SHANNON FOYNES PORT COMPANY

MAINTENANCE DREDGING

DUMPING AT SEA PERMIT APPLICATION

Application Attachments

SFPC Maintenance Dredging
Dumping at Sea Permit Application Attachments
-
04 July 2019

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Attachment A.2

NIS Prepared in Support of Statutory Application

(UNDER SEPARATE COVER)

Attachment A.4

Newspaper Advertisement

TO FOLLOW POST APPLICATION

Attachment A.7

Current/Previous Permits

Environmental Protection Agency
An Ghníomhaireacht um Chaomhnú Comhshaoil

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Mr John Carlton
Shannon Foynes Port Company
Foynes
Co Limerick

22 January 2013 Reg. No. S0009-02

re: Notice of a decision on a dumping at sea permit application in accordance with the Dumping at Sea Acts 1996 to 2012.

Dear Mr Carlton,

In accordance with the Dumping at Sea Acts as amended, the Agency hereby notifies you of its decision to grant a dumping at sea permit subject to conditions to Shannon Foynes Port Company. Please find accompanying a copy of the Agency's decision.

All documentation relating to the application is available to view on the Agency's website at www.epa.ie, including information on public participation and judicial review processes.

Please use the register number of the dumping at sea permit, **S0009-02**, in any future communication in respect of same.

You will be contacted in due course by an inspector in the Office of Environmental Enforcement, Environmental Protection Agency who will discuss the implementation of the conditions of the licence.

Yours sincerely,

Eve O'Sullivan
Programme Officer
Office of Environmental Licensing Programme

Encl.

Headquarters
P.O. Box 3000
Johnstown Castle Estate
County Wexford
Ireland

DUMPING AT SEA PERMIT

Permit Register Number:	**S0009-02**
Permit Holder:	**Shannon Foynes Port Company** **Mill House** **Foynes** **County Limerick**
Location of Loading:	**Foynes Port and Limerick Dock**
Location of Dumping:	**Shannon Estuary**

Environmental Protection Agency
An Ghníomhaireacht um Chaomhnú Comhshaoil

HEADQUARTERS
JOHNSTOWN CASTLE ESTATE
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DUMPING AT SEA ACTS 1996 TO 2010

DUMPING AT SEA PERMIT

Decision of the Agency, under Section 5(1) of the
Dumping at Sea Acts 1996 to 2010.

Reference number: **S0009-02**

The Agency in exercise of the powers conferred on it by the Dumping at Sea Acts 1996 to 2010, for the reasons hereinafter set out, hereby grants this dumping at sea permit to Shannon Foynes Port Company in respect of Foynes Port and Limerick Dock, subject to conditions, as set out in the schedule attached hereto.

The permit authorises the loading and dumping at sea of dredged material from Foynes Port and Limerick Dock subject to conditions.

A copy of the Decision is attached.

Loading and dumping at sea of a substance or material, in accordance with the Dumping at Sea Acts 1996 to 2010

GIVEN under the Seal of the Agency this 22nd day of January 2013

PRESENT when the seal of the Agency was affixed hereto:

Frank Clinton, Authorised Person

INTRODUCTION

This introduction is not part of the permit and does not purport to be a legal interpretation of the permit.

This permit is for the loading of dredged material from maintenance dredging at Foynes Port and Limerick Dock and the dumping of the dredged material in the Shannon Estuary. Chemical analysis has confirmed that the material in question is suitable for dumping at sea. Under this permit, a maximum of 276,000 tonnes of material shall be loaded and dumped annually by trailer suction hopper dredger, up to a total maximum of 1,656,000 tonnes over six years. A limited quantity of material (16,000 tonnes) is also permitted to be plough dredged annually, up to a total maximum of 96,000 tonnes over six years. The permit holder is required to manage the permitted activities to ensure the protection of the marine environment and to submit reports on the loading and dumping activities and monitoring results to the Agency.

The permit sets out in detail the conditions under which Shannon Foynes Port Company will carry out loading and dumping at sea.

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Glossary of Terms

All terms in this permit should be interpreted in accordance with the definitions in the Dumping at Sea Acts 1996 to 2010, unless otherwise defined in the section.

AER	Annual Environmental Report.
Agreement	Agreement in writing.
Annually	All or part of a period of twelve consecutive months.
Application	The application by the permit holder for this permit.
Attachment	Any reference to Attachments in this permit refers to attachments submitted as part of this permit application.
Campaign	A planned period of sustained activity.
CEN	Comité Européen De Normalisation – European Committee for Standardisation.
Chart	Any reference to a chart or chart number means a chart or chart number contained in the application, unless otherwise specified in this permit.
Competent laboratory	A testing facility meeting the general management and technical requirements of EN ISO/IEC-17025 standard, or other equivalent standards accepted at international level and utilising methods of analysis, including laboratory, field, and on-line methods, which are validated and documented in accordance with the above standard(s) for the specific tests.
Closed period	Period of time when loading and dumping at sea is prohibited in order to protect designated species or sites.
Day	Any 24 hour period.
Daytime	0800 hrs to 2200 hrs.
DBT	Dibutyltin
Documentation	Any report, record, results, data, drawing, proposal, interpretation or other document in written or electronic form which is required by this permit.
Dumping	(a) any deliberate disposal in the maritime area (including side-cast dredging, plough dredging, water injection dredging and other such dredging techniques) of a substance or material from or in conjunction with a vessel or aircraft or offshore installation; and (b) any deliberate disposal in the maritime area of vessels, aircraft or offshore installations.

Drawing	Any reference to a drawing or drawing number means a drawing or drawing number contained in the application, unless otherwise specified in this permit.
Environmental damage	As defined in Directive 2004/35/EC.
EPA	Environmental Protection Agency.
Exclusive economic zone	The outer limit of the exclusive economic zone is the line every point of which lies at a distance of 200 nautical miles from the nearest point of the baseline
Harbour Authority	As defined in Section 1 of the Dumping at Sea Acts 1996 to 2010.
HCB	Hexachlorobenzene
HCH	Hexachlorocyclohexane
Incident	The following shall constitute as incident for the purposes of this permit: (i) an emergency; (ii) any loading or dumping at sea activity which does not comply with the requirements of this permit; (iii) any indication that environmental pollution has, or may have, taken place; and (v) a complaint of an environmental nature.
Inland waters	All sea areas which lie on the landward side of the baseline of the territorial seas.
Maintain	Keep in a fit state, including such regular inspection, servicing, calibration and repair as may be necessary to perform its function adequately.
Master	The person having the command or charge of the vessel.
Monthly	A minimum of 12 times per year, at intervals of approximately one month.
Neap tide	The tide with the smallest tidal range (i.e. the lowest high water and the highest low water), occurring twice monthly at the middle of the moon's first and last quarters.
Noise-sensitive location (NSL)	Any dwelling house, hotel or hostel, health building, educational establishment, place of worship or entertainment, or any other facility or area of high amenity which for its proper enjoyment requires the absence of noise at nuisance levels.
OSPAR	Convention for the Protection of the Marine Environment of the North-East Atlantic

PAH	Polycyclic aromatic hydrocarbons
PCB	Polychlorinated biphenyls
Permit Holder	Shannon Foynes Port Company, Mill House, Foynes, County Limerick.
RPII	Radiological Protection Institute of Ireland.
Position	Latitude and longitude coordinates in degrees and decimal minutes, based on the WGS 84 datum.
Sample(s)	Unless the context of this permit indicates to the contrary, the term sample(s) shall include measurements taken by electronic instruments.
Spring tide	The tide with the greatest tidal range (i.e. the highest high water and the lowest low water), occurring twice monthly at the full and new moon periods.
Standard Method	A National, European or internationally recognised procedure (e.g., I.S. EN, ISO, CEN, BS or equivalent); or an in-house documented procedure based on the above references; a procedure as detailed in the current edition of "Standard Methods for the Examination of Water and Wastewater" (prepared and published jointly by A.P.H.A., A.W.W.A. & W.E.F.), American Public Health Association, 1015 Fifteenth Street, N.W., Washington DC 20005, USA; or an alternative method as may be agreed by the Agency.
TBT	Tributyltin
TEH	Total extractable hydrocarbons
The Agency	Environmental Protection Agency.
The Maritime Area	As defined in Section 1 of the Dumping at Sea Acts 1996 to 2010, 'the maritime area' comprises: (i) the inland waters and territorial seas of the State, and the seabed and subsoil beneath them; (ii) any area for the time being standing designated by order under section 2 of the Continental Shelf Act 1968 for the purposes of that Act, and the waters above it; and (iii) the exclusive economic zone of the State.
Triennially	Once every three years.

Decision & Reasons for the Decision

The Environmental Protection Agency is satisfied, on the basis of the information available, that subject to compliance with the conditions of this permit, the loading and dumping activities will comply with and will not contravene any of the requirements of Section 5 of the Dumping at Sea Acts 1996 to 2010.

In reaching this decision the Environmental Protection Agency has considered the application and supporting documentation received from the applicant, all submissions received from other parties and the report of its inspector.

Part I Schedule of Activities Permitted

In pursuance of the powers conferred on it by the Dumping at Sea Acts 1996 to 2010, the Environmental Protection Agency (the Agency), under Section 5 of the said Acts, grants this Dumping at Sea Permit to Shannon Foynes Port Company, Mill House, Foynes, County Limerick. The permit authorises the loading and dumping at sea activities described below, subject to conditions listed in Part II, with the reasons therefor and the associated schedules attached thereto.

Part II Conditions

Condition 1. Scope

1.1 Statutory Obligations

1.1.1 This permit is for the purposes of loading and dumping at sea under the Dumping at Sea Acts 1996 to 2010, only and nothing in this permit shall be construed as negating the permit holder's statutory obligations or requirements under any other enactments or regulations.

1.1.2 This permit may be technically amended, as and when considered necessary by the Agency.

1.2 The material or substance to which this permit relates shall be dredged material from that part of the sea specified in *Schedule A: Limitations*, of this permit.

1.3 For the purposes of this permit, the locations of the loading areas authorised by this permit are in those parts of the maritime area bounded by the coordinates specified in *Schedule A: Limitations,* of this permit and outlined in red on Drawings No. 1 and 2 of Attachment B.3 of the application for this permit. Any reference in this permit to "loading areas" shall mean the areas thus outlined. The permitted loading activity shall be carried out only within the areas outlined.

1.4 For the purposes of this permit, the locations of the dumping sites authorised by this permit are in those parts of the maritime area bounded by the coordinates specified in *Schedule A: Limitations,* of this permit and outlined in blue on Maps No. 3 and 4 of Attachment E.2 of the application for this permit. Any reference in this permit to "dumping sites" shall mean the areas thus outlined. The permitted dumping activity shall be carried out only within the areas outlined.

1.5 For the purposes of this permit, the locations of the plough dredging areas authorised by this permit are in those parts of the maritime area bounded by the coordinates specified in *Schedule A: Limitations*, of this permit. The permitted plough dredging activity shall be carried out only within the areas outlined.

1.6 Loading and dumping at sea shall be limited as set out in *Schedule A: Limitations*, of this permit.

1.7 Loading and dumping at sea shall be controlled and operated as set out in the permit. All programmes required to be carried out under the terms of this permit become part of this permit.

1.8 No change to the loading and dumping activities authorised by this permit shall be commenced without the prior written agreement of the Agency.

Reason: ***To clarify the scope of this permit.***

Condition 2. Management of the loading and dumping at sea activities

2.1 The permit holder shall adopt all reasonably practicable measures to minimise the noise impact of the permitted activities. Noise from the permitted activities shall not cause a nuisance at any NSLs.

2.2 The permit holder shall ensure that personnel performing specifically assigned tasks shall be qualified on the basis of appropriate education, training and experience as required and shall be aware of the requirements of this permit.

