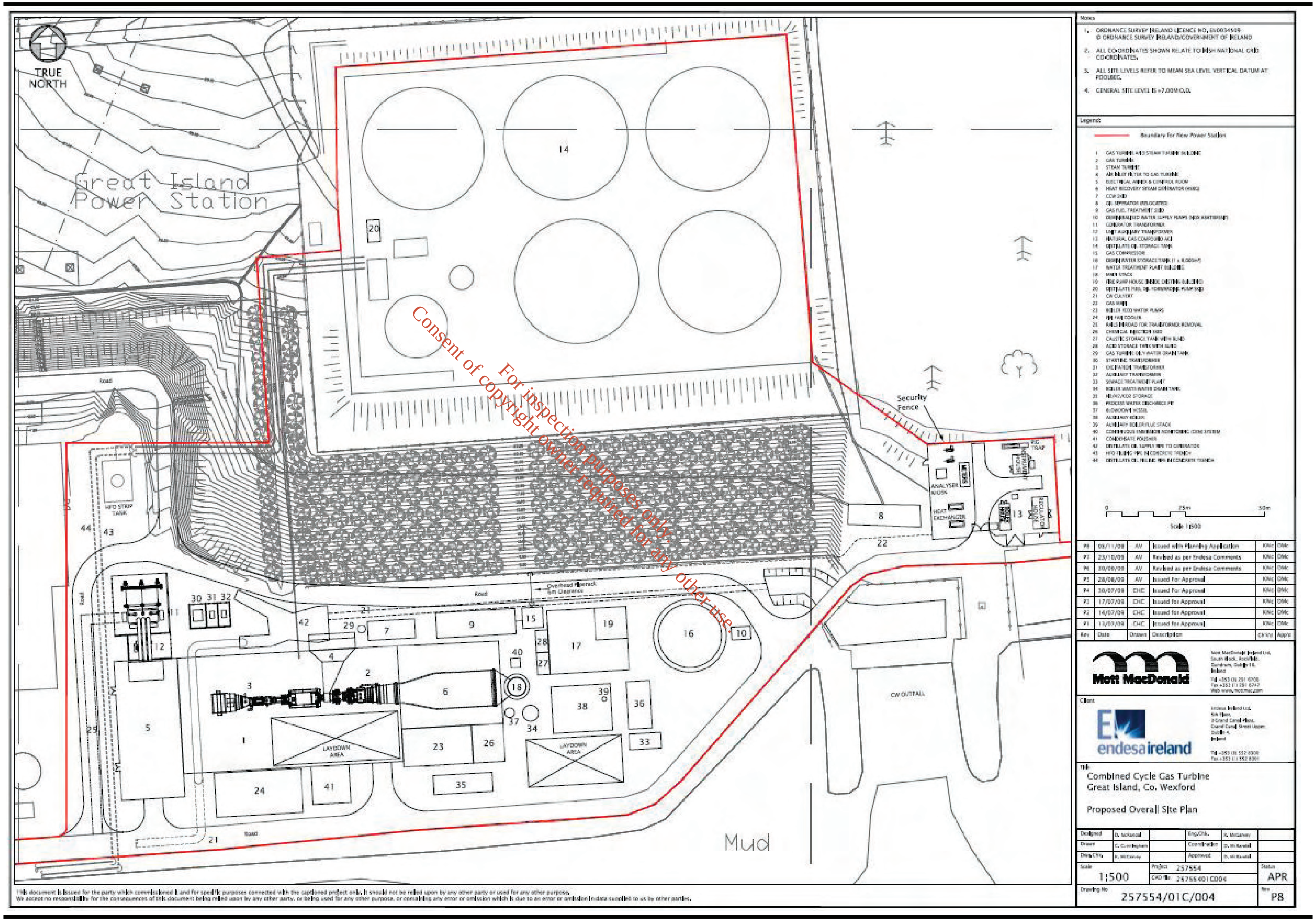


Figure 1.5 Proposed Facility Layout



1.5 REPORT LAYOUT

The remaining sections of this report are set out as follows:

- *Section 2* describes how the potential major accident scenarios included in the QRA and MATTE assessment were identified;
- *Section 3* presents the methods and data used in the calculation of the frequency of potential major accidents and MATTEs;
- *Section 4* details the analysis of the consequences of potential major accidents and MATTEs;
- *Section 5* describes risk criteria as used by the HSA;
- The calculation of the fatality risks and results obtained are presented in *Section 6* and the options for reducing environmental damage are presented and discussed in *Section 7*; and
- *Section 8* presents the study conclusions and recommendations.

2 IDENTIFICATION OF MAJOR ACCIDENT SCENARIOS

For the purposes of the QRA, the general approach taken for identification of the hazards has been to consider the loss of containment of hazardous materials for various failure sizes from isolatable sections of the plant facilities. The two main hazardous materials present at the Great Island combined cycle power plant will be natural gas and the distillate fuel oil. The hazardous properties of these materials and the potential outcomes arising from their accidental release are included in *Section 2.1.*

The plant facilities were broken down into a set of 'isolatable' inventories (i.e. sections of plant that could be isolated in the event of an accidental release) that would typically be achieved by the closure of emergency shutdown valves (ESDVs).

As stated, the accident scenarios included in the QRA were then obtained by assuming a range of failure sizes from each of the isolatable inventories, varying from a small hole to complete rupture. The inventories defined are listed in *Table 2.3* and the accident scenarios identified for the analysis are summarised in *Table 2.4*.

Additionally, major accidents involving the release of flammable and combustible liquids and natural gas that have occurred at Buncefield and Ghislenghien, Belgium are outlined. The lessons learned and recommendations arising from these accident events and their implications for the design and operation of the facilities at the Great Island combined cycle power plant are discussed. This is covered in *Section 2.2*.

2.1 PROPERTIES AND HAZARDS OF DISTILLATE AND NATURAL GAS

The principal hazardous materials with the potential to cause major accidents or MATTEs that will be present at the site are distillate and natural gas. Other hazardous materials that will be present but are not considered to give rise to potential major accidents are included in *Table 2.2*.

2.1.1 Distillate

Distillate is a generic name used to describe a complex mixture of hydrocarbons, mainly paraffinic, naphthenic and aromatic in the range C10-C28. Other commonly used names are diesel and gas oil. The distillate which will be used as a backup fuel at Great Island is classified as a Gas Oil Petroleum Product in the Seveso II Directive[3].

The generation of a distillate spray, vapour or mist can be a potential fire or explosion hazard and the thermal decomposition of the distillate may lead to the formation of a multiplicity of compounds some of which may be hazardous. With incomplete combustion smoke and hazardous fumes and gases, including carbon monoxide may be formed.

The distillate is also classified as dangerous for the environment.

2.1.2 *Natural Gas*

Natural gas used as the primary fuel at the power station is a mixture of low molecular weight (typically ≤ C_4) hydrocarbons (predominantly methane). The physical properties for methane, ethane and propane (the principal constituents of natural gas) are provided in *Table 2.1*[(4)].

Table 2.1 ***Properties of Hazardous Materials***

Substance	Methane	Ethane	Propane
Chemical Name	Methane	Ethane	Propane
Chemical Formula	CH_4	C_2H_6	C_3H_8
CAS Number	74-82-8	74-84-0	74-98-6
Appearance at 20°C	Colourless Gas	Colourless Gas	Colourless Gas
Atmospheric Boiling Point (°C)	-161.5	-88.6	-42.1
Melting Point (°C)	-182.5	-183.3	-187.7
Liquid Specific Gravity	0.422	0.546	0.59
Vapour Density (air = 1)	0.55	1.1	1.5
Lower flammable limit (vol %)	5	3	2.1
Upper flammable limit (vol %)	15	12	9.5
Flash Point (°C)	-188	-135	-104
Auto Ignition Temperature (°C)	595	504	450
Long term exposure limit	N/A	N/A	N/A
LD_{50}	N/A	N/A	N/A
Eco-toxicity	Unlikely to cause adverse effects	Unlikely to cause adverse effects	Unlikely to cause adverse effects
Degradability	Disperses rapidly	Disperses rapidly	Disperses rapidly

The principal hazards of the natural gas arise from its flammability; ignited releases can result in a jet flame, flash fire and explosions.

2.1.3 *Toxicity and Asphyxiation*

Methane, or natural gas, is not toxic or a carcinogen. There is no occupational exposure limit value (OELV) for methane in Ireland or immediately dangerous to life or health (IDLH) value in the United States. Methane is a simple asphyxiant gas. However, the risk of harm to personnel due to asphyxiation from releases of the natural gas (which comprises mostly methane) is deemed to be negligible and has been discounted from the analysis. This is because losses of containment of the gas would be at high pressures that would mix rapidly with air as it is released into the atmosphere and being lighter than air would disperse in an upward direction. Furthermore, the open nature of the site minimises the risks of accumulation in confined areas.

A fire involving distillate can produce a multiplicity of compounds some of which may be hazardous from a distillate fire. Furthermore, with incomplete combustion smoke, hazardous fumes and gases, including carbon monoxide, may be formed. However, the smoke and combustion products generated from the large fires at Buncefield did not cause any serious harm to people and on this evidence the risks from exposure to any toxic products generated in a distillate fire were considered to be negligible.

2.1.4 *Fire Hazards*

Pool Fire

When a flammable liquid is released from a storage tank or pipeline, a liquid pool may form. As the pool forms, some of the liquid will evaporate and, if flammable vapour finds an ignition source, the flame can travel back to the spill, resulting in a pool fire. However, since the distillate is not classified as a flammable liquid, a pool fire is only likely if there is a strong ignition source, such as from a jet flame or from hot work activities such as welding or cutting. A pool fire involves burning of vapour above the liquid pool as it evaporates from the pool and mixes with air.

Jet Fire

If gases are released from pipework under pressure, the material discharging through the hole will form a gas jet that entrains and mixes with the ambient air. If the material encounters an ignition source while it is in the flammable range, a jet fire may occur. Larger jet fires could occur from ignited releases from the high pressure (approximately 70 barg) import gas lines. Such fires could cause severe damage, but associated consequences are highly dependent on the direction of release (i.e. not omni-directional).

Flash Fire

When a volatile, flammable material is released to the atmosphere, a vapour cloud forms and disperses (mixing with air as it does so). If the resultant vapour cloud is ignited before the cloud is diluted below its lower flammable limit (LFL), a flash fire may occur. The combustion normally occurs within only portions of the vapour cloud (where mixed with air in flammable concentrations), rather than the entire cloud. A flash fire may burn back to the release point, resulting in a pool or jet fire but is unlikely to generate damaging overpressures (explode) when unconfined.

A gas jet release that loses its momentum, such as if directed towards the ground and/or on impact with surrounding equipment and structures is considered to form a flammable vapour cloud, which, if ignited would result in a flash fire.

Explosions

As discussed in the previous section, a flash fire can occur if the natural gas is released into the atmosphere and ignited. If ignited in open (unconfined) areas, pure methane is not known to generate damaging overpressures (explode). However, if some confinement of the vapour cloud is present, methane can produce damaging overpressures. Areas congested with equipment and structures can facilitate damaging overpressures if a vapour cloud is ignited within such an area. For example, if a vapour cloud infiltrates a process plant area with various vessels, structures and piping, and the cloud ignites, the portion of the cloud within that congested area may generate damaging overpressures.

2.1.5 *Other Hazardous Materials*

Other materials, some of which are categorised as being hazardous that are currently present at the Great Island combined cycle power plant site are listed in *Table 2.2*. An indication of their annual usage is also given.

At present, 1.5 tonnes of 4% hydrazine solution is stored on site. Although Hydrazine is a listed substance under Seveso with a lower tier threshold of 0.5 tonnes and an upper tier threshold of 2 tonnes, its concentration is such that the Seveso requirements do not apply. However, the hydrazine will be replaced by carbohydrazide, which is non-hazardous and has also been included in *Table 2.2*. Therefore, hydrazine has not been included in the hazard analysis.