2.3 The permit holder shall ensure that a nominated, suitably qualified and experienced person is present at all times when activities covered by this permit are ongoing.

2.4 The permit holder shall notify the Agency at least two weeks prior to the commencement of the loading and dumping activities, unless otherwise agreed by the Agency,

2.5 Documentation

The permit holder shall issue a copy of this permit to all relevant personnel whose duties relate to any condition of this permit.

2.6 Corrective Action

The permit holder shall initiate an investigation and corrective action in the event of a reported non-conformity with this permit to the satisfaction of the Agency.

2.7 Communications Programme

The permit holder shall, within one month of the date of grant of this permit, establish and maintain a Public Awareness and Communication Programme to ensure members of the public can obtain information at reasonable times.

Reason: ***To make provision for management of the loading and dumping at sea activities on a planned basis having regard to the desirability of ongoing assessment, recording and reporting of matters affecting the marine environment.***

Condition 3. Loading and dumping at sea activities

3.1 Loading and dumping activities must be completed within six years of the date of commencement of the permitted activities.

3.2 A closed period from 1st February to 30th June inclusive shall apply to all loading and dumping activities, including plough dredging, at Limerick Dock and Limerick Approach Channel.

3.3 Plough dredging that is urgently required for the purpose of navigational safety shall only be permitted during the closed period specified in Condition 3.2 with the prior written agreement of the Agency.

3.4 No material shall be dumped at sea which has been categorised as unsuitable for disposal.

3.5 Loading shall be carried out by trailing suction hopper dredger.

3.6 The permit holder shall take all reasonably practicable measures during loading to limit the release of suspended solids into the water column.

3.7 Dumping from the trailer suction hopper dredger shall be effected by release of the material through the hull of the vessel while the vessel is in motion.

3.8 Dumping activities shall be conducted to ensure a uniform spread of material throughout the dumping sites.

3.9 Every alternate load of material loaded from Limerick Dock and Limerick Approach Channel shall be dumped at Dumping Sites A, B and C in rotation.

3.10 Dumping at Dumping Sites A and B shall be conducted on ebb tides as far as reasonably practicable.

3.11 Plough dredging shall be confined to those areas specified in *Schedule A.3 Location of Plough Dredging Areas*, of this permit.

3.12 Plough dredging shall be conducted during daytime hours only.

3.13 Plough dredging shall be conducted on ebb tides only.

3.14 Plough dredging shall be conducted during spring tides as far as reasonably practicable.

3.15 All mitigation measures set out in the Natura Impact Statement submitted as part of the application for this permit shall be implemented unless otherwise agreed by the Agency.

3.16 Following submission of the results of the sediment analysis specified in Condition 4.5 and *Schedule B.1 Monitoring at Loading Areas*, of this permit, loading and dumping activities may not proceed without the written agreement of the Agency.

3.17 The permit holder shall liaise with the Harbour Master at the Shannon Foynes Port Company prior to the commencement of and during the loading and dumping activities.

3.18 Information relating to the activity shall be automatically recorded during each dumping voyage and shall as a minimum contain details of the following:

(i) The name of the vessel;

(ii) The source of the substance or material;

(iii) The date, time, location and position at which the voyage for the purposes of dumping began;

(iv) The date, time and position at which dumping began;

(v) The date, time and position at which dumping ended;

(vi) The quantity, stated in metric tonnes, of the substance or material dumped;

(vii) The date, time and position at which the vessel completed the voyage for the purpose of dumping; and

(viii) Logged vessel track record data.

3.19 Prior to the commencement of the permitted activity, the permit holder shall consult with the Marine Survey Office of the Department of Transport to ensure that all vessels used in connection with the loading and dumping activities specified in this permit meet the requirements of the Marine Survey Office. The permit holder shall ensure that the vessels used in connection with this permit are fully certified for the entire period of loading and dumping activities specified in this permit.

3.20 The permit holder shall permit authorised officers to be on board the vessel. They shall permit and facilitate the carrying out by the authorised officer of his functions under the Dumping at Sea Acts 1996 to 2010, and shall comply with the provisions of those Acts in relation to the authorised officer and those functions.

Reason: ***To provide for appropriate controls on loading and dumping at sea activities to ensure the protection of the marine environment.***

Condition 4. Control and Monitoring

4.1 The permit holder shall carry out such sampling, analyses, measurements, examinations, maintenance and calibrations as set out below and in accordance with *Schedule B: Monitoring* of this permit.

4.1.1 Analyses and measurements shall be undertaken by competent staff in accordance with documented operating procedures.

4.1.2 Such procedures shall be assessed for their suitability for the test matrix and performance characteristics shall be determined.

4.1.3 Such procedures shall be subject to a programme of Analytical Quality Control using control standards with evaluation of test responses.

4.1.4 Analysis for compliance purposes, including any sub-contracted analysis, shall be done by a competent laboratory or competent person.

4.2 The permit holder shall ensure that:

(i) sampling and analysis for all parameters listed in the schedules to this permit; and

(ii) any reference measurements for the calibration of automated measurement systems;

shall be carried out by an appropriate Standard Method.

4.3 The frequency, methods and scope of monitoring, sampling and analyses, as set out in this permit, may be amended with the agreement of the Agency following evaluation of test results.

4.4 Bathymetry

4.4.1 The permit holder shall carry out pre-loading and post-loading bathymetric surveys of the loading areas in accordance with *Schedule B.1 Monitoring at Loading Areas*, of this permit.

4.4.2 The permit holder shall carry out pre-dumping and post-dumping bathymetric surveys of the dumping sites in accordance with *Schedule B.2 Monitoring at Dumping Sites*, of this permit.

4.4.3 The permit holder shall carry out pre-dredge and post-dredge bathymetric surveys of the plough dredging areas in accordance with *Schedule B.3 Monitoring at Plough Dredging Areas*, of this permit.

4.5 Sediment analysis

4.5.1 The permit holder shall carry out analysis of the sediment at the loading areas in accordance with *Schedule B.1 Monitoring at Loading Areas*, of this permit. A report on this analysis shall be submitted to the Agency within 1 month of completion of the analysis.

4.6 Marine Mammals

4.6.1 An independent Marine Mammal Observer with relevant expertise shall accompany the loading/dumping vessel(s) in the vicinity of Foynes to monitor and record the activity of dolphins during the duration of the permitted activities.

4.6.2 All loading/dumping activity shall be suspended if dolphin activity occurs within a distance of 2.5 km (approximately 1.5 nautical miles) of the vessel(s).

4.6.3 A report on the monitoring to which this condition refers shall be forwarded to offshore@ahg.gov.ie within 1 month of completion of each loading/dumping campaign. The report shall also be submitted to the Agency as part of the Annual Environmental Report.

4.7 Archaeology

4.7.1 The Underwater Archaeology Unit of the Department of Arts, Heritage and the Gaeltacht shall be informed immediately if material of archaeological potential is recovered during the course of the loading activity.

4.7.2 The fishweir complex at O'Brien's Point shall be re-assessed in 2016 by a suitably qualified archaeologist under a licence issued by the Department of Arts, Heritage and the Gaeltacht. The archaeological report shall be submitted to the Agency as part of the Annual Environmental Report.

Reason: ***To provide for the protection of the marine environment by way of monitoring of the impacts associated with the loading and dumping at sea activities.***

Condition 5. Incident Prevention and Emergency Response

5.1 Incidents

In the event of an incident the permit holder shall immediately:

(i) identify the date, time and place of the incident;

(ii) as soon as practicable notify the Agency, in a format prescribed, and other relevant authorities;

(iii) carry out an investigation to identify the nature, source and cause of the incident and any impact arising therefrom;

(iv) isolate the source of any such impact;

(v) evaluate the environmental pollution, if any, caused by the incident; and

(vi) identify and execute measures to minimise the impact and the effects thereof;

5.2 The permit holder shall provide a report of the investigation into the incident to the Agency for its agreement within one month of the incident occurring or as otherwise agreed by the Agency. The report shall include a proposal to:

(i) identify and put in place measures to avoid recurrence of the incident; and

(ii) identify and put in place any other appropriate remedial actions.

5.3 The permit holder shall, in advance of the commencement of the activities, ensure that a documented Accident Prevention Procedure is in place that addresses hazards, particularly in relation to the prevention of accidents with a possible impact on the environment.

5.4 The permit holder shall, in advance of the commencement of the activities, ensure that a document Emergency Response Procedure is in place that addresses any emergency situation which may arise. This procedure shall include provision for minimising the effects of any emergency on the environment.

Reason: ***To provide for the protection of the marine environment.***

Condition 6. Notification, Records and Reports

6.1 The permit holder shall notify the Agency by both telephone and either email or webform, to the Agency's headquarters in Wexford, or to such other Agency office as may be specified by the Agency, as soon as practicable after the occurrence of any incident (as defined in this permit). The permit holder shall include as part of the notification, the date and time of the incident, summary details of the occurrence, and where available, the steps taken to minimise any impacts.

6.2 In the case of any incident relating to any impact on water, the permit holder shall notify the Marine Institute, Sea Fisheries Protection Authority, Inland Fisheries Ireland, Bord Iascaigh Mhara and any other relevant authorities as soon as practicable after such an incident.

6.3 In the case of any incident relating to archaeology, marine mammals or migratory fish, the permit holder shall notify the National Parks and Wildlife Service, Marine Institute, Sea Fisheries Protection Authority and Inland Fisheries Ireland and any other relevant authorities as soon as practicable after such an incident.

6.4 The permit holder shall make a record of any incident. This record shall include details of the nature, extent, and impact of, and circumstances giving rise to, the incident. The record shall include all corrective actions taken to manage the incident, and the effect on the marine environment, and avoid recurrence. The permit holder shall, as soon as practicable following incident notification, submit to the Agency the incident record.

6.5 The permit holder shall record all complaints related to the loading and dumping activities. Each such record shall give details of the date and time of the complaint, the name of the complainant (if provided), and give details of the nature of the complaint. A record shall be kept of the response made and any corrective action undertaken in the case of each complaint. This record shall be made available to the Agency upon request.

6.6 The permit holder shall as a minimum keep the following documents:

(i) the permit(s) relating to the dumping sites;

(ii) the previous years' AERs for the dumping sites;

(iii) records of all sampling, analyses, measurements, examinations, calibrations and maintenance carried out in accordance with the requirements of this permit and any previous permits dating back at least three years;

(iv) all correspondence with the Agency;

(v) complaints register; and

(vi) up to date drawings/plans showing the location of the loading areas and the dumping sites authorised by this permit.

This documentation shall be available to the Agency for inspection at all reasonable times and shall be submitted to the Agency, as required, in such a format as may be requested, including electronic submittal of the information or a summary of such information.

6.7 The permit holder shall submit electronically to the Agency, by the 31st March of each year, an AER covering the previous calendar year. This report shall include as a minimum the information specified in *Schedule C: Annual Environmental Report*, of this permit and shall be prepared in accordance with any relevant guidelines issued by the Agency or as otherwise prescribed by the Agency.

6.8 A full record, which shall be open to inspection by authorised officer of the Agency at all times, shall be kept by the permit holder on matters relating to each load of the substance or material intended to be dumped, and put on board the vessel. This record shall be maintained continually and shall as a minimum contain those details specified in Condition 3.19 of this permit. This information shall be submitted as required by and as may be prescribed by the Agency as part of the annual environmental report and immediately on request by an authorised officer.

6.9 All reports shall be certified accurate and representative by the permit holder, manager or a nominated, suitably qualified and experienced deputy.

6.10 The permit holder shall notify the Agency in writing upon completion of the loading and dumping activities to which this permit relates.