Table 2.2 Other Materials Present at Great Island Combined Cycle Power Plant Site

Material/ Substance	CAS Number	Hazard	Amount Stored	Annual Usage	Nature of Use	Risk Phrase, R	Safety Phrase, S
Acetylene	74-86-2	Explosive	10 bottles	9 bottles	Welding	5, 6, 12	9, 16, 33
Amino Acid F Reagent	None	Corrosive	15 litres	15 litres	Silica monitor reagent	36,	
Ammonia solution	7664-41-7	Corrosive	1.5 tonnes	3tonnes	Boiler treatment	34, 36/37/38	7, 26, 45
Argon	7440-37-1	None	9 bottles	15 bottles	Welding		
Carbohydrazide	497-18-7	None	1.5 tonnes	3 tonnes	Boiler treatment		
Carbon Dioxide	124-38-9	Asphyxiant	50 bottles	45 bottles	Generator purging		
Citric Acid / Surfactant Reagent	5949-29-1	Irritant	15 litres	15 litres	Silica monitor reagent	36	24/25
Fluorescein	05/07/2321	None	5 kg	5 kg	Condenser leak detection		
Hydrazine solution	302-01-2	Toxic	1.5 tonnes	3 tonnes	Boiler treatment	10, 23/24/25, 34, 43, 45	45, 53

Material/ Substance	CAS Number	Hazard	Amount Stored	Annual Usage	Nature of Use	Risk Phrase, R	Safety Phrase, S
Hydrogen	1333-74-0	Extremely flammable	105 bottles	510 bottles	Generator cooling	12	9-16-33
Ion Exchange Resins		None	None	As required	Water treatment		
Molybdate 3 Reagent		Irritant	15 litres	15 litres	Silica monitor reagent		
Nesslers Reagent (1.25% HgCl)4		Toxic	5 litres	5 litres	Laboratory analysis	35, 26-27-28-33	
Nicerol 3% protein foam concentrate			1000 litres	As required	Fire suppression		
Nitrogen	7727-37-9	None	60 bottles[3]	465 bottles[3]	Boiler waterside protection		
Oxygen	7782-44-7	Oxidising	10 bottles[3]	20 bottles[3]	Mechanical use	8	17
Propane	74-98-6	Flammable	1 tonne	2 tonnes	Ignition fuel	12	9, 16, 33
Propane	74-98-6	Flammable	6 Bottles	6 Bottles	Mechanical use	12	9, 16, 33
Sodium Hydroxide solution (30%)	1310-73-2	Corrosive	1 tonne	2 tonnes	WTP regeneration	35	26, 37/39, 45
Sodium Hydroxide solution (47%)	1310-73-2	Corrosive	30 tonnes	100 tonnes	WTP regeneration	35	26, 37/39, 45
Sodium Hypochlorite solution	7681-52-9	Corrosive	2 tonnes	5 tonnes	Cooling water treatment	31, 34	2, 28, 45, 50
Sulphuric Acid (Bulk)	7664-93-9	Corrosive	40 tonnes	100 tonnes	WTP regeneration	35	2, 26, 30
Sulphuric Acid	7664-93-9	Corrosive	1 tonne	2 tonnes	Neutralisation sump	35	2,26,30

The loss of containment of the other materials is also not considered to give rise to a major accident event. For instance, although some of the materials, such as the sodium hydroxide and sulphuric acid will be stored in large quantities of up to 30 and 40 tonnes, they are classified as being corrosive and their loss of containment would not constitute a major accident. The quantities of other materials, such as the hydrogen and acetylene, which are classified as extremely flammable and explosive respectively, will be stored in bottles well below their threshold levels of 10 and 5 tonnes respectively for lower tier Seveso sites.

2.2 HISTORICAL MAJOR ACCIDENTS

In the past there have been a number of fires and explosions that have occurred at major hazardous installations and pipelines conveying flammable materials. Two examples of accident events are outlined here – explosions and fires that resulted from the overflow of petroleum from a storage tank at the Buncefield Oil Terminal in the UK and a gas pipeline rupture that occurred in Belgium. The lessons learned from these accidents and the implications for the design and operation of Combined Cycle Power Plant at Great Island are then discussed.

2.2.1 *Buncefield Oil Storage Terminal, United Kingdom*

In the early hours of Sunday 11th December 2005, a number of explosions occurred at Buncefield Oil Storage Depot, Hemel Hempstead, Hertfordshire, UK. At least one of the initial explosions was of massive proportions and there was a large fire, which engulfed 23 large fuel storage tanks over a high proportion of the Buncefield site. The incident caused injuries to 43 people and although no one was seriously hurt, the fires and explosions resulted in significant damage to both commercial and residential properties near the Buncefield site. The fire burned for several days, destroying most of the site and emitting large clouds of black smoke into the atmosphere that dispersed over southern England and beyond. About 2000 people were evacuated from their homes and sections of the M1 motorway were closed. The fire burned for five days, destroying most of the site and emitting a large plume of smoke into the atmosphere.

Late on Saturday 10 December 2005 a delivery of unleaded petrol started to arrive at Tank 912 in bund A. The safety systems in place to shut off the supply of petrol to the tank to prevent overfilling failed to operate. Petrol cascaded down the side of the tank, collecting at first in bund A. As overfilling continued, the vapour cloud formed by the mixture of petrol and air, flowed over the bund wall, dispersed and flowed west off site towards the Maylands Industrial Estate. A white mist was observed in CCTV replays. The exact nature of the mist is not known with certainty: it may have been a volatile fraction of the original fuel such as butane, or ice particles formed from the chilled, humid air as a consequence of the evaporation of the escaping fuel.

2.2.2 *Gas Pipeline Rupture, Belgium*

In July 2004, an accident occurred involving a high pressure gas pipeline at Ghislenghien, Belgium. A high pressure natural gas pipeline ruptured and the leaking gas ignited, causing 25 fatalities and over 150 injuries, together with extensive damage to nearby factory buildings. Investigations revealed that the pipeline had been damaged by construction work taking place in the vicinity.

Accounts of the accident indicate that an odour of gas was first detected at around 07:30, but that the 'explosion' of the pipeline did not occur until 08:56. It seems possible that the incident started as a relatively small leak that later propagated into a rupture of the pipeline (the 'explosion' referred to by observers). The sudden rupture of the pipeline, coupled with ignition to give a fireball, would seem to account for the observations recorded.

A 'burn radius' of around 400 m (equating to a burn area of 502,655 m^2) is quoted in one source, although other sources give lower values of around 200 to 300m (equating to burn areas of 125,664 m^2 and 282,743 m^2 respectively).

2.2.3 *Implications for the Great Island Establishment*

The main explosion at Buncefield was unusual because it generated much higher overpressures than would usually have been expected from a vapour cloud explosion. The mechanism of the violent explosion is not fully understood and further scientific investigation has been commissioned to explain what occurs in large flammable vapour clouds (7).

However, the distillate stored in bulk at Great Island has a low volatility and so an explosion arising from a loss of containment similar to the one caused at Buncefield is considered to be very unlikely. In order to prevent overfilling, a robust shut-off system will be installed to stop the flow if distillate oil from the jetty in the event that the liquid level in the tank reaches a specified level. Furthermore, the operating envelope will be clearly defined in that the filling levels, temperatures, pressures and flow rates, for example, will remain within defined limits. An inspection regime will also be developed to ensure that the integrity of the storage tank is maintained.

The magnitude of the consequences of an accident similar those arising from the high pressure gas pipeline rupture at Ghislenghien, Belgium is deemed unlikely to occur at Great Island. This is because the natural gas onsite will be conveyed in smaller diameter pipelines and will be at lower pressures than the Belgium transmission pipeline.

2.3 *MAJOR ACCIDENT SCENARIOS*

Information about the distillate and natural gas contained within the isolatable sections of the plant at Great Island are reported in *Table 2.3*. The QRA performed by ERM included releases from all of the plant areas listed in *Table 2.3* and therefore potential accidental releases from all parts of the site have been considered in the analysis.

The pressure of the gas arriving at the site can be up to 70barg. However, it should be noted that the incoming gas pipeline has not been included in the analysis. This is because it will be owned and operated by Bord Gáis, who will have their own measures in place to minimise the risks from accidental releases.

Table 2.3 Process and Inventory Information

Node	Description	Information	Notes
A01	AGI	Pressure of gas delivered to AGI normally at 40 barg..	The Bord Gáis pipeline will normally deliver gas at a pressure of around 40barg. The pressure may however at times be higher or lower than this. The maximum pressure would be 70 barg and it is guaranteed that the pressure of the gas supplied would not be less than 19 barg. When necessary, the pressure will be reduced at the AGI to the pressure required by the gas turbine.
G01	Gas pipeline from AGI to gas compressor	250 mm underground flowline, at 40barg	
GCB01	Gas compressors	Pressure of compressed gas up to 50 barg depending on gas turbine generator selected.	If necessary, the gas is compressed before being fed the gas turbine generator.
G02	Gas pipeline from gas compressor to gas turbine	300 mm above ground flowline, up to 50 barg depending on turbine selected.	
TR01	Transformers	Oil-filled	Overheating of transformer oil.
J01	Jetty unloading arms		Backup distillate fuel will be delivered to the site via the jetty for the primary filling but will be tankered by road for annual refills of minor volumes infrequently (no more than once per year).
T01	Distillate storage tank	17,000 m^3 capacity	No more than 11,000m^3 of distillate fuel will be stored in the refurbished storage tank at any one time. The tank will be fitted with an automatic trip during filling when the capacity of the tank has reached 11,000m3.
DP01	Distillate flowlines	Ambient conditions	Flowlines convey distillate fuel from jetty to storage and from storage to power plant.

The accident scenarios considered in the QRA are summarised in *Table 2.4*. The impact of these potential major accidents on both personnel safety and the environment has been assessed.

Table 2.4 Major Accident Scenarios

Section	Scenario
AGI and gas line from AGI to gas compressor (40 barg)	
	4mm diameter hole leading to jet fire
	25mm diameter hole leading to jet fire
	1/3 diameter hole (approximately 80mm) leading to jet fire
	250mm rupture leading to jet fire
Gas compressors	
	Release of gas into compressor building leading to a VCE
Gas line from gas compressor to gas turbine (up to 50 barg)	

Section	Scenario
	4mm diameter hole leading to jet fire 25mm diameter hole leading to jet fire 1/3 diameter hole (approximately 80mm) leading to jet fire 300mm rupture leading to jet fire
Gas Turbine Building	
	Release of gas into gas turbine building leading to a jet flame
Distillate storage tank	
	Full bund fire Overtopped bund fire
Jetty unloading arms	
	Large release of distillate into the marine environment
Distillate flowlines	
	1/3 diameter hole (approximately 80mm) leading to jet fire 300mm rupture leading to jet fire
Transformers	
	Overheating of oil leading to fire and explosion

However, for the purpose of calculating the risk levels, the pressure of the gas in the line from the AGI to the compressor was also assumed to be at 50 barg, which is considered to be conservative.

2.3.1 *Causes of Major Accidents*

There can be a number of different causes leading to losses of containment from the AGI, distillate storage, gas pipelines and jetty facilities. The typical causes of potential major accidents for the various hazardous areas of the site are set out in *Table 2.5.*

In addition there are potential external causes that are common to all sections of the plant. These include for instance extreme weather conditions, lightning strikes, seismic activity, aircraft impact and sabotage/vandalism.

One other cause that is considered when assessing the risks from major accidents arises from the consequences of an accident at an adjacent facility (i.e. an escalated event). However, there are no other hazardous installations in the vicinity of the Great Island site and so the risks of escalation from accidents at an adjacent facility were discounted from the analysis. Similarly, the potential for escalation at other establishments caused by releases of gas and distillate at Great Island were also considered no further.

Table 2.5 Summary of Causes of Potential Major Accidents

Plant Section	Causes of Failure
AGI and gas lines from AGI to compressor and from compressor to gas turbine Distillate oil flowlines	• Impact from dropped object • Vehicle impact • Third party activities • Overpressure • Defective/wrong materials used during construction • Corrosion • Failure of gas line supports • Human error • Incorrectly fitted gasket/ defective gasket installed
Compressor failures	• Impact from dropped object • Overpressure • Low suction pressure • High/low temperature beyond design limits • Corrosion • Excessive vibration • Human error
Jetty unloading arms	• Poor connection • Loading arm failure due to excessive movement of moored vessel • Overpressure • Incorrectly fitted gasket/ defective gasket installed • Human error
Distillate storage tank	• Impact from dropped object • Overfilling • Overpressure • Defective/wrong materials used during construction • Corrosion
Transformer	• Overheated transformer oil

The failure rates considered in the frequency analysis in *Section 3* encompass all causes.

2.3.2 *Screening of major accident Events*

A number of potential major accident scenarios identified above were discounted from further detailed assessment. This was done on the basis that they were judged to not lead to a major accident event or the risks were deemed to be insignificant in terms of their impact on land use planning in the vicinity of the installation.