Reason: ***To provide for the collection and reporting of adequate information on the loading and dumping at sea activity.***

Condition 7. Financial Charges and Provisions

7.1 Agency Charges

7.1.1 The permit holder shall pay to the Agency a contribution or such sum, as the Agency from time to time determines having regard to variations in the extent of reporting, auditing, inspections, sampling and analysis or other functions carried out by the Agency, towards the cost of monitoring the discharges as the Agency considers necessary for the performance of its functions under the Dumping at Sea Acts 1996 to 2010.

7.1.2 The cost of any other tests, sampling, analysis and monitoring which the Agency may require in relation to the loading and dumping of the substance or material the subject of this permit shall be borne by the permit holder. Furthermore, the cost of any tests, sampling, analysis and monitoring surveys carried out by an authorised officer or by or on behalf of the Agency in relation to the sampling of a substance or material the subject of this permit shall also be borne by the holder of the permit.

7.2 The Permit Holder shall indemnify the Agency and its authorised officers against all cost occurred by him as a result of a breach of any of the conditions of this permit.

7.3 Environmental Liabilities

7.3.1 The permit holder shall as part of the AER, provide an annual statement as to the measures taken or adopted at the loading areas and the dumping sites in relation to the prevention of environmental damage, and the financial provisions in place in relation to the underwriting of costs for remedial actions following anticipated events or accidents/incidents, as may be associated with loading and dumping at sea.

7.3.2 The permit holder shall arrange for the completion, by an independent and appropriate qualified consultant, of a comprehensive and fully costed Environmental Liabilities Risk Assessment (ELRA) to address the liabilities from loading and dumping at sea. A report on this assessment, to the satisfaction of the Agency, shall be submitted as part of the second AER (required under Condition 6.7). The ELRA shall be reviewed as necessary to reflect any significant change to the volume or character of the material/substance to be loaded and dumped at sea, and in any case every three years following initial agreement. The results of the review shall be notified as part of the AER.

7.3.3 As part of the measures identified in Condition 7.3.1, the permit holder shall, to the satisfaction of the Agency, make financial provision to cover any liabilities identified in Condition 7.3.2. The amount of indemnity held shall be reviewed and revised as necessary, but at least triennially. Proof of renewal or revision of such financial indemnity shall be included in the annual 'Statement of Measures' report identified in Condition 7.3.1.

7.3.4 The permit holder shall have regard to the most recent Environmental Protection Agency Guidance on Environmental Liability Risk Assessment, Decommissioning Management Plans and Financial Provision when implementing Conditions 7.3.2 and 7.3.3 above.

Reason: ***To provide for adequate financing for monitoring and financial provisions for measures to protect the marine environment.***

SCHEDULE A: Limitations

A.1 Dumping at sea of a material/substance

Quantity of Material to be Loaded and Dumped at Sea

Material/ substance	Dumping Site	Maximum quantity to be dumped annually (tonnes)	Total maximum quantity to be dumped over 6 years (tonnes)
Dredged material	Dumping Site A	40,000	240,000
	Dumping Site B	40,000	240,000
	Dumping Site C	196,000	1,176,000
	Total	276,000	1,656,000

Quantity of Material to be Plough Dredged

Material/ substance	Plough Dredging Area	Maximum quantity to be dumped annually (tonnes)	Total maximum quantity to be dumped over 6 years (tonnes)
Dredged material	A: Limerick Dock	1,000	6,000
	B: Limerick Approach Channel	5,000	30,000
	C: Foynes Harbour	10,000	60,000
	Total	16,000	96,000

A.2 Location of Loading Areas

Loading Area A: Limerick Dock

	Latitude	Longitude
(i)	52°39.600′ N	8°38.370′ W
(ii)	52°39.546′ N	8°38.328′ W
(iii)	52°39.444′ N	8°38.664′ W
(iv)	52°39.474′ N	8°38.682′ W
(v)	52°39.492′ N	8°38.616′ W
(vi)	52°39.498′ N	8°38.622′ W
(vii)	52°39.498′ N	8°38.676′ W
(viii)	52°39.510′ N	8°38.676′ W
(ix)	52°39.510′ N	8°38.616′ W
(x)	52°39.558′ N	8°38.568′ W

Loading Area B: Limerick Approach Channel

	Latitude	Longitude
(i)	52°39.558′ N	8°38.916′ W
(ii)	52°39.558′ N	8°38.676′ W
(iii)	52°39.498′ N	8°38.676′ W
(iv)	52°39.498′ N	8°38.916′ W

Loading Area C: Foynes Harbour

	Latitude	Longitude
(i)	52°36.816′ N	9°6.624′ W
(ii)	52°36.918′ N	9°6.576′ W
(iii)	52°36.918′ N	9°6.498′ W
(iv)	52°36.954′ N	9°6.222′ W
(v)	52°36.978′ N	9°6.138′ W
(vi)	52°36.990′ N	9°6.066′ W
(vii)	52°36.990′ N	9°6.024′ W
(viii)	52°36.984′ N	9°5.982′ W
(ix)	52°36.966′ N	9°5.934′ W
(x)	52°36.948′ N	9°5.916′ W
(xi)	52°36.912′ N	9°5.916′ W
(xii)	52°36.894′ N	9°5.934′ W
(xiii)	52°36.768′ N	9°6.354′ W

Loading Area D: Foynes Approach Channel

	Latitude	Longitude
(i)	52°36.816′ N	9°6.624′ W
(ii)	52°36.918′ N	9°6.822′ W
(iii)	52°37.122′ N	9°7.854′ W
(iv)	52°37.176′ N	9°7.854′ W
(v)	52°36.942′ N	9°6.654′ W
(vi)	52°36.918′ N	9°6.576′ W

A.3 Location of Plough Dredging Areas

Plough Dredging Area A: Limerick Dock

	Latitude	Longitude
(i)	52°39.600′ N	8°38.370′ W
(ii)	52°39.546′ N	8°38.328′ W
(iii)	52°39.444′ N	8°38.664′ W
(iv)	52°39.474′ N	8°38.682′ W
(v)	52°39.492′ N	8°38.616′ W
(vi)	52°39.498′ N	8°38.622′ W
(vii)	52°39.498′ N	8°38.676′ W
(viii)	52°39.510′ N	8°38.676′ W
(ix)	52°39.510′ N	8°38.616′ W
(x)	52°39.558′ N	8°38.568′ W

Plough Dredging Area B: Limerick Approach Channel

	Latitude	Longitude
(i)	52°39.500′ N	8°38.680′ W
(ii)	52°39.500′ N	8°38.850′ W
(iii)	52°39.530′ N	8°38.850′ W
(iv)	52°39.520′ N	8°38.680′ W

Plough Dredging Area C: Foynes Harbour

	Latitude	Longitude
(i)	52°36.890′ N	9°5.930′ W
(ii)	52°36.770′ N	9°6.350′ W
(iii)	52°36.820′ N	9°6.620′ W
(iv)	52°36.840′ N	9°6.620′ W
(v)	52°36.800′ N	9°6.350′ W
(vi)	52°36.910′ N	9°5.950′ W

A.4 Location of Dumping Sites

Dumping Site A

	Latitude	Longitude
(i)	52°40.542′ N	8°44.394′ W
(ii)	52°40.350′ N	8°43.794′ W
(iii)	52°40.440′ N	8°44.424′ W

Dumping Site B

	Latitude	Longitude
(i)	52°40.668′ N	8°51.192′ W
(ii)	52°40.722′ N	8°50.688′ W
(iii)	52°40.620′ N	8°50.658′ W
(iv)	52°40.572′ N	8°51.108′ W

Dumping Site C

	Latitude	Longitude
(i)	52°37.194′ N	9°8.850′ W
(ii)	52°37.542′ N	9°8.484′ W
(iii)	52°37.458′ N	9°8.328′ W
(iv)	52°37.122′ N	9°8.688′ W

A.5 Closed Period

From	To	Applicable Areas	Reason for Closed Period
1st February	30th June	Loading Areas A and B Dumping Sites A and B Plough Dredging Areas A and B Note 1	Primarily for the protection of migratory fish

Note 1: With the exception of emergency plough dredging agreed by the Agency in accordance with Condition 3.3 of this permit.

SCHEDULE B: Monitoring

B.1 Monitoring at Loading Areas [Note 1]

Parameters	Timing	Monitoring Locations	Analysis Method/Technique
Bathymetry & concurrent tide observations	Within one week prior to the commencement of each loading campaign. Within one week following completion of each loading campaign.	Loading Areas A, B, C and D.	Bathymetric survey lines to run perpendicular to direction of residual flow; vertical resolution ≥20 cm; horizontal control by DGPS; line interval at 25 m. Tidal height measurements to be taken every 15 minutes at levelled benchmark.
Sediment analysis: Granulometry [Note 2] Total organic carbon Mercury Zinc Nickel Copper Chromium Aluminium Manganese Lithium Lead Arsenic Cadmium Dibutyl tin Tributyl tin γ-HCH (Lindane) HCB PCB 7 [Note 3] PAH [Note 4] TEH Radionuclides	2017	Grab samples of surface sediments to be taken at: Limerick: DR1: 52°39.536′ N, 08°38.825′ W DR2: 52°39.539′ N, 08°38.734′ W DR2: 52°39.461′ N, 08°38.825′ W DR3: 52°38.686′ N, 08°38.825′ W DR4: 52°39.558′ N, 08°38.541′ W DR5: 52°39.580′ N, 08°38.381′ W Foynes: DR6: 52°36.836′ N, 09°06.172′ W DR7: 52°36.810′ N, 09°06.513′ W DR8: 52°36.872′ N, 09°06.689′ W DR9: 52°37.005′ N, 09°06.987′ W	Standard method [Note 5]
Radionuclides	2017	To be agreed by the RPII	Standard method
Marine mammals	Duration of the loading activities	Loading Areas C and D	Monitoring to be undertaken by an independent Marine Mammal Observer with relevant experience

Note 1: The frequency, methods and scope of monitoring, sampling and analyses may be amended in accordance with Condition 4.3.

Note 2: Monitoring of granulometry shall include the following fractions: >2 mm, <2 mm, >63 μm and <63 μm.

Note 3: ICES 7 polychlorinated biphenyls: PCB 028/052/101/138/153/180/118.

Note 4: Polycyclic aromatic hydrocarbons: Naphthalene, Acenaphthylene, Acenaphthene, Fluorene, Phenanthrene, Anthracene, Fluoranthene, Pyrene, Benzo(a)anthracene, Chrysene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Benzo(a)pyrene, Dibenzo(ah)anthracene, Benzo(ghi)perylene, Indeno(123-cd)pyrene.

Note 5: Sampling and analyses shall be conducted in accordance with the analytical and quality requirements set out in: *M. Cronin et al. 2006. Guidelines for the Assessment of Dredge Material for Disposal in Irish Waters. Marine Environment & Health Series, No. 24. Marine Institute.*

B.2 Monitoring at Dumping Sites Note 1

Parameters	Timing	Monitoring Locations	Analysis Method/Technique
Bathymetry & concurrent tide observations	Within one week prior to commencement of each dumping campaign. Within one week following completion of each dumping campaign.	Dumping Sites A, B and C.	Bathymetric survey lines to run perpendicular to direction of residual flow; vertical resolution ≥20 cm; horizontal control by DGPS; line interval at 25 m. Tidal height measurements to be taken every 15 minutes at levelled benchmark.
Marine mammals	Duration of the dumping activities	Dumping Site C	Monitoring to be undertaken by an independent Marine Mammal Observer with relevant experience
Archaeology	2016	Fishweir complex at O'Brien's Point adjacent to Dumping Site C.	Monitoring to be undertaken by a suitably qualified archaeologist under a licence issued by the Department of Arts, Heritage and the Gaeltacht

Note 1: The frequency, methods and scope of monitoring, sampling and analyses may be amended in accordance with Condition 4.3.