It is expected that the transfer of the distillate oil from the jetty to bulk storage would only take place once and it is expected that the operation would take less than 24 hours. Since the distillate oil flowlines would be purged and maintained in a dry condition once transfer has been completed, they are only likely to contain any distillate for around 0.3% of the time. Therefore, the scenario of a pipeline failure leading to a significant loss of distillate has not been included in the analysis because it is judged to have a very low likelihood.

One of the major accident scenarios considered in the analysis is overheating of the oil in the transformers giving rise to a fire and possible explosion. However, there are protection systems incorporated into the design of modern transformers that would activate their shutdown in the event of overheating. Therefore, fires and explosions arising from an overheated transformer are considered to be extremely unlikely and if there were such an accident event, the extent of the consequences would not extend to offsite areas where people would be present. The transformer bund is designed to minimise contamination across the site.

3 *FREQUENCY ANALYSIS*

3.1 *RELEASE FREQUENCIES*

The frequency of releases from equipment has been determined by high level parts counting and application of generic frequency data. The parts count was performed using the Process Flow Diagrams (PFDs).

The frequency data have been taken from the Health and Safety Executive Failure Rate and Event Data (FRED), contained within their Planning Case Assessment Guide [(2)]. Where appropriate, event frequencies quoted in the recently published Policy & Approach of the Health & Safety Authority to COMAH Risk-based Land-use Planning[(1)] have also been considered in the frequency analysis. With respect to the frequency of releases of the distillate at the jetty, the frequency of failure of unloading arms have been derived from work performed by the Advisory Committee on Dangerous Substances (ACDS) in the UK[(8)].

3.1.1 *Pipes*

The failure frequencies for conventional single-walled pipework are a function of pipe diameter and length. The values used are shown in *Table 3.1* (the highlighted column indicates the set of frequencies applicable to the gas line from the AGI to the gas turbine).

Table 3.1 Failure Frequencies: Pipework

Release Hole Size (mm)	Failure Frequency (per metre year) for Pipe Diameter (mm)				
	<50	50-149	150-299	300-499	500-1000
3	1×10^{-5}	2×10^{-6}			
4			1×10^{-6}	8×10^{-7}	7×10^{-7}
25	5×10^{-6}	1×10^{-6}	7×10^{-7}	5×10^{-7}	4×10^{-7}
1/3 pipe diameter			4×10^{-7}	2×10^{-7}	1×10^{-7}
Full bore	1×10^{-6}	5×10^{-7}	2×10^{-7}	7×10^{-8}	4×10^{-8}

3.1.2 *Tanks*

The HSA Policy & Approach to COMAH Risk-based Land-use Planning does not give failure rates specifically for tank failures. For large scale flammable storage, a frequency of 1×10^{-3} per year is quoted for pool fires, which cover the entire surface of the bund. Also, a frequency of not less than 1×10^{-4} per year should be used for a major uncontained pool fire extending up to 100m from the bund wall. These frequency figures are higher than the failure rates in FRED for single walled storage tanks that are shown in *Table 3.2*. Furthermore, the probability of ignition would then need to be applied to the figures given in *Table 3.2* to obtain the frequency of a pool fire.

Table 3.2 Failure Frequencies: Single Walled Storage Tanks

Scenario	Frequency (per tank year)
Catastrophic failure	4×10^{-5}
1000 mm hole at base	1×10^{-4}
300 mm hole at base	8×10^{-5}

It should be noted that the frequency figures given in the HSA policy document relate to a storage area containing 10 tanks. The pool fire frequencies quoted by the HSA, which have been used in the analysis, are regarded as being conservative since there are only 5 storage tanks at the Great Island site.

3.1.3 Compressor

The release of gas from the compressor has been derived from figures quoted in the E&P Forum (9) and for release sizes greater than 1 kg/s the failure frequency would be 9.45×10^{-4} per annum. In order to account for gas releases within the compressor enclosure from associated valves, piping and fittings beyond the first flange the failure frequency has been doubled. However, since the compressor enclosure would be a zoned area, the probability of ignition would be low, and if a figure of 0.07 is assumed (10), the frequency of an ignited gas release within the compressor enclosure would be:

$0.07 \times 2 \times 9.45 \times 10^{-4} = 1.325 \times 10^{-4}$ per annum.

3.1.4 Unloading Arms

The failure rates used in the analysis have been based on work performed by the Advisory Committee on Dangerous Substances (ACDS) in the UK (8). This study considers the risks from the transport of dangerous substances, including the transfer of hazardous cargoes from ship to shore.

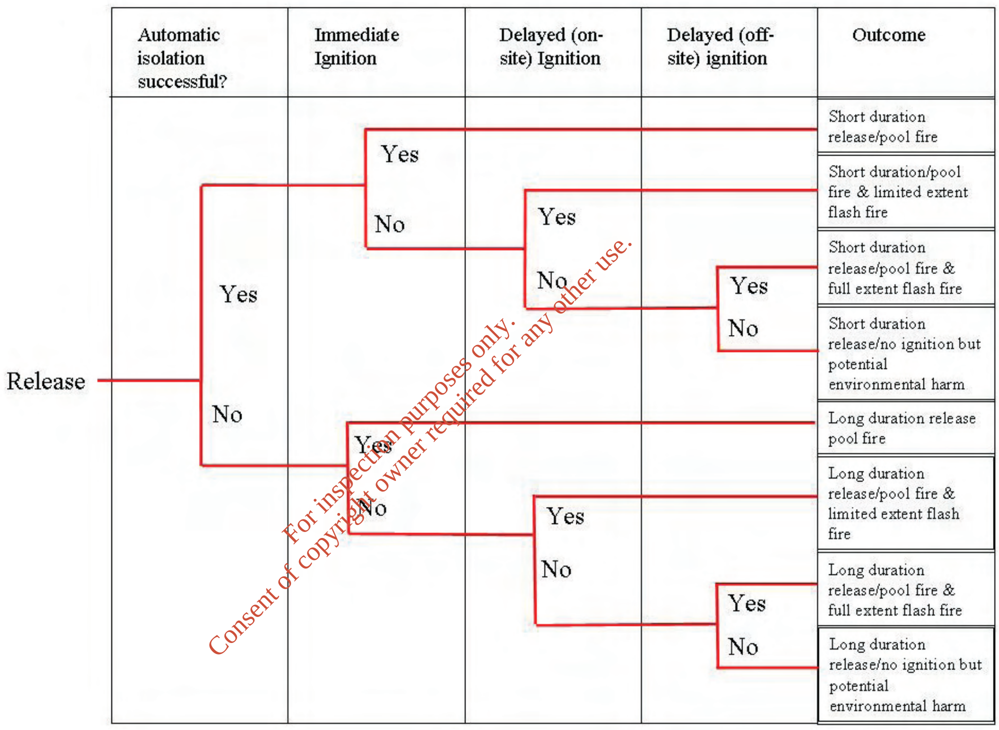
The ACDS Port Study gives the spill frequency per cargo transferred from historical data of ports in the UK and quotes frequencies of: 7.6×10^{-5} and 1.8×10^{-4} for LPG and low flash products respectively. For the purpose of predicting the frequency of a release, the distillate is considered to be represented by low flash products. Therefore, the spill frequency used in the analysis was 1.8×10^{-4} per transfer. Since there will only be a once-off transfer (assuming a one in ten year potential emergency use of all distillate and subsequent refill from the jetty), this equates to a failure frequency of 1.8×10^{-5} per year.

3.2 RELEASE OUTCOME FREQUENCY

A given release of flammable or combustible material may ultimately result in a variety of outcomes, depending on a number of factors, including whether automatic isolation is successful, whether ignition of the release occurs immediately or whether it is delayed. Ordinarily event outcome frequencies are calculated using a simplified event tree and *Figure 3.1* is typical for a release of flammable liquid. In the event of a distillate release, which is not classified as a flammable liquid, the generation of a flammable vapour, and hence a flash fire is considered to be very unlikely.

With respect to pool fires, the ignition probabilities are accounted for in the frequencies quoted in the HSA Policy & Approach to COMAH Risk-based Land-use Planning.

Figure 3.1 ***Simplified Event Tree***



All gas releases are assumed to ignition; an immediate ignition probability of 0.5 and a delayed ignition probability of 1 have been used.

3.3 FATALITY PROBABILITY

Fatality probabilities have been specified for the purposes of calculating individual risk and the societal risk of fatality to the population surrounding the proposed installation. The risk to people, both outdoors and indoors from exposure to thermal radiation from fires and the blast effects from VCEs have been considered in the analysis.

The relationship between the level of consequence and the probability of fatality is generally characterized by a probit relationship that can be used to estimate the proportion of the population that may be affected by exposure to a particular harm.

The Probits referenced in the HSA Policy & Approach document were used in determining the fatality probabilities from the exposure to the effects of fires and blast overpressures generated by VCEs.

3.3.1 Thermal Radiation

Fatality Probability - People Outdoors

The Probit most commonly used to determine the risk from thermal radiation is the Eisenberg Probit [11], i.e.

Probit = -14.9 + 2.56 ln ($I^{1.33}$ t) with I in kW/m^2 and t in seconds

This relationship applies to people exposed outdoors. However, it can be reasonably applied for most exposed population.

For long duration fires, such as pool fires and jet fires, it is generally reasonable to assume exposure duration of 75 seconds (to take account of the time required to escape). Hence, based on the above, the fatality probabilities for people outdoors are listed in *Table 3.3*.

Table 3.3 Fatality Probabilities from Thermal Radiation, People Outdoors

Thermal Flux (kW.m^{-2})	Fatality Probability
13.4	0.5
9.23	0.1
6.8	0.01

Fatality Probability - People Indoors

In order to estimate the fatality probability of people indoors, it is necessary to determine the effect that different levels of thermal radiation will have on the building. A British Code of Practice on fire precautions in chemical plant (BS 5908:1990) suggests that spontaneous (non-piloted) ignition of wood could occur at fluxes of 25 kW.m^{-2}, with piloted ignition of wood occurring at 12.5 kW.m^{-2}. Ignition of wood, textiles or other combustible materials in a building would result in secondary fires in the building, potentially causing direct harm to the occupants or forcing them to escape and be exposed to the incident thermal radiation as a result.

It is conservatively assumed that a building would catch fire quickly if it becomes exposed to a thermal flux of more than 25.6kW.m^{-2} and is considered to result in a high probability of fatality. Between thermal flux levels of 12.7 and 25.6kW.m^{-2} people are assumed to escape outdoors, and the probability of fatality is assumed to correspond to that for people outdoors. At thermal flux levels below 12.7kWm^{-2} building occupants are assumed to be protected.

Taking these factors into consideration, the fatality probabilities for people indoors were established, as shown in *Table 3.4*.

Table 3.4 *Fatality Probabilities from Thermal Radiation, People Indoors*

Thermal Flux (kW.m^{-2})	Fatality Probability
>25.6	1.0
12.7 to 25.6	As for people outdoors
<12.7	0.0

3.3.2 *Blast Overpressure*

One of the most commonly used Probits to determine the risk from blast overpressure is the relationship put forward by Hurst, Nussey and Pape (12):

Probit = 1.47 + 1.35 ln (P) with P in psi (NB 1 psi = 68.947573 mbar)

This relationship only applies to people exposed outdoors, and implies the fatality probabilities set out in *Table 3.5*:

Table 3.5 *Fatality Probabilities from Blast Overpressures, People Outdoors*

Blast Overpressure		Fatality Probability
psi	mbar	
2.44	168	0.01
5.29	365	0.10
13.66	942	0.50

People outdoors could either be more or less vulnerable to the effects of overpressures generated by a VCE, depending on the type of structure. The Chemicals Industry Association (CIA) has published relationships between fatality probabilities for people inside four different categories of building (13), namely,

- Category 1: hardened structure building
- Category 2: typical office block;
- Category 3: typical domestic building; and
- Category 4: portacabin type timber construction

The CIA Category 3 Curve (typical domestic building: two-storey, brick walls, timber floors) provides a reasonably conservative basis for assessing the risk of fatality to most residential populations. The table below gives the fatality probabilities associated with various levels of overpressure for people inside a category 3 type building.

Table 3.6 Fatality Probabilities from Blast Overpressures, People Indoors

Blast Overpressure		**Fatality Probability**
psi	mbar	
14.5	1000	1.0
8.70	600	0.70
4.35	300	0.50
1.45	100	0.05
0.725	50	0.01
0.145	10	0

4 CONSEQUENCE MODELLING

Losses of containment of the hazardous substances present at the Great Island site have the potential to harm both people and the environment. The QRA carried out for the site has used the DNV *Phast* (Process Hazard Analysis Software Tool) suite of consequence models (version 6.53). Also, the Jo and Ahn method was used for assessing the risks associated with natural gas pipelines. A number of methods for predicting bund overtopping volumes and their application are described. The results in terms of the distances to specified fatality probabilities from jet fires, thermal flux levels from pool fires and overpressure levels from gas explosions are presented. The percentage overtopping of the storage tank bund using different methodologies and arrangements are also given together with the environmental cost liabilities.

4.1 RELEASE DURATIONS

4.1.1 *Releases from Pipes*

Releases from pipes have been assumed to continue for:

- one minute plus the time taken to empty the contents of the inventory for isolated cases (the valves have been designed to close 60 seconds after being activated); and
- 10 minutes plus the time taken to empty the contents of the inventory for non-isolated cases.

These estimated release durations are based on judgements around the closing time of emergency valves. The detection systems to be provided at the facility would enable leaks to be detected rapidly.

4.1.2 *Releases from Distillate Storage Tanks*

The duration of a release from a storage tank has been assumed to be equal to the time taken to empty the tank contents.

4.2 HUMAN IMPACT MODELLING SOFTWARE

The impact of the outcomes from losses of containment of the hazardous materials on people has been assessed by using the DNV *Phast* (Process Hazard Analysis Software Tool) suite of consequence models (version 6.53). *Phast* is a comprehensive hazard analysis software tool for all stages of design and operation.

Phast examines the progress of a potential incident from the initial release to far-field dispersion including modelling of pool spreading and evaporation, and flammable and toxic effects.

Phast is designed to comply with the regulatory requirements of many countries. For example, specific modules have been included to ensure compliance with the Dutch Yellow Book, US EPA and UK HSE regulations.

Phast contains models tailored for hazard analysis of offshore and onshore industrial installations. These include:

- Discharge and dispersion models, including a Unified Dispersion Model (UDM);

- Flammable models, including resulting radiation effects, for jet fires, pool fires and BLEVEs; and

- Explosion models, to calculate overpressure and impulse effects. Available models include the Baker Strehlow, TNO Multi-Energy and TNT explosion models.

4.3 DISPERSION OF FLAMMABLE VAPOURS

Dispersion of natural gas can be dependent on several parameters, including: surface roughness, averaging time, material properties, wind speed and weather conditions. However, the gas delivered to the site will normally be at a pressure of 40 barg, with a minimum guaranteed supply pressure of 19 barg, but on occasions, could be as high as 70 barg. The pressure of the gas discharged from the compressor and fed to the gas turbine would normally be in the order of 50 barg. For the purpose of the analysis, the pressure in all of the gas pipeline from the AGI to the gas turbine, via the compressor was taken to be 50 barg. Any releases would not therefore be strongly influenced by the meteorological conditions.

A flammable vapour cloud is considered only to be formed in the event of a natural gas release losing its momentum from impact with the ground or surrounding structures and equipment, which then disperses as a low density gas.

Averaging Time

When using gas dispersion models the 'averaging time' is a description of the time over which a gas concentration is averaged. At a particular point in space the concentration of a gas cloud at equilibrium will vary for two reasons. Firstly, as the wind direction is not perfectly constant the plume will meander about a mean value. Secondly, there are 'in-cloud' fluctuations due to the turbulence inherent in the atmosphere. As dispersion models aim to show a 'time averaged' concentration at a particular point, this average will depend on the length of time over which the concentration was 'sampled'. The situation is made more complicated because the different types of dispersion model assume different definitions of 'averaging time'.

The use of a short averaging time will maximise the recorded concentration at a given point, whereas a longer averaging time will give a lower value. This is because the use of a short averaging time captures the concentration 'peaks' at a location.

In this study an averaging time of 18.75 s has been used (this is the *Phast* recommended value for flammable gases).

The concentrations of interest for gas dispersion outputs are 5% v/v and 2.5% v/v methane in air; corresponding to the lower flammable limit (LFL) and ½LFL respectively.

Meteorological conditions

Within a risk assessment, weather conditions are usually described as a combination of a letter with a number, such as 'F2'. The letter denotes the Pasquill stability class and the number gives the wind speed in metres per second.

The Pasquill stability classes describe the amount of turbulence present in the atmosphere and range from A to F. Stability class A corresponds to 'unstable' weather, with a high degree of atmospheric turbulence, as would be found on a bright sunny day. Stability class D describes 'neutral' conditions, corresponding to an overcast sky with moderate wind. A clear night with little wind would be considered to represent 'stable' conditions, denoted by stability class F.

Wind speeds range from light (1-2 m/s) through moderate (around 5 m/s) to strong (10 m/s or more). The probability of the wind blowing from a particular direction is commonly displayed graphically as a 'wind rose'.

Event consequences have been modelled in 2m/s and 5m/s wind speeds with the largest being applied in the risk model.

4.4 *HUMAN IMPACT CRITERIA*

The impact criteria for thermal radiation from fires were discussed in *Section 3.3*.

4.5 *BUND OVERTOPPING*

Tanks used for bulk storage of hazardous liquids are often completely surrounded by a wall or earth embankment with the aim of providing secondary containment for any spillage from the tank. If the walls of the bunded area have been designed, built and maintained in line with current standards then they will provide full containment of the more likely spills, but they will not contain the surge of liquid that would follow a catastrophic failure of the tank; even if the surge does not destroy the bund wall, the flood wave is likely to overtop it.

The bunds or earth banks that commonly surround tanks used for storing hazardous liquids are often designed with a capacity equal to 110% of the capacity of the largest storage tank within the bund, the excess height being claimed in part to prevent liquid surging over the top of the bund following sudden failure of a tank. In reality, whilst a 110% capacity bund will contain the release for less extreme modes of failure, it is unlikely to do so for more extreme modes. A series of experiments reported in HSE Contract Research Report 405/2002, in which the contents of a model storage tank were released gently into a 110% bund over a period of 30 seconds, showed that the bund was overtopped in almost every case. More severe modes of release would clearly give more overtopping.

Whilst catastrophic failure of bulk storage tanks is rare, the consequences for site personnel, any local community and the environment can be severe. Such failures have occurred in the USA, in Greece and in Lithuania, for example. Specific examples include the following:

- Floreffe, January 1988 – failure of a 4 million gallon tank of fuel oil at Ashland Oil released a wave of oil that surged through the bunded area damaging another tank and overtopping the bund.

- Iowa, March 1997 – failure of a 1 million gallon tank of ammonium phosphate.

- Michigan, July 1999 – a 1 million gallon tank of ammonium polyphosphate ruptured and damaged three other tanks.

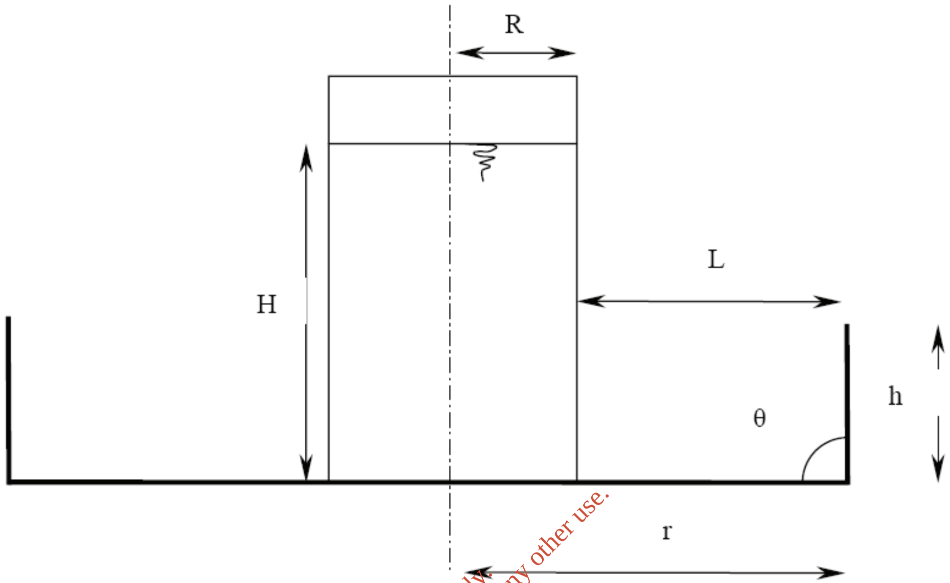
- Ohio, August 2000 – a 1 million gallon tank of liquid fertilizer ruptured and damaged nearby tanks. The resulting wave of liquid broke through a concrete bund and hit five tractor-trailer rigs, pushing them into the Ohio River.

- Ohio, August 2000 – later that month a 1.5 million gallon tank of ammonium phosphate ruptured at the same storage facility. It damaged three other tanks causing them to leak, with liquid overflowing the bund. A total of 450,000 gallons of contaminated water was reclaimed from the sewers and the public drinking water system was feared contaminated, resulting in the widespread use of bottled water as reported by the United States Environmental Protection Agency (2001).

There have been a number of research projects investigating bund overtopping; Greenspan and Johansson carried out experiments and published papers in the early 1980s and Liverpool John Moores University completed a Research Report for the UK Health and Safety Executive in 2005.

All of the experimental projects applied the nomenclature shown in *Figure 4.1*.

Figure 4.1 Tank and Bund Nomenclature for Circular Geometry



4.5.1 Greenspan and Johansson

The major finding from Greenspan and Johansson indicated that the overtopping was dependant mainly on h/H, the ratio of the height of the barrier to the height of the fluid released from the tank with little dependence on L/R, the ratio of tank wall/barrier separation and the distance from the back of the tank to the sliding wall. This was found to be true for all combinations of barrier and tank heights in the range $0.33 \leq L/R \leq 4$. It was also determined that the height of the fluid plume exceeded the initial height of fluid in the tank with the flight of particles from the leading edge of the surge reaching three times the height of the tank fill level.

Greenspan and Johansson (1981) [14] stated that the manner in which the wave overtops the barrier depends upon the shape of the dyke or bund. The fluid may vault an inclined embankment or accumulate rapidly behind a vertical bund and then overtop.

The tests were axisymmetric in nature with an instantaneous release of fluid from the storage tank, whereby a stationary column of fluid was allowed to fall and spread under the action of gravity. The Greenspan and Johansson experiments, led to a conclusion that simple formulae to estimate the overtopping fraction could probably be based on dimensionless combinations of parameters:

$$Q = Q\,(h/H,\ r/H,\ R/H,\ \theta)$$

Two sets of researchers have proposed functions based on the small-scale test data of Greenspan and Johansson. Clark put forward the following relationship to predict the overtopping fraction, Q_C:

$Q_c = e^{[-p.(h/H)]}$

Where, p = 3.89, 2.43 or 2.28 when θ = 90˚, 60˚ or 30˚.

Generally, it was found that the overtopping fraction Q_C and the relationship with h/H held true over the range $0.33 \leq (r - R) / R \leq 4$.

Independently, Hirst derived formulae fitted to the same test data to predict the overtopping fraction, Q_H

$Q_H = A + [B.\ln(h/H)] + [C.\ln(r/H)]$

Where A = 0.044, B = –0.264 & C = –0.116 for θ = 90˚
A = 0.287, B = –0.229 & C = –0.191 for θ = 60˚
A = 0.155, B = –0.360 & C = –0.069 for θ = 30˚

Both Clark's and Hirst's correlations gave good fits to the data of Greenspan and Johansson on which they were based.

4.5.2 *Liverpool John Moores' Correlation*

The Methodology and Standards Development Unit of the United Kingdom Health and Safety Executive (HSE) contracted Liverpool John Moores University (LJMU) to construct a laboratory facility and to conduct a series of tests simulating the sudden failure of a tank such as is used industrially for the storage of hazardous liquids. Such failures are rare. However, history has shown that when they occur a large proportion of the liquid is likely to escape over the surrounding bund wall or embankment, even if the force of the wave impact does not damage the retaining structures.

This research was entitled "an experimental investigation of bund wall overtopping and dynamic pressures on the bund wall following catastrophic failure of a storage vessel".

The LJMU results are separated into three groups corresponding to different levels of tank fill called "squat", "medium" and "tall". The researchers found that the Clark correlation seems to be in keeping with most of the LJMU test results when the plot of overtopping fraction against h/H is considered for squat tanks. However, at lower ratios of h/H and higher bund containment ratios, the Hirst correlation gives better agreement.