B.3 Monitoring at Plough Dredging Areas Note 1

Parameters	Timing	Monitoring Locations	Analysis Method/Technique
Bathymetry & concurrent tide observations	Within one week prior to commencement of each plough dredging campaign. Within one week following completion of each plough dredging campaign.	Plough Dredging Areas A, B and C.	Bathymetric survey lines to run perpendicular to direction of residual flow; vertical resolution ≥20 cm; horizontal control by DGPS; line interval at 25 m. Tidal height measurements to be taken every 15 minutes at levelled benchmark.

Note 1: The frequency, methods and scope of monitoring, sampling and analyses may be amended in accordance with Condition 4.3.

SCHEDULE C: Annual Environmental Report

Annual Environmental Report Content Note 1
Register/log of loading and dumping activities.
OSPAR dumping report.
Marine positional log.
Reported incidents summary.
Complaints summary.
Monitoring summary.
Marine mammal monitoring report.
Accident prevention procedure.
Emergency response procedure.
Statement of measures in relation to prevention of environmental damage and remedial actions (Environmental Liabilities).
Environmental Liabilities Risk Assessment Review (every three years or more frequently as dictated by relevant on-site change including financial provisions.
Any other items specified by the Agency.

Note 1: Content may be revised subject to the agreement of the Agency.

Sealed by the seal of the Agency on this the 22nd day of January 2013

PRESENT when the seal of the Agency
Was affixed hereto:

Frank Clinton, Authorised Person

Attachment A.8

Summary of Activities

- Drawings showing locations of proposed loading areas and dump sites provided in Appendix A.
- Attachment D.3 outlines the proposed loading and dumping methodologies.

Attachment B.1

Sediment Chemistry Results

Attachment B.1 (I)

Dumping at Sea Material Analysis Reporting Form

Copy of Dumping at Sea Material Analysis Reporting Form (in excel format) provided with application.

1. General Information	Applicant (company name)	Shannon Foynes Port Company
	Location (port/harbour)	Foynes and Limerick Dock
	Dredge Quantity (tonnes)	
	Permit Application Reg. No. (to be assigned by EPA)	

2. Survey Information	Survey Company	Hydrographic Surveys Ltd
	Sampling Date	17th July 2017
	Analysing Laboratory	RPS Laboratories
	Sub Contract Lab	
	Analysis Date	19/07/2017 to 14/08/2017

3. Methods Information	Fraction analysed	All testing carried out using the <2mm fraction
	Water content of sample (reported as %)	A portion of the wet sediment is dried at 105°C to constant weight
	Are results reported as wet weight or dry weight?	Dry
	Granulometry method	Wet and dry sieving followed by laser diffraction analysis.
	TEH method	GCFID analysis following extraction of the wet sediment with dichloromethane:methanol by ultrasonic extraction and subsequent partitioning with water. Extract cleaned-up with silica and activated copper
	Organic carbon (OC) method	Combustion and infrared analysis following carbonate removal with hydrochloric acid
	Metals (incl. mercury & arsenic) extraction type	ICP-MS analysis following microwave assisted digestion in hydrofluoric acid of the dried (<30°C) and ground sediment.
	Methods of detection (metals, incl. mercury & arsenic)	ICP-MS analysis following microwave assisted digestion in hydrofluoric acid of the dried (<30°C) and ground sediment.
	Organics extraction types	Combustion and infrared analysis following carbonate removal with hydrochloric acid
	Methods of detection (PCBs / PAHs / TBT / DBT)	TBT & DBT - GCMS analysis following the extraction of the wet sediment and subsequent derivatisation. PCBs and PAHs - GCMS analysis following extraction of the wet sediment with hexaneacetone by ultrasonic and equlibrium extraction. Extract cleaned-up with alumina and activated copper.

EPA Dumping at Sea Permit Application - Material Analysis Reporting Form (Version 1.0)
Sheet 3. Results

SampleIDCode	CompanyName	Location	SamplingDate	SamplingLocationID	PositionLatitude_dec.deg	PositionLongitude_dec.deg	SamplingDepth	LabReportID	SampleAppearance	Moisture_PerCent	2mm_PerCent Greater	2mm_63um_PerCentBetween
DP-01A	*<example> Dublin Port Co.*	*Dublin Port*	*2010-08-23*	*DP-01*	*53.33225*	*6.25664*	*0.2*	*20024124-1*	*Grey-black silty mud, no visible signs of life*	*56.95*	*24.8*	*12.7*
DR-1	Shannon Foynes Port Company	Limerick Approach Channel	17/07/2017	DR-1	52.65889	-8.64705	Surface	335194	Colour - dark grey sediment, Texture - smooth, sand-like, Odour - not abnormal, No presence of animals	57.2	0	8.17
DR-2	Shannon Foynes Port Company	Limerick Approach Channel	17/07/2017	DR-2	52.65895	-8.64556	Surface	335195	Colour - grey/brown sediment, Texture - smooth, sand-like, Odour - not abnormal, No presence of animals	64	0	9.07
DR-3	Shannon Foynes Port Company	Ted Russel Dock	17/07/2017	DR-3	52.65768	-8.64460	Surface	335196	Colour - dark grey sediment, Texture - gritty, sand-like, Odour - not abnormal, No presence of animals	60.2	4.66	8.8
DR-4	Shannon Foynes Port Company	Ted Russel Dock	17/07/2017	DR-4	52.65920	-8.64234	Surface	335197	Colour - grey/brown sediment, Texture - smooth, Odour - not abnormal, No presence of animals	61.3	0	9.49
DR-5	Shannon Foynes Port Company	Ted Russel Dock	17/07/2017	DR-5	52.65944	-8.63968	Surface	335198	Colour - grey sediment, Texture - gritty, Odour - not abnormal, No presence of animals	51.5	0	8.32
DR-6	Shannon Foynes Port Company	Foynes	17/07/2017	DR-6	52.61402	-9.10272	Surface	335199	Colour - grey/black sediment, Texture - smooth, Odour - not abnormal, No presence of animals	44.5	0	18.22
DR-7	Shannon Foynes Port Company	Foynes	17/07/2017	DR-7	52.61349	-9.10834	Surface	335200	Colour - grey/brown sediment, Texture - smooth, sand-like, Odour - not abnormal, No presence of animals	44.2	0	17.24
DR-8	Shannon Foynes Port Company	Foynes	17/07/2017	DR-8	52.61433	-9.11152	Surface	335201	Colour - grey sediment, Texture - gritty, Odour - not abnormal, presence of animals - yes	44.9	64.99	6.29
DR-9	Shannon Foynes Port Company	Foynes	17/07/2017	DR-9	52.61672	-9.11728	Surface	335202	Colour - grey/black sediment, Texture - gritty, Odour - not abnormal, No presence of animals	52	78.37	3

SampleIDCode	63um_PerCent Less	OC_Per Cent	Cd_mg.kg-1	Hg_mg.kg-1	As_mg.kg-1	Cr_mg.kg-1	Cu_mg.kg-1	Pb_mg.kg-1	Ni_mg.kg-1	Zn_mg.kg-1	TEH_g.kg-1	Mn_mg.kg-1	Li_mg.kg-1	Al_mg.kg-1	DBT_mg.kg-1	TBT_mg.kg-1	TBT_DBT_mg.kg-1	PCB028_ug.kg-1	PCB052_ug.kg-1	PCB101_ug kg^{-1}
DP-01A	*62.5*	*1.23*	*0.307*	*0.104*	*16.5*	*47.4*	*62.5*	*43*	*18.9*	*167*	*0.0653*	*322*	*37.7*	*27000*	*0.02*	*0.06*	*0.08*	*< 0.100*	*< 0.100*	*< 0.100*
DR-1	91.85	8.26	0.46	0.06	9.63	50.1	10.3	27.5	26.9	81.1	< 0.023		34.7	29900	<0.01	<0.01		< 0.23	< 0.23	< 0.23
DR-2	90.97	5.32	0.51	0.08	12.4	58.4	12.9	33.7	29.9	99.5			41.5	41100	<0.01	<0.01		3.61	15.5	8.32
DR-3	86.63	1.64	1.06	0.19	15.1	57.6	75.4	141	34.8	242	< 0.025		34.2	27300	0.02	0.02	0.04	0.75	3.77	1.76
DR-4	90.44	3.51	0.48	0.07	11.5	51.7	12.2	30	27.6	96.8			35.9	39000	<0.01	<0.01		1.55	7.75	3.62
DR-5	91.7	6.93	0.78	0.16	11.8	57.4	40.7	62.3	30.4	209	0.072		36.7	42100	0.01	0.01	0.02	0.41	< 0.21	< 0.21
DR-6	81.82	5.9	0.4	0.04	8.82	33.3	6.84	17.8	16.4	56.5			25	26000	<0.01	<0.01		< 1.00	< 0.70	< 0.60
DR-7	82.75	5.07	0.44	0.04	10.2	38.2	7.78	20.6	19.2	61.1	< 0.01		30.7	31300	<0.01	<0.01		< 1.00	< 0.70	< 0.60
DR-8	28.76	3.25	0.44	0.04	12.8	50.7	10.2	26.9	26.3	78.8			35.7	35000	<0.01	<0.01		< 1.00	< 0.70	< 0.60
DR-9	18.61	3.38	0.36	0.04	9.84	42.1	9.07	22.9	21.3	67.2	< 0.02		31.9	35000	<0.01	<0.01		< 0.21	< 0.21	< 0.21

SampleIDCode	PCB138_ug.kg-1	PCB153_ug.kg-1	PCB180_ug.kg-1	PCB118_ug.kg-1	PAHAcenaphthene_ug.kg-1	PAHAcenaphthylene_ug.kg-1	PAHAnthracene_ug.kg-1	PAHBenzo_a_Anthracene_ug.kg-1	PAHBenzo_A_Pyrene_ug.kg-1	PAHBenzo_B_Fluoranthene_ug.kg-1	PAHBenzo_ghi_Perylene_ug.kg-1	PAHBenzo_k_fluoranthene_ug.kg-1	PAHChrysene_ug.kg-1
DP-01A	*< 0.100*	*< 0.100*	*< 0.100*	*< 0.100*	*15.6*	*43.2*	*47.6*	*167*	*185*	*245*	*186*	*99.3*	*203*
DR-1	< 0.23	< 0.23	0.7	< 0.23	1.94	1.61	8.18	28.4	51.8	43.1	28.5	12.1	17.5
DR-2	1.94	2.22	0.55	3.88									
DR-3	1.01	1.01	< 0.25	1.26	70.6	26.9	206	531	703	432	238	104	331
DR-4	0.77	1.03	0.52	1.81									
DR-5	< 0.21	0.41	< 0.21	< 0.21	11.4	2.76	25.5	66.4	95.2	77.6	65.1	19.7	40.5
DR-6	< 0.50	< 0.50	< 0.60	< 0.80									
DR-7	< 0.50	< 0.50	< 0.60	< 0.80	< 1.70	< 2.00	5.18	18.7	28.7	31.4	23.6	9.73	12.3
DR-8	< 0.50	< 0.50	< 0.60	< 0.80									
DR-9	< 0.21	< 0.21	0.62	< 0.21	< 0.208	1.02	4.31	14.6	21.3	25.6	19.8	6.68	9.1