For medium tanks, both correlations show general agreement with the test results.

For tall tanks, the Clark correlation most closely fits the test results, with both Clark and Hirst correlations approaching the test results at smaller values of h/H.

New correlations were derived by LJMU to fit the LJMU test results. The following base function was derived:

$$Q = A \times \exp\left[-B \times (h / H)\right]$$

This is of the same form as the Clark correlation. The range of validity is 0.66 ≤ (r – R) / R ≤ 5.32. It should be noted that high-collar bunds are excluded from the range of validity, as the overtopping fraction is negligible, usually less than 5%. Omitting the high-collar bunds improves the quality of fit for the smaller bunds at greater radii, where frictional forces start to affect the result.

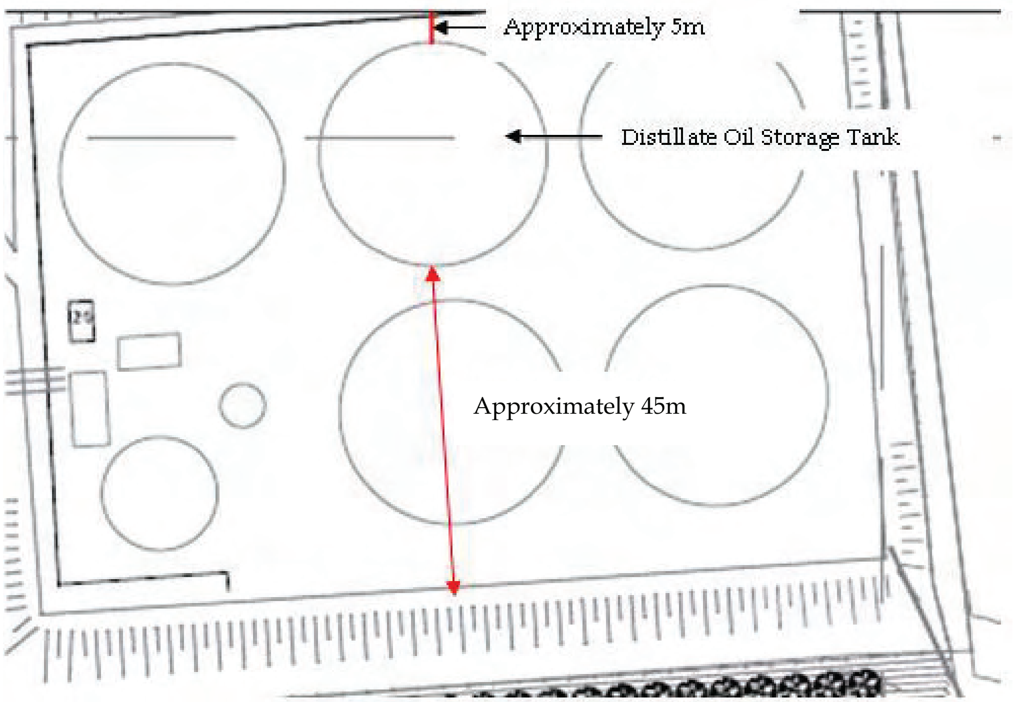
The refurbished tank at Great Island would be classed as 'squat' because of the ratio of liquid height to diameter. Values of A and B for squat tanks are shown in *Table 4.1*.

Table 4.1 LJMU Parameters

Tank Type	**Bund Capacity (%)**	**A**	**B**
Squat	110	0.5789	2.0818
Squat	120	0.5193	1.9671
Squat	150	0.3978	2.0051
Squat	200	0.1824	0.4972

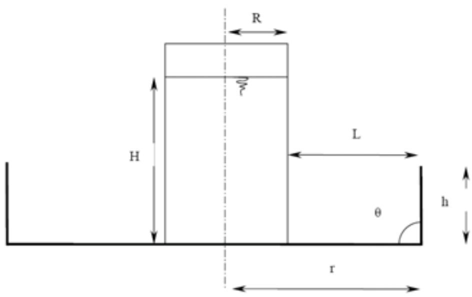
The storage tank area at Great Island is provided with a bund for the purpose of providing secondary containment of any releases that may occur from tanks and process equipment. The bund has the approximate dimensions of 140m x 100 m x 2.5 m deep.

Figure 4.2 *Layout of Great Island Tank Bunds*



The facility at Great Island will be required to store enough backup fuel to meet at least five days operating capacity; this equates to approximately 10,000 tonnes or 11,000m³. It will be Endesa Ireland's policy to store no more distillate fuel than this legal minimum amount.

Based on a distillate volume of 11,000m³



H = 9.7m
R = 19m
h = 2.5m
L_{min} = 5m
L_{max} = 45m

4.5.3 *Codes used by the UK HSE*

The UK HSE has two codes available for estimating the volume of material that may overtop a bund following catastrophic tank failure; OVERTOP and LSMS. Both OVERTOP and LSMS estimate the fraction of the liquid released that overtops a surrounding bund following catastrophic failure of an atmospheric storage vessel which is surrounded by a concentric circular bund.

OVERTOP

HSE internal guidance(14) states that "*the results and the graphs* [from Greenspan and Johansson] *must be treated with caution. A major uncertainty is the applicability of the results to full-scale industrial facilities. In addition, the combinations of parameters investigated in the tests were limited, and the form of presentation of the results does not allow easy interpolation between them.*"

To overcome the latter problem the full test results were reconstructed using the graphs and other information, and a fitting algorithm derived and encoded in the OVERTOP computer program. The algorithm developed by HSE is that presented above by Hirst. The HSE goes on to say that the algorithm "*reproduces the test data on which it is based extremely well, and gives plausible results when applied to real storage tanks*".

LSMS

LSMS (Liquid Spill Modelling System) is a computer code developed by Cambridge Environmental Research Consultants Ltd to calculate the spreading and vaporisation of a liquid pool, with sponsorship by BG, Gaz de France, the US Gas Research Institute and HSE. It solves the hydrodynamic shallow-layer equations in one (x or r) dimension and includes interaction with a vertical retaining bund wall, including overtopping and further spreading of liquid beyond the bund. It allows a solid, porous or liquid substrate.

All of the methods described above have been used to estimate the volume of material overtopping the bund following catastrophic tank failure. The most appropriate model to represent the Great Island bund case is the Hirst method (implemented by HSE as the OVERTOP model). This is because at lower ratios of h/H and higher bund containment ratios, the Hirst correlation gives better agreement than Clark and it also allows the slope of the bund embankment to be modelled.

4.5.4 Environmental Cost Estimation

The US Environment Protection Agency (EPA) Basic Oil Spill Cost Estimation Model (BOSCEM) was developed to provide the EPA Oil Program with a methodology for estimating oil spills costs, including response costs and environmental and socioeconomic damages, for actual or hypothetical spills.

EPA BOSCEM was created as a custom modification to the proprietary cost modelling program, EPC BOSCEM, created by extensive analyses of oil spill response, socioeconomic, and environmental damage cost data from historical oil spill case studies and oil spill trajectory and impact analyses[15].

The model requires the specification of oil type and amount and primary response methodology and effectiveness to determine base costs. Cost modifiers based on location medium type, location-specific relative socioeconomic/cultural value category, location-specific freshwater use, location-specific habitat and wildlife sensitivity category are then applied to the base costs.

The following assumptions were made when estimating costs using the EPA BOSCEM.

Oil Type:	Light Fuel
Response Method:	Mechanical with 90% effectiveness
Location Medium Type Category:	Open Water/Shore giving a cost modifier of 1.0
Socioeconomic and cultural value ranking:	Very High (e.g. national park/reserves for ecotourism/nature viewing; historic areas) giving a cost modifier of 1.7
Freshwater vulnerability category:	Wildlife use giving a cost modifier of 1.7
Habitat and wildlife sensitivity category:	River/stream giving a cost modifier of 1.5

4.6 *RELEASES ON THE JETTY*

The unloading lines run from the jetty head and along the jetty before reaching land. Clearly, in the case of a release from the unloading line on the jetty, there is the potential for at least a proportion of the release to fall on to water.

In the event of a leak, it would be necessary for the escaping liquid to make its way through the hole in pipework and through the surrounding insulation. In this process the release would lose momentum and fall to the surface beneath rather than be projected as a jet. Hence smaller leaks from these pipes have been treated as falling on to the jetty surface (considered to be concrete) rather than on to water.

However, in the event of a large failure or rupture, it is considered that the emerging liquid would retain significant momentum and that at least some of the liquid would spill on to the water.

In view of the above discussions, the following approach has been adopted:

- Smaller leaks have been modelled as falling on to the jetty surface (considered to be concrete); and
- Large leaks and ruptures have been modelled as falling on to water.

The quantity of distillate released into the water arising from jetty failures is estimated from the transfer rate of 7.64m^3/min (assuming that 11,000m^3 is transferred over a period of 24 hours) and the duration of the release, which is determined from the time taken to identify that there is a release and stop the transfer.

4.7 *Human Consequence Results*

The results obtained for the consequence analysis are presented in *Table 4.2*, *Table 4.3*, and *Table 4.4* for pool fires, jet flames and flash fires respectively and in *Table 4.5* for overpressures arising from gas explosions within the compressor enclosure.

Table 4.2 ***Pool Fire Consequence Results***

Scenario	**Distance to Thermal Flux Level (m)**				
	25.6 KW m^{-2}	**13.4 KW m^{-2}**	**12.7 KW m^{-2}**	**9.23 KW m^{-2}**	**6.8 KW m^{-2}**
Bund Fire	Not reached	47	48	65	89
Overtopped poolfire	Not reached	51	53	70	96

Table 4.3 ***Jet Fire Consequence Results***

Release	**Distance to Fatality Probability (m)**			
Scenario	**0.99**	**0.50**	**0.10**	**0.01**
AGI and gas line from AGI to gas compressor (40 barg, but assumed to be 50 barg for analysis)				
4mm hole	1	2	2	2
25mm hole	9	12	14	17
1/3 diameter	29	45	52	60
Rupture	85	122	148	172
Gas line from gas compressor to gas turbine (50 barg)				
4mm hole	1	2	2	2
25mm hole	9	12	14	17
1/3 diameter	29	45	52	60
Rupture	85	122	148	172

Table 4.4 ***Flash Fire Results***

Release Scenario	**Hazard Distances (m)**			
	LFL		**0.50LFL**	
	Downwind	**Crosswind**	**Downwind**	**Crosswind**
AGI and gas line from AGI to gas compressor (40 barg, but assumed to be 50 barg for analysis)				
4mm hole	Not reached	Not reached	Not reached	Not reached
25mm hole	Not reached	Not reached	36	1
1/3 diameter	77	2	158	6
Rupture	235	10	346	16
Gas line from gas compressor to gas turbine (50 barg)				
4mm hole	Not reached	Not reached	Not reached	Not reached
25mm hole	Not reached	Not reached	36	1
1/3 diameter	97	4	185	7
Rupture	270	12	386	19

Although the downwind distances to the LFL and 0.5LFL could reach up to 270 and 385m respectively, the flammable clouds would only be 'thin' in that the corresponding crosswind distances would only be 12 and 19m.

Table 4.5 ***Overpressure Consequence Results***

	Distance to Fatality Probability (m)					
	1.0	**0.70**	**0.50**	**0.10**	**0.05**	**0.01**
Outdoors	Not reached	-	Not reached	15	-	32
Indoors	Not reached	3	18	-	55	100

Domino effects are the effects arising from an event at one establishment which could initiate a major accident at another establishment in the vicinity. Since the distances to consequence levels quoted in the above tables do not extend to any other establishments in the vicinity, there is no escalation potential.

4.8 ENVIRONMENTAL CONSEQUENCE RESULTS

4.8.1 *Bund Overtopping*

Overtopping results have been generated using each of the methods described above. The percentage overtopping (of 11,000m^3) and corresponding volumes predicted by each method are reported in *Table 4.6* and *Table 4.7* shows the BOSCEM cost liabilities estimated using the parameters described in *Section 4.5.4*. The angle of the bund for the storage tanks at Great Island is 60^0 and was used to determine the overtopping fraction (except for the LSMS method which only considers vertical bunds).