SampleIDCode	PAHDibenz_ah_anthracene_ug.kg-1	PAHFlourene_ug.kg-1	PAHFluoranthene_ug.kg-1	PAHIndeno123cd__ug.kg-1	PAHNaphthalene_ug.kg-1	PAHPhenanthrene_ug.kg-1	PAHPyrene_ug.kg-1	c_HCH_ug.kg-1	HCB_ug.kg-1	Notes_comments
DP-01A	*38.4*		*274*	*209*	*188*	*195*	*258*	*0.1*	*0.6*	
DR-1	8.25	6.34	44.4	22.8	10.1	28	34.6	< 2.34	< 2.34	
DR-2								< 2.77	< 2.77	
DR-3	80.6	187	868	171	173	997	769	< 2.52	< 2.52	
DR-4								< 2.58	< 2.58	
DR-5	16	23.8	117	38.7	29.9	88.8	109	< 2.06	< 2.06	
DR-6								< 1.00	< 1.00	
DR-7	6.22	4.95	36	18.9	7.1	17.8	25.7	< 1.00	< 1.00	
DR-8								< 1.00	< 1.00	
DR-9	5.96	5.08	29.8	14.4	10.7	16.6	22.2	< 2.08	< 2.08	

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Sheet 4. QA

Reference Type	Reference Material	OC %	TEH g kg^{-1}	Cu mg kg^{-1}	Zn mg kg^{-1}	Cd mg kg^{-1}	Hg mg kg^{-1}	Pb mg kg^{-1}	As mg kg^{-1}	Cr mg kg^{-1}	Mn mg kg^{-1}	Ni mg kg^{-1}	Li mg kg^{-1}	Al mg kg^{-1}	DBT mg kg^{-1}	TBT mg kg^{-1}
CRM (meas)	SRM-2702/NIST-1944	n/a		n/a	422	0.91	0.36	132	41	284		63	n/a	79000	613.5	476
CRM (certified value)		n/a			485.3	0.817	0.4474	132.8	45.3	352		75.4	n/a	84100	770	480
Blank	Blank															
AQC Spike (meas)		n/a													n/a	n/a
Spike on clean sediment ("X"ug/kg)		n/a													25	25

EPA Dumping at Sea Permit Application - Material Analysis Reporting Form (Version 1.0)
Sheet 4. QA

Reference Type	Σ TBT + DBT mg kg^{-1}	PCB 028 ug kg^{-1}	PCB 052 ug kg^{-1}	PCB 101 ug kg^{-1}	PCB 138 ug kg^{-1}	PCB 153 ug kg^{-1}	PCB 180 ug kg^{-1}	PCB 118 ug kg^{-1}	PCB Σ7 PCB ug kg^{-1}	PAH Acenaphthene ug kg^{-1}	PAH Acenaphthylene ug kg^{-1}	PAH Anthracene ug kg^{-1}
CRM (meas)	1089.5	36.55	47.96	42.77	42.65	58.92	24.77	27.46	281.08	n/a	n/a	3.1
CRM (certified value)	1250	44	38	44	44.2	50	22.4	27.5	270.1	n/a	n/a	3.59
Blank												
AQC Spike (meas)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	59.66	47.06	n/a
Spike on clean sediment ("X"ug/kg)		25	25	25	25	25	25	25	175	50	50	50

EPA Dumping at Sea Permit Application - Material Analysis Reporting Form (Version 1.0)
Sheet 4. QA

Reference Type	PAH Flourene ug kg^{-1}	PAH Naphthalene ug kg^{-1}	PAH Benzo (a) anthracene ug kg^{-1}	PAH Benzo (a) pyrene ug kg^{-1}	PAH Benzo (b) fluoranthene ug kg^{-1}	PAH Benzo (ghi) perylene ug kg^{-1}	PAH Benzo (k) fluoranthene ug kg^{-1}	PAH Chrysene ug kg^{-1}	PAH Dibenz (a,h) anthracene ug kg^{-1}	PAH Fluoranthene ug kg^{-1}
CRM (meas)	4.09	n/a	6.57	5.4	23.55	7.34	13.84	6.32	n/a	23.28
CRM (certified value)	5.98	n/a	7.15	4.57	24.9	6.76	12.3	8.39	n/a	25.1
Blank										
AQC Spike (meas)	n/a	45.41	n/a	n/a	n/a	n/a	n/a	n/a	42.34	n/a
Spike on clean sediment ("X"ug/kg)	50	50	50	50	50	50	50	50	50	50

EPA Dumping at Sea Permit Application - Material Analysis Reporting Form (Version 1.0)
Sheet 4. QA

Reference Type	PAH Indeno (1,2,3–cd) pyrene ug kg^{-1}	PAH Phenanthrene ug kg^{-1}	PAH Pyrene ug kg^{-1}	PAH Σ 16 ug kg^{-1}	γ–HCH (Lindane) ug kg^{-1}	HCB ug kg^{-1}	Notes / comments:
CRM (meas)	5.39	20.55	20.65	132.89	n/a	n/a	
CRM (certified value)	5.6	24.5	22.2	141.47	n/a	n/a	
Blank							
AQC Spike (meas)	n/a	n/a	n/a	194.47	51.05	48.72	
Spike on clean sediment ("X"ug/kg)	50	50	50	800	50	50	

Attachment B.1 (II)

Laboratory Report

Foynes and Limerick Dock Sampling Survey Report attached (Hydrographic Surveys Ltd-August 2017).

Refer to drawing M0742-RPS-XX-DS-DR-C-0009 in Appendix A for sampling locations at Limerick.

Figure B.1 (II)-1 Sampling Positions- Limerick (Ted Russel Dock & approach channel)

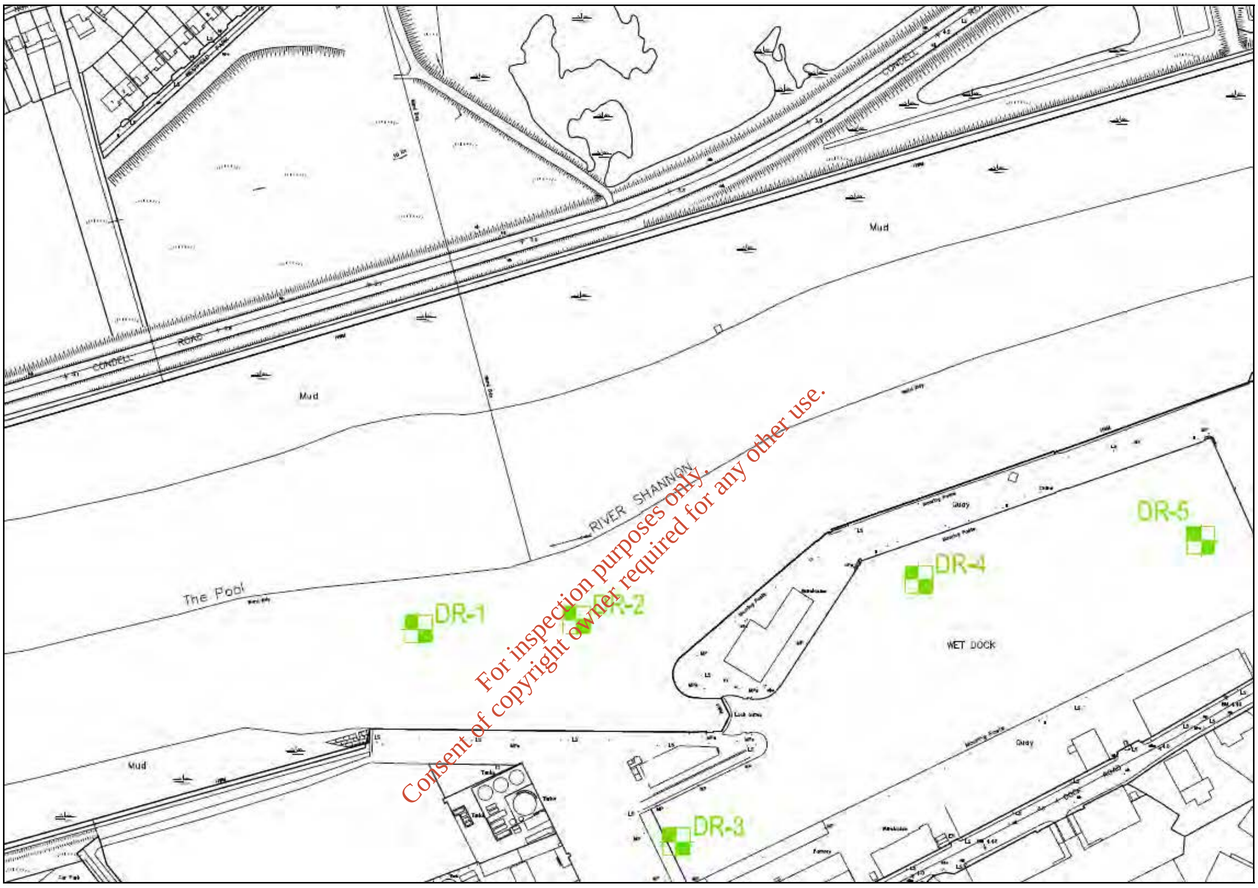
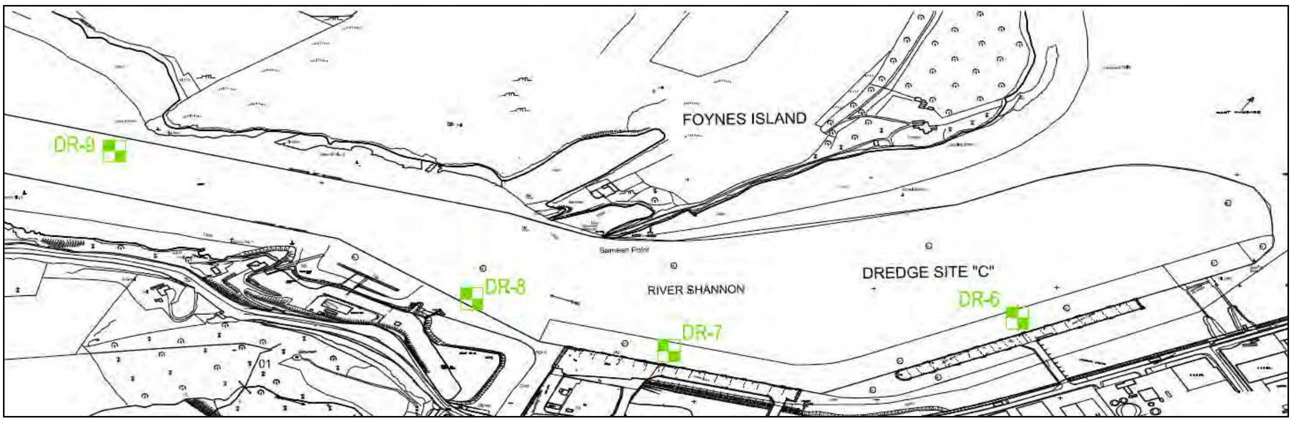


Figure B.1 (II)-2 Sampling Positions- Foynes Harbour

Refer to drawing M0742-RPS-XX-DS-DR-C-0008 in Appendix A for sampling locations at Foynes.



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Foynes and Limerick Dock

Sampling Survey Report

Report No. PH17021_Rp_Rev.01

August 2017

Client:

Shannon Foynes
PORT COMPANY

REPORT CONTROL SHEET

Client	Shannon Foynes Port Company					
Project Name	Foynes and Limerick Dock Sampling Survey					
Report Name	Foynes and Limerick Dock Sampling Survey Report					
Project Number	PH17021					
This Report Comprises of	TOC	Text	No. of Volume	No. of Appendices	Drawings	Electronic data
	1	12	1	2	0	*.pdf,

Revision	**Status**	**Author(s)**	**Approved By:**	**Issue Date**
Rev.00	Draft	HP	JBJ	30.08.2017
Rev.01	Final	HP	JBJ	05.10.2017

TABLE OF CONTENTS

1. Executive Summary

Hydrographic Surveys Ltd. (herein referred to as HSL) was requested by the Shannon Foynes Port Company (herein referred to as SFPC) to undertake a marine sediment sampling survey at Foynes and Limerick Dock, Co. Limerick.

The sampling involved taking 9 no. surface samples and was undertaken by HSL on the 17th July 2017. The coordinates of samples are listed in the report below. Each sample was acquired using a Van Veen stainless steel grab sampler. Each sampling location was sampled in sufficient quantities for the appropriate analysis.

Please see APPENDIX A: 2017 GEOCHEMICAL ANALYSIS RESULTS for a full quantitative breakdown of the survey sampling results as well as CRM yields.

This report also gives details of the 2012 sampling campaign and provides a comparison of both sets of results.

1. Introduction

1.1 Survey Description

Hydrographic Surveys Ltd. (herein referred to as HSL) was requested by the Shannon Foynes Port Company (herein referred to as SFPC) to undertake a marine sediment sampling survey at Foynes and Limerick Dock, Co. Limerick.

The sampling involved taking 9 no. surface samples and was undertaken by HSL on the 17th July 2017. The proposed coordinates of samples are listed in Table 1.1 below. Each sample was acquired using a Van Veen stainless steel grab sampler.

The locations for the sampling were as previously devised in 2012 in a sampling plan submitted by the Marine Institute to SFPC.

All samples were analysed by RPS Laboratories Ltd. for the criteria as set out for the original 2012 sampling campaign.

Sample Name	Latitude [WGS84]	Longitude [WGS84]	Location Description
DR-1	52.65894	-8.64708	Limerick Approach Channel
DR-2	52.65899	-8.64558	Limerick Approach Channel
DR-3	52.65769	-8.64477	Ted Russel Dock
DR-4	52.65930	-8.64235	Ted Russel Dock
DR-5	52.65966	-8.63968	Ted Russel Dock
DR-6	52.61394	-9.10287	Foynes
DR-7	52.61350	-9.10855	Foynes
DR-8	52.61454	-9.11148	Foynes
DR-9	52.61659	-9.11705	Foynes

Table 1.1 Proposed sampling locations (all surface samples)

2. Survey Methodology

2.1.1 Horizontal Control

Horizontal control for the survey was provided by a Trimble differential GPS receiver. The differential signal was received from the OmniSTAR™ geostationary satellite. The accuracy of this system is < 1m 95% of the time.

2.1.2 Sample Acquisition.

The samples were taken under the direction of the analysing laboratory, RPS Laboratories Ltd.

The sampling survey took place onboard the SFPC M.V. Shannon 1 in Foynes and onboard the SFPC pilot boat for Limerick Dock on the 17th July 2017.

All surface samples were acquired with a Van Veen stainless steel grab sampler lowered from the survey vessels.

All samples were placed directly into the appropriate containers using powdered latex gloves and couriered in a cool box to the certified laboratories RPS Laboratories Ltd. for geochemical analysis.

The 9 no. samples were dispatched to RPS Laboratories Ltd. via fast track courier on 17th July 2017.

2.2 Geotechnical and Geochemical Analysis

The geotechnical analysis involved the following for the 9 no. samples;

Sample Name	Analysis
DR-1	1,2,3,4a,4b,4c,4d,4e,4f,4g
DR-2	1,2,3,4a,4b,4c,4d,4f
DR-3	1,2,3,4a,4b,4c,4d,4e,4f,4g
DR-4	1,2,3,4a,4b,4c,4f
DR-5	1,2,3,4a,4b,4c,4d,4e,4f,4g
DR-6	1,2,3,4a,4b,4c,4f
DR-7	1,2,3,4a,4b,4c,4d,4e,4f,4g
DR-8	1,2,3,4a,4b,4c,4f
DR-9	1,2,3,4a,4b,4c,4d,4e,4f,4g

Table 2.1 Sampling analysis requirements

1. Visual inspection, to include colour, texture, odour, presence of animals etc.
2. Water content, density (taking into account sample collection and handling)
3. Granulometry including % gravel (> 2mm fraction), % sand (< 2mm fraction) and % mud (< 63μm fraction).
4. The following determinants in the sand-mud (< 2mm) fraction:

a) Total organic carbon

b) Carbonate

c) Zinc, Nickel. Copper, Lead, Arsenic, Cadmium, Lithium, Aluminium, Chromium, Mercury

d) Organochlorines including - HCH (Lindane) and PCBs (to be reported as the 7 individual PCB congeners: 28, 52, 101, 118, 138, 153, and 180)

e) Total extractable hydrocarbons

f) Tributyltin (TBT) and dibutyltin (DBT)

g) Polycyclic aromatic hydrocarbons (PAH) - Acenaphthene, Acenaphthylene, Anthracene, Benzo (a) anthracene, Benzo (a) pyrene, Benzo (b) fluoranthene, Benzo (ghi) perylene, Benzo (k) fluoranthene, Chrysene, Dibenz (a,h) anthracene, Flourene, Fluoranthene, Indeno 1,2,3 – cd pyrene, Naphthalene, Phenanthrene, Pyrene

This criteria for analysis was taken from the original document as provided to SFPC on 5th June 2012 by the Marine Institute for the 2012 sampling campaign. RPS Laboratories Ltd. were furnished with a copy of the document outlining requirements for analysis as well as the minimum required detection limits. The minimum detection limits are given below in units dry weight.

- Mercury 0.05 mg kg^{-1}
- Arsenic 1.0 mg kg^{-1}
- Cadmium 0.1 mg kg^{-1}
- Copper 5.0 mg kg^{-1}
- Lead 5.0 mg kg^{-1}
- Zinc 10 mg kg^{-1}
- Chromium 5.0 mg kg^{-1}
- Nickel 15 mg kg^{-1}
- Total extractable hydrocarbons 10.0 mg kg^{-1}
- TBT and DBT (not organotin) 0.01 mg kg^{-1}
- PCB – individual congener 1.0 µg kg^{-1}
- OCP – individual compound 1.0 µg kg^{-1}
- PAH – individual compound 20 µg kg^{-1}

An appropriate marine Certified Reference Material (CRM) was run with each sample batch, and has been reported in full with sample results (see APPENDIX A: 2017 GEOCHEMICAL ANALYSIS RESULTS).

3. Survey Results

The sampled locations for the 9 no. samples are as outlined below in Table 3.1. Some samples were moved slightly due to hard ground conditions.

Sample Name	Latitude [WGS84]	Longitude [WGS84]	Location Description
DR-1	52.65889	-8.64705	Limerick Approach Channel
DR-2	52.65895	-8.64556	Limerick Approach Channel
DR-3	52.65768	-8.64460	Ted Russel Dock
DR-4	52.65920	-8.64234	Ted Russel Dock
DR-5	52.65944	-8.63968	Ted Russel Dock
DR-6	52.61402	-9.10272	Foynes
DR-7	52.61349	-9.10834	Foynes
DR-8	52.61433	-9.11152	Foynes
DR-9	52.61672	-9.11728	Foynes

Table 3.1 As sampled locations (all surface samples)

The RPS sediment sample analysis report (*17-63882-1Marine Report*) for the 9 no. samples is included in APPENDIX A: 2017 GEOCHEMICAL ANALYSIS RESULTS.

Sample analysis results were also formatted into a Microsoft Excel spreadsheet and a copy of this file *"Haulbowline Sampling Sheet Report No. 17-63882-1.xlsx"* is provided with this report.

Sample results were also compiled in the official EPA Material Analysis Reporting Form in Microsoft Excel format and is supplied with this report.

Table 3.2 and 3.3 shows the results of the two phases of the sampling survey with relation to the Upper and Lower Level of sediment quality as set out in "Guidelines for the assessment of dredge material disposal in Irish waters" (Marine Institute, April 2006).

Each parameter has been compared against the Irish Upper and Lower Limits and are summarised below. Reference is made to the 2012 sampling campaign, the results of which are presented in APPENDIX B: 2012 GEOCHEMICAL ANALYSIS RESULTS.

3.1.1 Arsenic

From the 2017 sampling survey, concentrations of arsenic were seen to be marginally above the Irish Lower Level (9mg/kg) for all sampling locations. The average value for arsenic concentrations was seen to be 11mg/kg (max 15mg/kg / min 9mg/kg).

From the 2012 sampling survey, concentrations of arsenic were seen to be marginally above the Irish Lower Level (9mg/kg) for sample locations Dr-1 (11mg/kg), DR-2 (12mg/kg) and DR-3 (12mg/kg). All other sampling locations ranged from 5 to 7mg/kg.

According to "Guidelines for the assessment of dredge material disposal in Irish waters" (Marine Institute, April 2006) "in some locations natural levels of arsenic will exceed this [Irish Lower Level] value and in such instances this guidance value will not be appropriate". The Irish Lower Level for arsenic is taken from the United States ERL (Effect Range Low). It is also noted in the document that there is insufficient Irish background data available to establish a lower level.

3.1.2 Cadmium

From the 2017 sampling survey, concentrations of cadmium were seen to be below the Irish Lower Level (0.7mg/kg) for all sampling locations apart from DR-3 (1.1mg/kg) and DR-5 (0.8mg/kg), both located within Ted Russel Dock.

From the 2012 sampling survey, concentrations of cadmium were seen to be marginally above the Irish Lower Level for DR-2 (0.9mg/kg) and DR-3 (0.8mg/kg) located in the Limerick Approach Channel and Ted Russel Dock respectively.

3.1.3 Chromium

From the two sampling surveys concentrations of chromium were seen to be below the Irish Lower Level (120mg/kg) for all sampling locations.

3.1.4 Copper

From the 2012 sampling survey, concentrations of copper were seen to be below the Irish Lower Level (40mg/kg) for all sampling locations.

From the 2017 sampling survey, concentrations of Copper were seen to be above the Irish Lower Limit (40mg/kg) but below the Irish Upper Limit (110mg/kg) for sampling locations DR-3 (75mg/kg) and DR-5 (41mg/kg), both located within Ted Russel Dock.

3.2 Lead

From the 2012 sampling survey, concentrations of lead were seen to be marginally above the Irish Lower Limit (60mg/kg) for sampling locations DR-1 (64mg/kg), DR-2 (62mg/kg) and DR-3 (62mg/kg).

From the 2017 sampling survey, concentrations of lead was seen to be marginally above the Irish Lower Limit for sampling location DR-5 (62mg/kg). A higher concentration of 141mg/kg was seen at sampling location DR-3, this concentration sits halfway between the Irish Lower Limit (60mg/kg) and the Irish Upper Limit (218mg/kg).

3.2.5 Mercury

From the 2012 and 2017 sampling surveys concentrations of mercury were seen to be below the Irish Lower Level (0.2mg/kg) for all sampling locations apart from DR-3 where the concentration was 0.2mg/kg for both years. From the 2017 sampling campaign DR-5 was also seen to be marginally above the Irish Lower Level at 0.2mg/kg.

3.2.6 Nickel

From the 2012 sampling survey, concentrations of nickel were seen to be marginally above the Irish Lower Level (21mg/kg) for sampling locations DR-1 (27mg/kg), DR-2 (25mg/kg) and DR-3 (24mg/kg).

From the 2017 sampling survey, concentrations of nickel were seen to have increased slightly with an average value for nickel concentrations was seen to be 26mg/kg (max 35mg/kg / min 16mg/kg). The Irish Lower Level for nickel is taken from the United States ERL (Effect Range Low); (Long *et al*., 1998). It is noted that there is insufficient Irish background data available to establish a lower level.