Table 4.6 ***Base Case Overtopping Volumes***

Method	**Distance to Bund Wall**	**Bund Wall Angle (o)**	**Percentage Overtopping**	**Overtopping volume (m3)**
Clark	Not a variable	60	53.5%	5880
Hirst (OVERTOP)	Long	60	23.7%	2608
	Short	60	24.4%	2683
LJMU*	Not a variable	60	23.7%	2608
LSMS*	Long	90	7.5%	825

* these methods are based on a vertical bund wall only

As shown in *Figure 4.2* the storage tank being considered for storage of distillate is not located in the centre of the bund. Also, the height of the bund wall on the northern side is 5.5m and 2.5m on the southern side of the bund. The 'long' and 'short' distances in *Table 4.6* relate to the nearest and furthest distances between the storage tank and bund wall. The results in *Table 4.6* show that the overtopping fractions determined using the Hirst method are similar on the northern and southern sides of the bund and are also similar to the amount of overtopping calculated using LJMU, which assumes a vertical wall only.

However, the Clark and LJMU methods do not take the distance between the tank and bund wall into account in determining the overtopping fraction and therefore are not considered appropriate in this case, but are presented for comparison.

The LSMS method assumes that the spread of a spill is the same in all directions (i.e. a circle) and originates in the centre of the bund. The storage tank identified for conversion (middle tank on the northern side of the storage area) is not positioned within a circular bund and not located at the centre of the bund. The short separation between the tank and the north bund wall could not be modelled directly because the subsequent circular bund would have a volume less than the volume of the material being released. The furthest distance from the tank to the bund wall was modelled to represent overtopping over the southern side of the bund, using a separation distance which gave a bund volume equal to the actual bund volume. The results obtained using the LSMS method are perceived to be overly optimistic when compared with overtopping volumes calculated using the other methodologies.

Table 4.7 ***Base Case Environmental Cost Liability***

Method	**Spill Response and Cleanup (€)**	**Socioeconomic (€)**	**Environment (€)**	**Total Cost Liability (€)**
Clark	€40,388,644	€237,671,636	€62,136,375	€340,196,655
Hirst (OVERTOP)	€43,943,972	€120,491,537	€34,021,1407	€198,456,648
LJMU*	€42,746,653	€117,208,565	€33,094,183	€193,049,401
LSMS*	€13,512,403	€37,050,137	€10,461,215	€61,023,755

* these methods are based on a vertical bund wall only, 2.5m high

The Hirst methodology is considered to be the most relevant for Great Island. This is because it accounts for the different separation distances between the storage tank and the bund wall and because the overtopping results are within the highest and lowest estimated volumes using the other methods. Therefore, the results obtained using Hirst were used to assess the benefits of the considered options for reducing the overtopping risks.

4.8.2 *Jetty Releases*

The ACDS document states that transfer spill incidents are often quite minor and so it can be interpreted that most of the releases arising from transfer spills would not have a significant environmental impact. ACDS also gives probabilities of different release durations for large and small leaks. *Table 4.8* gives the spill volumes for the durations for the large releases, assumed to be equivalent to full bore.

Table 4.8 Distillate Spill Sizes (Full bore releases)

Release duration (mins)	Spill Volume (m^3)
2	15.3
5	38
10	76
20	153

The volumes of the distillate spillages at the jetty are considerably less than those obtained for bund overtopping resulting from the catastrophic failure of a distillate storage tank.

5 RISK CRITERIA

5.1 INDIVIDUAL RISK CRITERIA FOR LUP

The HSA policy in relation to proposals for new major hazard establishments is as follows [1]:

- Individual risk of fatality not to exceed 5×10^{-6} per year for non-residential neighbours;
- Individual risk of fatality not to exceed 1×10^{-6} per year at nearest residential property.

In addition, the HSA will also consider the existing land use within three concentric zones around the proposed establishment. The zone boundaries are established as follows:

- Innermost Zone (Zone 1): within 1×10^{-5} per year individual risk of fatality contour;
- Middle Zone (Zone 2): between 1×10^{-5} and 1×10^{-6} per year individual risk of fatality contours;
- Outermost Zone (Zone 3): between 1×10^{-6} and 1×10^{-7} per year individual risk of fatality contours.

The acceptability of different land uses within these zones is summarised in the HSA advice matrix for different PADHI sensitivity levels shown in *Table* 5.1. Typical developments for each of the PADHI sensitivity levels are set out in *Table 5.2*.

Table 5.1 Acceptable Land Uses within Risk Zones

Sensitivity	Zone 1 (Inner)	Zone 2 (Middle)	Zone 3 (Outer)
Level 1	√	√	√
Level 2	**X**	√	√
Level 3	**X**	**X**	√
Level 4	**X**	**X**	**X**

Table 5.2 PADHI Sensitivity Levels

Sensitivity level	Development Type	Examples
1	Work places	Offices, factories, farm buildings, non-retail markets
	Parking areas	Car parks, truck parks, lock-up garages
2	Housing	Houses, flats, residential caravans
	Hotels/ holiday accommodation	Hotels, motels, youth hostels, halls of residences, holiday caravan and camping sites.

Sensitivity level	Development Type	Examples
	Transport links	Motorway, dual carriageways
	Indoor use by public	Restaurants, cafes, shops, libraries, colleges of further education, bus and train stations, leisure centres, conference centres
	Public outdoor use	Picnic areas, markets, theme parks, playing fields
3	Institutional accommodation and education	Nursing and old people's homes (with warden on site or on call), schools for children up to school leaving age
	Prisons	Prison, remand centres
4	Institutional accommodation	Large hospitals, convalescent homes, nursing homes
	Very large outdoor use by public	Large sports stadia, pop festivals, open air markets

5.2 *SOCIETAL RISK OF FATALITY*

Societal risk can be defined as the relationship between the frequency and the number of people exposed to a specified level of harm, such as thermal radiation from fires, explosion overpressures, and doses of toxic gas in a given population.

The risk integral (RI) concept can be used when assessing major hazard installations and is able to provide an indication of the level of societal risk without the need for detailed analysis. It is defined as:

$$RI = \sum_{N=1}^{Nmax} f(N).N^a$$

Where, f(N) is the frequency in chances per million (cpm) of events leading to N fatalities and 'a' is a constant, which is usually set at 1.4. RI values of 2000 are judged to be broadly acceptable and are interpreted as being significant if the value is 500,000 or greater.

One estimation of the level of societal risk, which is best used as an initial screening tool, is to calculate the Societal Risk Index (SRI);

SRI = (P x R x T)/A
Where,

P = population factor, defined as $(n + n^2)/2$
n = number of people at the development
R = average level of individual risk (cpm)
T = proportion of time that the development is occupied by n persons
A = area of the development in hectares

A more detailed analysis for calculating societal risk is by determining the number of fatalities by each accident event and summing all the frequencies that give a specified number, or more of fatalities. The results are presented in graphical form by plotting cumulative frequencies (F) of giving N or more fatalities against N and is often referred to as the F/N curve.

With regard to societal risk, the HSE document(16) states that:

"…the risk of an accident causing the death of 50 people or more in a single event should be regarded as intolerable if the frequency is estimated to be more than one in five thousand per annum."

This gives a criterion 'point' from which intolerable, tolerable and broadly acceptable regions can be extrapolated when considered in conjunction with individual risk criteria. It should be noted that:

- taken in context, the criterion refers to fatalities among members of the public from accidents at a 'single major industrial activity'; and

- the criterion appears to be referring to a cumulative frequency (since it refers to '50 people or more') rather than the single value associated with a single release outcome.

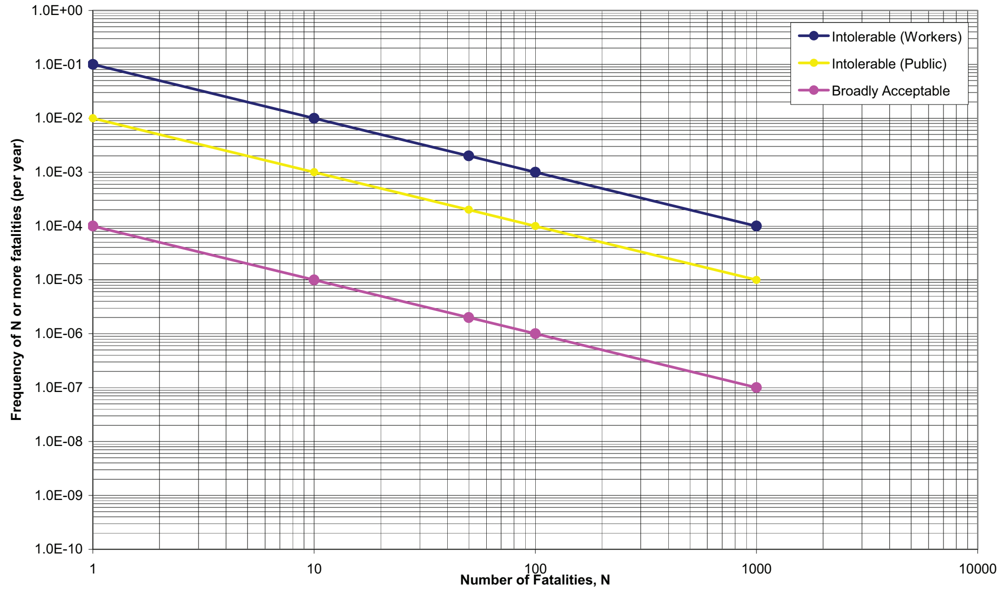
With this in mind, the following extrapolations have been performed:

- the criterion for workers at the site is taken to be ten times higher than that for members of the public, i.e. – the risk of an accident causing the death of 50 workers or more should be regarded as intolerable if the frequency is greater than one in five hundred per annum;

- the broadly acceptable region is taken to be two orders of magnitude lower than the criterion point for members of the public, i.e. - risk of an accident causing the death of 50 people or more is taken to be broadly acceptable if the estimated frequency is less than one in 500,000 per annum; and

- each individual point is plotted on a graph and criterion lines extrapolated through them, to give the Cumulative Frequency (F) – Number of Fatality (N) criteria lines shown in *Figure 5.1*.

Figure 5.1 Cumulative F-N Criteria Lines



5.3 *ENVIRONMENT IMPACT CRITERIA*

The HSA Policy and approach for COMAH risk-based LUP makes reference to EPA's 'Guidance Note on the Storage and Transfer of Scheduled Activities' (available from EPA website http://www.epa.ie/) that provides a detailed approach for conducting an environmental risk assessment.

The major concern at Great Island generally relates to whether a distillate spill (or contaminated firewater) could escape and pollute the surrounding land and the damage the marine environment.

The assessment criteria are based on using water hazard classes (WHCs), which are:

- Non hazardous;
- WHC 1 – low hazard;
- WHC 2 – hazardous; and
- WHC 3 – severe hazard

The risk category table presented as *Table 5.3* is based on four levels of risk classification. Generally, category A equates to low risk, B to medium risk, while categories C and D equate to higher risk. It should be noted that the nature of dangerous substances and their associated volumes stored at petroleum bulk stores is likely to classify such sites as category C or D inasmuch that there is a high potential for pollution in the event of a major release.

Table 5.3 Risk Category Matrix

Vol. (m3) or mass (tonnes)	**Risk Category**		
	WHC 1	**WHC 2**	**WHC 3**
<0.10	A	A	A
0.10 – 1.0	A	A	B
1.0 -10	A	B	C
10 - 100	A	C	D
100 – 1000	B	D	D
>1000	C	D	D

Based on the quantity of distillate that would be present at the Great Island combined cycle power plant, and assuming WHC 1 it would be classified a category C site as a minimum.

6 *RISK CALCULATION*

Individual and societal risk calculations have been performed using ERM's *ViewRisk* software, combining the frequency and consequence information. The development of *ViewRisk* was funded under contract to the UK Health and Safety Executive (HSE) and is regularly used for calculating risks from major accident hazard installations.

6.1 *RISK TO HYPOTHETICAL HOUSE RESIDENTS*

Since, in the event of a major accident, the likelihood of harm to a person indoors differs from that for a person outdoors (see *Section 3.3*) it is necessary to consider the proportion of time individuals may spend indoors and outdoors. To account for time spent indoors and outdoors, the HSA employs the concept of a 'hypothetical house resident'. The hypothetical house resident is present all of the time at their dwelling, spending 90% of their time indoors. The calculation of individual risk has therefore used these 'hypothetical house resident' assumptions.

6.2 *POPULATION DATA*

For the purposes of calculating societal risk, it is necessary to define the population distribution around the proposed facility. However, since the hazard distances predicted for potential major accidents at the Great Island site do not extend to areas where people would normally be present, it has therefore not been necessary to include the population data in the analysis.