3.2.7 Zinc

From the 2012 sampling survey, concentrations of zinc exceeded the Irish Lower Limit (160mg/kg) at sample locations DR-1 (197mg/kg), DR-2 (188mg/kg) and DR-3 (181mg/kg).

From the 2017 sampling survey, concentrations of zinc exceeded the Irish Lower Limit (160mg/kg) at sample locations DR-3 (242mg/kg), and DR-5 (209mg/kg).

Samples did not exceed the Irish Upper Limit (410 mg/kg) at any location.

3.2.8 Σ TBT & DBT

The sum of TBT and DBT was very marginally above the Irish Lower Limit (0.1mg/kg) at sampling locations DR-1 (0.1mg/kg), DR-2 (0.1mg/kg) and DR-3 (0.11mg/kg) from the 2012 survey and DR-3 (0.1mg/kg) from the 2017 survey. All other sampling locations showed concentrations below the Irish Lower Limit.

3.2.9 γ-HCH (Lindane) and HCB

Concentrations of γ-HCH and HCB were not detected across any of the 2017 samples.

The method for γ-HCH (Lindane) and HCB used by RPS Laboratories has a reporting limit of 1.0µg/kg.

3.2.10 PCB (Σ ICES 7)

From the 2012 sampling survey, concentrations of PCBs were lower than the Irish Lower Limit (7µg/kg) at all analysed sample locations.

From the 2017 sampling survey, concentrations of PCBs exceeded the Irish Lower Limit (7µg/kg) at sample locations DR-2 (36µg/kg), DR-3 (10µg/kg) and DR-4 (17µg/kg).

It is noted in "Guidelines for the assessment of dredge material disposal in Irish waters" (Marine Institute, April 2006) that no natural background figures exist for these substances but they are widespread in the environment. The 95%iles of background data has been used to set the lower guidance values for PCBs.

3.2.11 PAH (Σ 16)

From the two sampling surveys concentrations of PAH (Σ 16) were seen to be below the Irish Lower Level (4000µg/kg) for all sampling locations apart from the 2017 analysis of DR-3 (5888µg/kg).

3.2.12 Total Extractable Hydrocarbons

From the two sampling surveys concentrations of total extractable hydrocarbons (taken from parameter "total petroleum hydrocarbons by GCFID (C10 - C40)" in the RPS Laboratories report) were seen to be below the Irish Lower Level (1g/kg) for all sampling locations in both surveys.

2012 Sampling Campaign	Sample Number:	DR-1	DR-2	DR-3	DR-4	DR-5	DR-6	DR-7	DR-8	DR-9
	Sample Depth:	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface
Arsenic	mg kg-1	11	12	12	7	7	6	6	5	7
Cadmium	mg kg-1	0.6	0.9	0.8	0.3	0.3	0.3	0.2	0.2	0.2
Chromium	mg kg-1	34	32	30	23	23	17	18	20	21
Copper	mg kg-1	30	35	35	10	12	7	7	7	8
Lead	mg kg-1	64	62	62	24	24	17	18	19	22
Mercury	mg kg-1	0.1	0.1	0.2	0.1	0.0	0.0	0.0	0.0	0.0
Nickel	mg kg-1	27	25	24	20	19	13	15	16	17
Zinc	mg kg-1	197	188	181	85	85	63	63	66	69
S TBT & DBT	mg kg-1	0.1	0.1	0.1	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
g-HCH (Lindane)	µg kg-1	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
HCB	µg kg-1	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
PCB (S ICES 7)	µg kg-1	<1.0	n/a	<1.0	<1.0	<0.1	n/a	<0.1	n/a	<0.1
PAH (S 16)	µg kg-1	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Total Extractable Hydrocarbons	mg kg-1	228.0	n/a	142.0	n/a	4.4	n/a	1.9	n/a	4.2

Table 3.2: 2012 Sampling Results vs. Irish Lower Limits and Irish Upper Limits. orange highlighted cells are over Irish Lower Limit. Red highlighted cells are over Irish Upper Limit (none identified).

2017 Sampling Campaign	Sample Number:	DR-1	DR-2	DR-3	DR-4	DR-5	DR-6	DR-7	DR-8	DR-9
	Sample Depth:	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface
Arsenic	mg kg-1	10	12	15	12	12	9	10	13	10
Cadmium	mg kg-1	0.5	0.5	1.1	0.5	0.8	0.4	0.4	0.4	0.4
Chromium	mg kg-1	50	58	58	52	57	33	38	51	42
Copper	mg kg-1	10	13	75	12	41	7	8	10	9
Lead	mg kg-1	28	34	141	30	62	18	21	27	23
Mercury	mg kg-1	0.1	0.1	0.2	0.1	0.2	0.0	0.0	0.0	0.0
Nickel	mg kg-1	27	30	35	28	30	16	19	26	21
Zinc	mg kg-1	81	100	242	97	209	57	61	79	67
S TBT & DBT	mg kg-1	<0.02	<0.02	0.10	<0.02	0.08	<0.01	<0.01	<0.01	<0.01
g-HCH (Lindane)	µg kg-1	<2.34	<2.77	<2.52	<2.58	<2.06	<1.00	<1.00	<1.00	<2.08
HCB	µg kg-1	<2.34	<2.77	<2.52	<2.58	<2.06	<1.00	<1.00	<1.00	<2.08
PCB (S ICES 7)	µg kg-1	1	36	10	17	1	<1	<1	<1	1
PAH (S 16)	µg kg-1	348	n/a	5888	n/a	827	n/a	246	n/a	207
Total Extractable Hydrocarbons	mg kg-1	<23.37	n/a	<25.15	n/a	72.10	n/a	<10.0	n/a	<20.82

Table 3.3: 2017 Sampling Results vs. Irish Lower Limits and Irish Upper Limits. Orange highlighted cells are over Irish Lower Limit. Red highlighted cells are over Irish Upper Limit (none identified).

APPENDIX A: 2017 GEOCHEMICAL ANALYSIS RESULTS

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Certificate of Analysis

Report No.: 17-63882-1

Issue No.: **1**
Date of Issue **14/08/2017**

Customer Details:	Hydrographic Surveys Ltd, The Cobbles, Crosshaven, County Cork,
Customer Contact:	Hugh Power (2)
Customer Order No.:	9780
Customer Reference:	Not Supplied
Quotation Reference:	170615/03
Description:	9 sediment samples
Date Received:	18/07/2017
Date Started:	19/07/2017
Date Completed:	14/08/2017
Test Methods:	Details available on request (refer to SOP code against relevant result/s)
Notes:	None

Approved By: **Matthew Hickson, Laboratory Manager**

This certificate is issued in accordance with the accreditation requirements of the United Kingdom Accreditation Service.
This certificate shall not be reproduced except in full without the prior written approval of the laboratory.
Observations and interpretations are outside of the scope of UKAS accreditation.
Results reported herein relate only to the items supplied to the laboratory for testing.

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Results Summary - Dry Weights, Moisture, Total Organic Carbon, TPH, Organotins & Density

Report No.: **17-63882**
Customer Reference: Not given
Order No: 9780

Customer Sample No					**Certified Reference Material**			**AQC spike**			**1**	**2**	**3**	**4**	**5**	**8**	**9**	**10**	**11**
Customer Sample ID																			
RPS Sample No											335194	335195	335196	335197	335198	335199	335200	335201	335202
Sample Type					**SEDIMENT**			**SEDIMENT**			**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**
Sample Location					**CRM BCR-646**			**Spike on clean sediment**											
Sample Depth (m)																			
Sampling Date											17/07/2017	17/07/2017	17/07/2017	17/07/2017	17/07/2017	17/07/2017	17/07/2017	17/07/2017	17/07/2017
Sampling Time																			
Determinand	**CAS No**	**Codes**	**SOP**	**Units**	**Assigned Value**	**Measured Value**	**Recovery %**	**Assigned Value**	**Measured Value**	**Recovery %**									
dry solids (at 105°C)		N	397	%	n/a	n/a	n/a	n/a	n/a	n/a	42.8	36.0	39.8	38.7	48.5	55.5	55.8	55.1	48.0
carbonate % dry matter		N	In house	%	n/a	n/a	n/a	n/a	n/a	n/a	8.26	5.32	1.64	3.51	6.93	5.90	5.07	3.25	3.38
total organic carbon*		N	404	%	n/a	n/a	n/a	n/a	n/a	n/a	4.44	5.88	20.62	5.73	4.69	1.66	1.72	2.78	2.88
dibutyltin (DBT)	1002-53-5	U	395.00	ug/kg DW	770	613.5	79.7%	n/a	n/a	n/a	< 11.69	< 13.87	18.4	< 12.91	10.7	< 5.00	< 5.00	< 5.00	< 10.41
tributyltin (TBT)	56573-85-4	U	395.00	ug/kg DW	480	476	99.2%	n/a	n/a	n/a	< 4.67	< 5.55	84.0	< 5.17	69.8	< 2.00	< 2.00	< 2.00	< 4.16
density (on dry solid)		N	In house	g/cm3	n/a	n/a	n/a	n/a	n/a	n/a	1.6	1.4	1.3	1.8	1.4	1.3	0.7	1.6	1.7

Dibutyltin and tributyltin results have been dry weight corrected

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Results Summary - Metals

Report No.: **17-63882**
Customer Reference: Not given
Order No: 9780

				Customer Sample No	**Standard Reference Material**			**1**	**2**	**3**	**4**	**5**	**8**	**9**	**10**	**11**
				Customer Sample ID												
				RPS Sample No				335194	335195	335196	335197	335198	335199	335200	335201	335202
				Sample Type	**SEDIMENT**			**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**
				Sample Location	**SRM-2702**											
				Sample Depth (m)												
				Sampling Date				17/07/2017	17/07/2017	17/07/2017	17/07/2017	17/07/2017	17/07/2017	17/07/2017	17/07/2017	17/07/2017
				Sampling Time												
Determinand	**CAS No**	**Codes**	**SOP**	**Units**	**Assigned Value**	**Measured Value**	**Recovery %**									
aluminium	7429-90-5	USI	M-129	mg/kg DW	84100	79000	93.9%	29900	41100	27300	39000	42100	26000	31300	35000	35000
arsenic	7440-38-2	USI	M-129	mg/kg DW	45.3	41	90.5%	9.63	12.4	15.1	11.5	11.8	8.82	10.2	12.8	9.84
cadmium	7440-43-9	USI	M-129	mg/kg DW	0.817	0.91	111.4%	0.46	0.51	1.06	0.48	0.78	0.40	0.44	0.44	0.36
chromium	7440-47-3	USI	M-129	mg/kg DW	352	284	80.7%	50.1	58.4	57.6	51.7	57.4	33.3	38.2	50.7	42.1
copper	7440-50-8	USI	M-129	mg/kg DW	Not certified	n/a	n/a	10.3	12.9	75.4	12.2	40.7	6.84	7.78	10.2	9.07
lead	7439-92-1	USI	M-129	mg/kg DW	132.8	132	99.4%	27.5	33.7	141	30.0	62.3	17.8	20.6	26.9	22.9
lithium	7439-93-2	USI	M-129	mg/kg DW	Not certified	n/a	n/a	34.7	41.5	34.2	35.9	36.7	25.0	30.7	35.7	31.9
mercury	7439-97-6	USI	M-129	mg/kg DW	0.4474	0.36	80.5%	0.06	0.08	0.19	0.07	0.16	0.04	0.04	0.04	0.04
nickel	7440-02-0	USI	M-129	mg/kg DW	75.4	63	83.6%	26.9	29.9	34.8	27.6	30.4	16.4	19.2	26.3	21.3
zinc	7440-66-6	SI	ICP-MS	mg/kg DW	485.3	422	87.0%	81.1	99.5	242	96.8	209	56.5	61.1	78.8	67.2