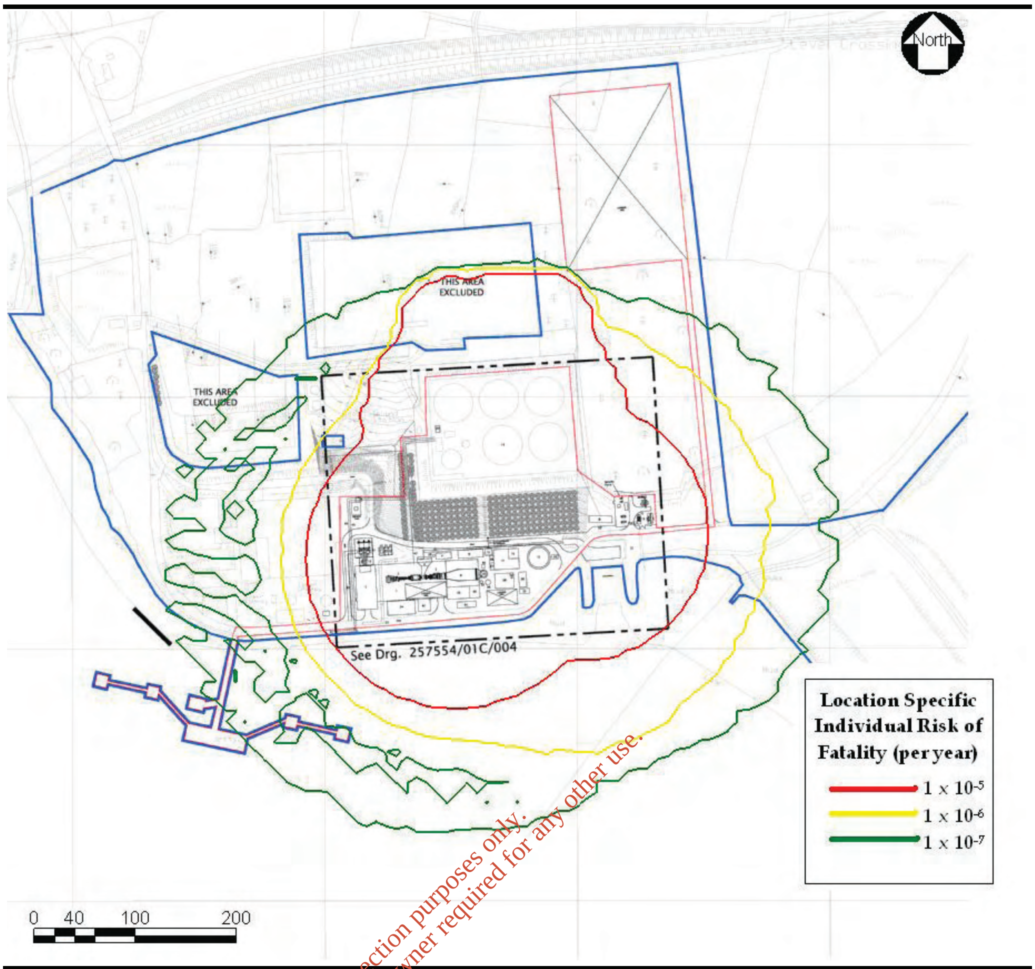
6.3 *INDIVIDUAL RISK RESULTS*

The individual risk of fatality contours displayed in *Figure 6.1* are based on an individual being present outdoors for 10% of the time and indoors for 90% of the time.

The inner zone (1×10^{-5} /yr risk contour) covers virtually all of the Great Island power plant facilities and extends beyond the site boundary over the coastal area to the south.

Whilst each of the zones extends outside the site boundary, with the outer zone (1×10^{-7} /yr risk contour) extending to the eastern unloading berths at the jetty area, they only cover a small area beyond the coastline, where no people would be present. The middle and outer zones also cover a small offsite area of vegetation to the east, but do not encompass any developments where people would normally be present.

Figure 6.1 Individual Risk of Fatality Contours for People Outdoors



6.4 SOCIETAL RISK RESULTS

Only the 1×10^{-7} /yr risk contour extends to locations offsite where people could be present, which would be at the eastern berths at the jetty. However, the societal risk can be deemed to be negligible if the probability of people being present at this location is taken into account. No member of the general public would normally be encompassed by any of the zones. The jetty is used for unloading oil, and although there is no scheduled use of the jetty for passengers, it is sometimes used by cruise liners as a contingency arrangement and occurs with a frequency of less than once per year since the early 1990's.

On site, the distribution of personnel is assumed to be similar to that presented in the assessment of major accident hazards for the Toomes Power Station[17] and summarised in *Table 6.1*.

Table 6.1 Occupancy Levels

Building	Normal	
	Day	Night
Turbine Hall	1	1
Canteen	3	1
Admin building	8	0
Gatehouse	1	1
Central Control Room	3	3

The F-N data obtained for personnel on site is summarised in *Table 6.2* and so the societal risks are interpreted as being in the broadly acceptable region (see *Figure 5.1*).

Table 6.2 F-N Data

N	**F**
1	6.38×10^{-5}
2	6.34×10^{-5}
4	4.29×10^{-5}

7 *RISK OF MAJOR ACCIDENTS TO THE ENVIRONMENT*

7.1 *BUND OVERTOPPING*

7.1.1 *Methods for reducing overtopping risks*

Methods for reducing the volume of material overtopping the bund and entering the environment following catastrophic tank failure considered for the Great Island establishment are listed below.

1. Construction of a double-walled tank;
2. Maintaining the height of the bunding, but increasing the angle of the embankment to 90^0;
3. Maintaining the slope of the embankment, but increasing the height of wall by 2m;
4. Installation of tertiary containment and drainage system outside the bund;
5. Increasing the height of the existing bund wall to ensure complete containment;
6. Construction of a baffle wall within the existing bunded area at the toe of the dyke; and
7. Construction of a 2.5m baffle wall within the existing bunded area at the base of the dyke, increase height of bund by 2m, same slope.

The overtopping risks have considered for one tank only. The distillate will be stored in the tank located in the middle of the three tanks to the north. This tank will have its own dedicated filling pipe from the jetty and no piping will be installed that would make it possible for distillate to be transferred to any of the other tanks.

The fraction of liquid overtopping the bunded area following catastrophic failure of the distillate tank will depend on the direction in which the liquid is released, which in turn will be governed by the section of the tank which fails.

The land rises steeply by about 5.5m from the floor of the bund to the level of the surrounding ground at the northern side of the Great Island storage tank bund. For the purpose of estimating the overtopping fraction at the northern boundary, the bund is considered to be a 5.5m embankment at an angle of 60^0. The amount of distillate overtopping the bund was calculated to be $2683m^3$, which corresponds to 24.4% of the tank inventory. However, there would be some ground contamination beyond the 2.5m concrete section of bunding.

If the release were directed to the south, the overtopping volume over the southern embankment is estimated to be $2608m^3$ (23.7%), which is similar to the fraction that would overtop the bund on the northern side. Any impact from the presence of the tanks on the south side of the storage area have not been taken into account in the analysis.

Therefore, various bund containment options need to be considered around the entire perimeter of the tank storage area.

7.1.2 Analysis of Measures

The effectiveness of the proposed measures in terms of the volume and fraction of distillate that would overtop the bund on the north and south side of the storage is given in *Table 7.1.*

Table 7.1 Effectiveness of Measures to Control Bund Overtopping – Catastrophic Tank Failures

Measure	**Potential Overtopping**			
	North side of Bund		**South side of Bund**	
	%	**Volume (m3)**	**%**	**Volume (m3)**
1. Double walled tank	24.4	2683	23.7	2608
2. Increased embankment angle to 90^0 but maintain bund wall height	8.9	976	18.3	2014
3. Maintaining the slope of the embankment, but increasing the height of wall by 2m	17.3	1902	10.2	1128
4. Tertiary containment (beyond existing bunded area)	0	0	0	0
5. Increase embankment angle to 90^0 and increase bund wall height to 7.7m (north) and 5m (south), which ensures containment	0	0	0	0
6. Construction of a 1.5m baffle wall within the existing bunded area at the base of the dyke, maintain height of bund	22.3	2495	26.2	2879
7. Construction of a 2.5m baffle wall within the existing bunded area at the base of the dyke, increase height of bund by 2m, same slope.	6	673	7.6	837

The figures in *Table 7.1* show that there are clear differences in the effectiveness of the measures considered for reducing the risk of bund overtopping from a catastrophic failure of a distillate storage tank. Furthermore, there are differences in the effectiveness of the measures on the north and south sides of the bunded storage area. Therefore, it may be appropriate to incorporate different measures on different sides of the bund.

One approach to assess the reasonableness of these proposed measures is to compare the cost of implementing the measure with the reduction in environmental spill liability across the lifetime of the plant, referred to as the threshold cost.

The threshold cost is calculated by:

Total liability cost x spill frequency (per year) x 30 years x disproportionate factor (5).

The threshold costs for a single tank containing $11,000m^3$ distillate are reported in *Table 7.2*.

Table 7.2 Cost Benefit Threshold Costs – Catastrophic Tank Failures

Measure	**North side**		**South Side**	
	Potential Residual Cost Liability (€)	**Threshold Cost (€)**	**Potential Residual Cost Liability (€)**	**Threshold Cost (€)**
1. Double walled tank	€198,456,648	€267,916	€192,909,034	€260,427
2. Increased embankment angle to 90^0 but maintain bund wall height	€72,192,951	€189,396	€148,971,931	€74,227
3. Maintaining the slope of the embankment, but increasing the height of wall by 2m	€140,687,494	€86,654	€83,436,116	€172,531
4. Tertiary containment (beyond existing bunded area)	0	€297,685	0	€297,685
5. Increase embankment angle to 90^0 and increase bund wall height to 7.7m (north) and 5m (south), which ensures containment	0	€297,685	0	€297,685
6. Construction of a 1.5m baffle wall within the existing bunded area at the base of the dyke, maintain height of bund	€184,550,629	€20,8549	€212,954,413	-€20,8549
7. Construction of a 2.5m baffle wall within the existing bunded area at the base of the dyke, increase height of bund by 2m, same slope.	€49,1780,591	€223,014	€61,911,373	€204,818

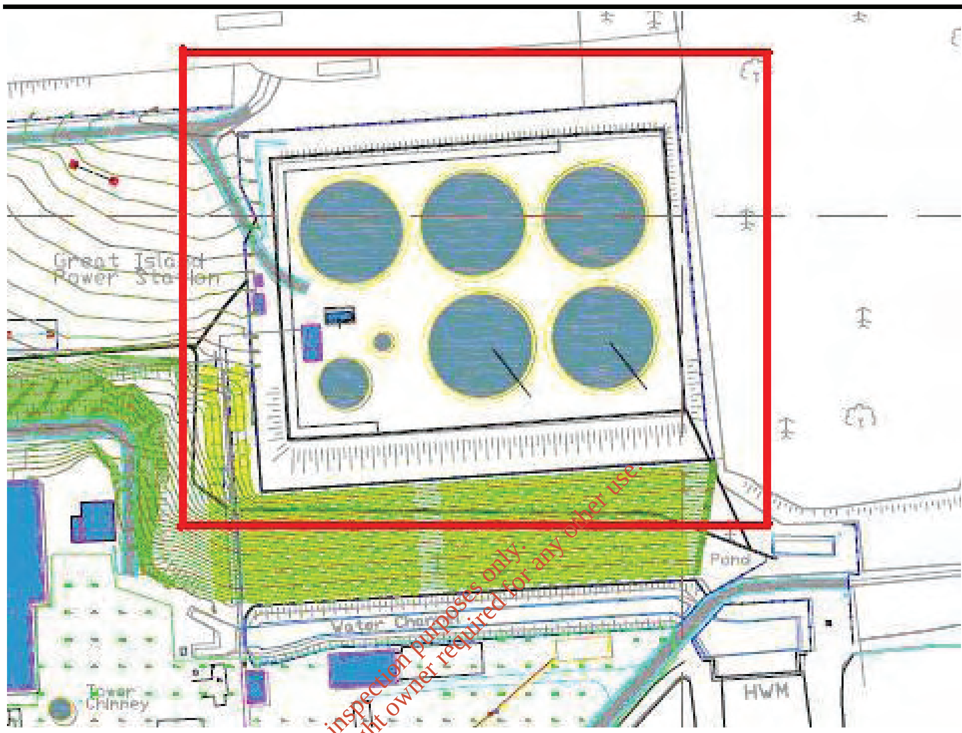
The threshold costs are based on a catastrophic tank failure of 1×10^{-5} per year. However, if the probability of the tank failing in a particular direction were taken into account, then the threshold costs would be lower. For instance if it were assumed that failure of the tank on the north and south sides were equally likely then the above threshold costs could be halved.

It can be deduced from a straightforward examination that some of the considered measures can be discounted from the cost benefit analysis.

The construction of a double walled tank (No. 1) would not reduce the overtopping fraction if it were to fail, but the likelihood of its failure would be reduced. Since the estimated cost for a double-walled tank would be in the region of €3.34 million, it is more than an order of magnitude higher than the threshold cost. Therefore, this measure is deemed not to be economically viable and was therefore dismissed as an option.

An indication of the extent of tertiary containment beyond the existing bunded storage area (No. 4), which would be designed to prevent any of the liquid released from reaching the marine environment is shown in *Figure 7.1,* However, this is perceived to be an impractical option and very costly incorporating measures to seal the area encompassed by the tertiary containment to prevent ground contamination.

Figure 7.1 ***Tertiary Containment***



In order to contain all 11,000m³ of liquid released from a catastrophic tank failure, the bunding would need to comprise a 7.7m vertical wall along the northern boundary and a 5m vertical wall on the south side of the bund (No. 5). This is not considered to be a practical option and so was not examined further.

Increasing the embankment angle to 90⁰ but maintain bund wall height (No. 2) would reduce the overtopping fraction on the north side from 24.4% to 8.9%., but would be less effective on the south side when the overtopping fraction would be reduced to 18.3%.

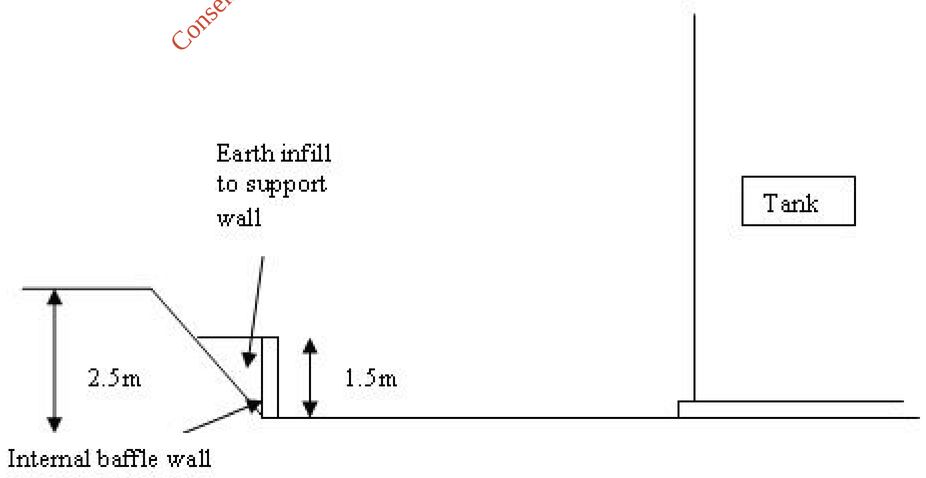
Installing a 1.5m vertical baffle wall at the base of the dyke, such as shown in *Figure 7.2* (No. 6) would not be effective. The construction of a 2.5m baffle wall within the existing bunded area at the base of the dyke and increasing the height of bund by 2m and maintaining the 60⁰ slope (No. 7) would reduce the overtopping fraction to 6% and 7.6% on the north and south sides respectively.

A less expensive, but less effective option would be to increase the height of bund by 2m and maintaining the 60⁰ slope (No. 3), which would decrease the overtopping fraction by 7.1% to 17.3% on the north side and by 13.5 % on the south side. The cost to implement this measure on the east west and south sides has been estimated to be €740,000, but is still considerable higher than the threshold costs. Furthermore, whilst credit has been taken for a 5.5m sloping bund on the northern side, only 2.5m has been concreted and so there would be a need to seal the bund to the full height, otherwise there would be ground contamination form the distillate.

In all the cases considered the expected cost of implementing the mitigation measures exceeds the calculated threshold cost.

The most cost effective way of controlling overtopping of the bund is to consider different measures on different sides of the bund. On the basis that the middle tank on the north side will be used to store the distillate, it is proposed that that the height of the dyke on the south, east and west sides is increased by 2m, maintaining the slope at 60°. On the north side, increasing the embankment angle to 90° but maintain bund wall height at 5.5m would be effective in reducing the overtopping fraction to 8.9%, but would be very costly to implement. It is expected that some of the overtopping on the northern side would flow back into the bund. As stated, if the frequency of the tank failing catastrophically on a particular side were taken into account, then the threshold figures would be lower than those presented in *Table 7.2* and it can be argued that the cost to implement measures on the northern side of the bunded area would be grossly disproportionate to the benefit gained.

Figure 7.2 Proposed Baffle Wall Arrangement



7.2 *JETTY RELEASES*

The ACDS, Major Hazard Aspects of the Transport of Dangerous Substances(8) quotes an accident frequency figure of 1.8×10^{-4} per cargo transferred for low flash and high flash products, and so was considered appropriate for distillate. There will be a requirement to use the distillate for start up, but the quantities involved would only be low. Replenishment of the distillate used during start-up could therefore be supplied from road tanker deliveries. Large volumes of distillate would only be used in the event of the gas supply not being available and is assumed that such occurrences would arise once in 10 years. Therefore there would only be a requirement to transfer distillate from the jetty once every 10 years and the frequency of a release is therefore estimated to be 1.8 x 10^{-5} per year.

The spill sizes were calculated for release durations of 2, 5, 10 and 20 min and the probability and frequencies of the various spill volumes for full bore releases are set out in *Table 7.3* together with the potential cost liabilities and threshold costs. The total potential liability and threshold costs were estimated to be €40,615,193 and €2,287 respectively.

Table 7.3 Cost Benefit Threshold Costs - Jetty Releases (Full Bore)

Release duration (mins)	**Spill Volume (m3)**	**Probability**	**Frequency (/yr)**	**Potential Cost Liability (€)**	**Threshold Cost (€)**
2	15.3	0.101	1.82 x 10^{-6}	€4,219,674	€1,152
5	38	0.037	6.66 x 10^{-7}	€5,179,887	€518
10	76	0.012	2.16 x 10^{-7}	€10,359,773	€3,578
20	153	0.005	9.00 x 10^{-8}	€20,855,859	€282
Total				**€40,615,193**	**€2,287**

8 CONCLUSIONS AND RECOMMENDATIONS

A quantitative risk assessment (QRA) and environmental assessment of the proposed facilities at the Combined Cycle Gas Turbine (CCGT) power plant establishment at Great Island has been conducted. For the purposes of the QRA, the facilities were considered to be:

- the AGI;
- gas line between the AGI and the gas compressor;
- gas compression;
- gas line between the gas compressor and gas turbine;
- the jetty unloading arms; and
- distillate storage tank.

The jetty unloading lines (from jetty head to distillate storage); and transformer fires and explosions were also considered, but were not included in the quantified analysis as the associated risk levels were not deemed to be significant.

8.1 FATALITY RISKS

The inner, middle and outer zones, corresponding to individual risk levels of $1x10^{-5}$, 1×10^{-6} and 1×10^{-7} respectively were computed. None of these contours extended to areas offsite where members of the general public would normally be present. The inner zone covered most of the plant facilities and whilst the zones extended outside the site boundary, they only covered a small area beyond the coastline to the south and an area of vegetation to the east where members of the general public would not be expected to be present. The hazards distances do not extend other offsite buildings that could result in escalation. Although the flammability envelope and the effects from jet flames could extend to the jetty area, the risk of escalation to any ships refuelling would be negligible on the basis of the low risk of occurrence and the probability of a ship being present.

The HSA guidance document for COMAH based land use planning states that with respect to new establishments the individual risk of fatality should not be greater than 5×10^{-6} (per year) to their current non-residential type neighbours or a risk of fatality greater than 1×10^{-6} (per year) to the nearest residential type property. Since the individual risk of fatality contours do not encompass any offsite developments, it can be demonstrated that the risks are acceptable.

No societal risks were calculated for offsite personnel because none of the risk zones encompassed areas where people would normally be present. The societal risks therefore only related to members of the workforce and these were determined to be broadly acceptable.

8.2 ENVIRONMENTAL RISK

The environmental risks were considered to arise from spills of distillate being released into the marine environment from failures during unloading and catastrophic failure of a storage tank.

A number of proposed measures were assessed for reducing the environmental risks through containing and preventing distillate from reaching the marine environment following catastrophic failure of a storage tank. For a single distillate tank, the calculated threshold costs ranged from €74,227 for increasing the embankment angle (on the south side) so that it is vertical to €297,685 for tertiary containment or increasing the embankment angle to 90^0 and increasing the bund wall height so that all the distillate released would be contained.

There was a considerable variation in the estimated costs for implementing the measures, which ranged from €300,000 for constructing a 1.5m baffle wall within the existing bunded area at the base of the dyke to around €3.34 million for the installation of a single doubled-walled tank. In all cases the estimated costs exceed the calculated threshold cost. The recommended measure for implementation is to increase the height of the bund wall by 2m, but maintain the slope of the embankment at 60 degrees, on the south, east and west sides of the storage area. This is estimated to cost €740,000.

Bearing in mind that some of the liquid overtopping the bund on the northern side is likely to flow back into the bund and that the cost to implement measures on the northern side would be significantly greater than the threshold cost, it can be argued that there is no need to implement measures in terms of increasing the bund angle or height on the northern side. The upper 3m of the dyke should be sealed to prevent any ground contamination in the event of a spillage. This is estimated to cost €45,000.

9 REFERENCES

1. Policy and Approach of the Health and Safety Authority to COMAH Risk-based Land Use Planning, HSA (2009)

2. HSE (2000). Risk Assessment Methodology for Storage of Refrigerate Flammable Liquids. Planning Case Assessment Guide Chapter 6K.

3. Council Directive, 96/82/EC on the control of major accident hazards involving dangerous substances.

4. G. Weiss, Hazardous Chemicals Data Book, Second Edition (1986).

5. National Authority for Occupational Safety and Health (2002). Code of Practice for the Safety, Health and Welfare at Work (Chemical Agents) Regulations (2001).

6. NTIS Publication No. PB-94-195047: Documentation for Immediately Dangerous to Life or Health Concentrations (IDLH): NIOSH Chemical Listing and Documentation of Revised IDLH Values

7. The Buncefield Incident 11 December 2005: The Final Report of the Major Incident Investigation Board (2008). Available at: http://www.buncefieldinvestigation.gov.uk/reports/volume1.pdf [Accessed 27 August 2009]

8. ACDS, Major Hazard Aspects of the Transport of Dangerous Substances, (1991).

9. The Oil Industry International Exploration and Production (E&P) Forum, 1992, Hydrocarbon Leak and Ignition Data Base. Report No. 11.4/180.

10. A W Cox, F P Lees and M L Ang, Classification of Hazardous Locations, IChemE, (1990).

11. Eisenberg, N.A., Lynch, C.J. and Breeding, R.J., 'Vulnerability Model. A Simulation System for Assessing Damage Resulting from Marine Spills', NTIS report AD-A015-245, 1975.

12. Hurst, N.W., Nussey, C. and Pape, R.P., 'Development and Application of a Risk Assessment Tool (RISKAT) in the Health and Safety Executive', Chem. Eng. Res. Des., Vol. 67, (July 1989).

13. Chemical Industries Association, 'Guidance for the Location and Design of Occupied Buildings on Chemical Manufacturing Sites', Second Edition, (2003).

14. UK HSE PCAS Chapter 5A

15. Modelling Oil Spill Response and Damage Costs Dagmar Schmidt Etkin, 2004. Environment Research Consulting Cortlandt Manor, NY, USA

16. HSE (2001). Reducing Risks, Protecting People. HSE Books, C100

17. Mott McDonald, Toomes CCGT Power Station, Major Accident Hazards, February 2008

ERM has over 100 offices Across the following countries worldwide

Argentina
Australia
Belgium
Brazil
China
France
Germany
Hong Kong
Hungary
India
Indonesia
Ireland
Italy
Japan
Korea
Malaysia
Mexico
Netherlands
Peru
Poland
Portugal
Puerto Rico
Singapore
Spain
Sweden
Taiwan
Thailand
UK
USA
Venezuela
Vietnam

ERM's Dublin Office

Suite 508
The Capel Building
Mary's Abbey
Dublin 7
Tel: 01 814 7700
Fax: 01 814 7777

ERM