RPS

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Results Summary - Polycyclic Aromatic Hydrocarbons (EPA 16 PAHs)

Report No.: **17-63882**
Customer Reference: Not given
Order No: 9780

				Customer Sample No	Certified Reference Material			AQC spike			**1**	**2**	**3**	**4**	**5**	**8**	**9**	**10**	**11**
				Customer Sample ID															
				RPS Sample No							335194	335195	335196	335197	335198	335199	335200	335201	335202
				Sample Type	**SEDIMENT**			**SEDIMENT**			**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**
				Sample Location	NMIJ CRM-7307a			Spike on clean sediment											
				Sample Depth (m)															
				Sampling Date							17/07/2017	17/07/2017	17/07/2017	17/07/2017	17/07/2017	17/07/2017	17/07/2017	17/07/2017	17/07/2017
				Sampling Time															
Determinand	**CAS No**	**Codes**	**SOP**	**Units**	**Assigned Value**	**Measured Value**	**Recovery %**	**Assigned Value**	**Measured Value**	**Recovery %**									
naphthalene	91-20-3	N	396	ug/kg DW	Not certified	n/a	n/a	50	45.41	90.8%	10.1		173		29.9		7.10		10.7
acenaphthylene	208-96-8	N	396	ug/kg DW	Not certified	n/a	n/a	50	47.06	94.1%	1.61		26.9		2.76		< 2.00		1.02
acenaphthene	83-32-9	N	396	ug/kg DW	Not certified	n/a	n/a	50	59.66	119.3%	1.94		70.6		11.4		< 1.70		< 0.208
fluorene	86-73-7	N	396	ug/kg DW	5.98	4.09	68.4%	50	n/a	0.0%	6.34		187		23.8		4.95		5.08
phenanthrene	85-01-8	N	396	ug/kg DW	24.5	20.55	83.9%	50	n/a	0.0%	28.0		997		88.8		17.8		16.6
anthracene	120-12-7	N	396	ug/kg DW	3.59	3.1	86.4%	50	n/a	0.0%	8.18		206		25.5		5.18		4.31
fluoranthene	206-44-0	N	396	ug/kg DW	25.1	23.28	92.7%	50	n/a	0.0%	44.4		868		117		36.0		29.8
pyrene	129-00-0	N	396	ug/kg DW	22.2	20.65	93.0%	50	n/a	0.0%	34.6		769		109		25.7		22.2
benzo(a)anthracene	56-55-3	N	396	ug/kg DW	7.15	6.57	91.9%	50	n/a	0.0%	28.4		531		66.4		18.7		14.6
chrysene	218-01-9	N	396	ug/kg DW	8.39	6.32	75.3%	50	n/a	0.0%	17.5		331		40.5		12.3		9.10
benzo(b)fluoranthene	205-99-2	N	396	ug/kg DW	24.9	23.55	94.6%	50	n/a	0.0%	43.1		432		77.6		31.4		25.6
benzo(k)fluoranthene	207-08-9	N	396	ug/kg DW	12.3	13.84	112.5%	50	n/a	0.0%	12.1		104		19.7		9.73		6.68
benzo(a)pyrene	50-32-8	N	396	ug/kg DW	4.57	5.4	118.2%	50	n/a	0.0%	51.8		703		95.2		28.7		21.3
indeno(1,2,3-c,d)pyrene	193-39-5	N	396	ug/kg DW	5.6	5.39	96.3%	50	n/a	0.0%	22.8		171		38.7		18.9		14.4
dibenzo(a,h)anthracene	53-70-3	N	396	ug/kg DW	Not certified	n/a	n/a	50	42.34	84.7%	8.25		80.6		16.0		6.22		5.96
benzo(g,h,i)perylene	191-24-2	N	396	ug/kg DW	6.76	7.34	108.6%	50	n/a	0.0%	28.5		238		65.1		23.6		19.8

PAH results have been dry weight corrected

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Results Summary - Organochlorine Pesticides & Polychlorinated Biphenyls (ICES 7)

Report No.: **17-63882**
Customer Reference: Not given
Order No: 9780

				Customer Sample No	Certified Reference Material			AQC spike			1	2	3	4	5	8	9	10	11
				Customer Sample ID															
				RPS Sample No							335194	335195	335196	335197	335198	335199	335200	335201	335202
				Sample Type	SEDIMENT			SEDIMENT			SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT
				Sample Location	CRM BCR-536			Spike on clean sediment											
				Sample Depth (m)															
				Sampling Date							17/07/2017	17/07/2017	17/07/2017	17/07/2017	17/07/2017	17/07/2017	17/07/2017	17/07/2017	17/07/2017
				Sampling Time															
Determinand	**CAS No**	**Codes**	**SOP**	**Units**	**Assigned Value**	**Measured Value**	**Recovery %**	**Assigned Value**	**Measured Value**	**Recovery %**									
aldrin	309-00-2	N	396	ug/kg DW	n/a	n/a	n/a	50	43.21	86.4%	< 2.34	< 2.77	< 2.52	< 2.58	< 2.06	< 1.00	< 1.00	< 1.00	< 2.08
alpha-hexachlorocyclohexane (alpha-HCH)	319-84-6	N	396	ug/kg DW	n/a	n/a	n/a	50	53.72	107.4%	< 2.34	< 2.77	< 2.52	< 2.58	< 2.06	< 1.00	< 1.00	< 1.00	< 2.08
beta-hexachlorocyclohexane (beta-HCH, beta-BHC)	319-85-7	N	396	ug/kg DW	n/a	n/a	n/a	50	40.09	80.2%	< 2.34	< 2.77	< 2.52	< 2.58	< 2.06	< 1.00	< 1.00	< 1.00	< 2.08
delta-hexachlorocyclohexane (delta-HCH)	319-86-8	N	396	ug/kg DW	n/a	n/a	n/a	50	60.25	120.5%	< 2.34	< 2.77	< 2.52	< 2.58	< 2.06	< 1.00	< 1.00	< 1.00	< 2.08
gamma-hexachlorocyclohexane (lindane)	58-89-9	N	396	ug/kg DW	n/a	n/a	n/a	50	51.05	102.1%	< 2.34	< 2.77	< 2.52	< 2.58	< 2.06	< 1.00	< 1.00	< 1.00	< 2.08
hexachlorobenzene (HCB)	118-74-1	N	396	ug/kg DW	n/a	n/a	n/a	50	48.72	97.4%	< 2.34	< 2.77	< 2.52	< 2.58	< 2.06	< 1.00	< 1.00	< 1.00	< 2.08
dieldrin	60-57-1	N	396	ug/kg DW	n/a	n/a	n/a	50	46.31	92.6%	< 2.34	< 2.77	< 2.52	< 2.58	< 2.06	< 1.00	< 1.00	< 1.00	< 2.08
endrin	72-20-8	N	396	ug/kg DW	n/a	n/a	n/a	50	43.21	86.4%	< 2.34	< 2.77	< 2.52	< 2.58	< 2.06	< 1.00	< 1.00	< 1.00	< 2.08
p,p'-DDD	3424-82-6	N	396	ug/kg DW	n/a	n/a	n/a	50	48.51	97.0%	< 2.34	< 2.77	< 2.52	< 2.58	< 2.06	< 1.00	< 1.00	< 1.00	< 2.08
p,p'-DDT	72-54-8	N	396	ug/kg DW	n/a	n/a	n/a	50	53.11	106.2%	< 2.34	< 2.77	< 2.52	< 2.58	< 2.06	< 1.00	< 1.00	< 1.00	< 2.08
p,p'-DDE	50-29-3	N	396	ug/kg DW	n/a	n/a	n/a	50	43.89	87.8%	< 2.34	< 2.77	< 2.52	< 2.58	< 2.06	< 1.00	< 1.00	< 1.00	< 2.08
2,4,4'-trichlorobiphenyl (PCB congener 28)	7012-37-5	N	396	ug/kg DW	44	36.55	83.1%	25	n/a	0.0%	< 0.23	3.61	0.75	1.55	0.41	< 1.00	< 1.00	< 1.00	< 0.21
2,2',5,5'-tetrachlorobiphenyl (PCB congener 52)	35693-99-3	N	396	ug/kg DW	38	47.96	126.2%	25	n/a	0.0%	< 0.23	15.5	3.77	7.75	< 0.21	< 0.70	< 0.70	< 0.70	< 0.21
2,2',4,5,5'-pentachlorobiphenyl (PCB congener 101)	37680-73-2	N	396	ug/kg DW	44	42.77	97.2%	25	n/a	0.0%	< 0.23	8.32	1.76	3.62	< 0.21	< 0.60	< 0.60	< 0.60	< 0.21
2,3',4,4',5-pentachlorobiphenyl (PCB congener 118)	31508-00-6	N	396	ug/kg DW	27.5	27.46	99.9%	25	n/a	0.0%	< 0.23	3.88	1.26	1.81	< 0.21	< 0.80	< 0.80	< 0.80	< 0.21
2,2',3,4,4',5-hexachlorobiphenyl (PCB 138)	35065-28-2	N	396	ug/kg DW	44.2	42.65	96.5%	25	n/a	0.0%	< 0.23	1.94	1.01	0.77	< 0.21	< 0.50	< 0.50	< 0.50	< 0.21
2,2',4,4',5,5'-hexachlorobiphenyl (PCB 153)	35065-27-1	N	396	ug/kg DW	50	58.92	117.8%	25	n/a	0.0%	< 0.23	2.22	1.01	1.03	0.41	< 0.50	< 0.50	< 0.50	< 0.21
2,2',3,4,4',5,5'-heptachlorobiphenyl (PCB 180)	35065-29-3	N	396	ug/kg DW	22.4	24.77	110.6%	25	n/a	0.0%	0.70	0.55	< 0.25	0.52	< 0.21	< 0.60	< 0.60	< 0.60	0.62

OCL and PCB results have been dry weight corrected

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Results Summary - PSA Results

Report No.: **17-63882**
Customer Reference: Not given
Order No: 9780

				Customer Sample No	**1**	**2**	**3**	**4**	**5**	**8**	**9**	**10**	**11**
				Customer Sample ID									
				RPS Sample No	335194	335195	335196	335197	335198	335199	335200	335201	335202
				Sample Type	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**
				Sample Location									
				Sample Depth (m)									
				Sampling Date	17/07/2017	17/07/2017	17/07/2017	17/07/2017	17/07/2017	17/07/2017	17/07/2017	17/07/2017	17/07/2017
				Sampling Time									
Determinand	**CAS No**	**Codes**	**SOP**	**Units**									
sample type		S	In-house		Unimodal, Poorly Sorted	Unimodal, Poorly Sorted	Trimodal, Very Poorly Sorted	Bimodal, Poorly Sorted	Unimodal, Poorly Sorted	Bimodal, Very Poorly Sorted	Trimodal, Very Poorly Sorted	Unimodal, Extremely Poorly Sorted	Unimodal, Extremely Poorly Sorted
textural group (GRADISTAT)		S	In-house		Mud	Mud	Slightly Gravelly Mud	Mud	Mud	Sandy Mud	Sandy Mud	Muddy Gravel	Muddy Gravel
sediment name		S	In-house		Coarse Silt	Medium Silt	Slightly Very Fine Gravelly Medium Silt	Coarse Silt	Medium Silt	Very Fine Sandy Very Coarse Silt	Very Fine Sandy Very Coarse Silt	Medium Silty Very Coarse Gravel	Fine Silty Very Coarse Gravel
arithmetic mean (method of moments)		S	In-house	um	30.8	39.3	355	41.2	37.1	41.7	38.7	21200	52200
arithmetic sorting (method of moments)		S	In-house	um	83.1	114	1560	120	112	84.6	74.2	17400	34300
arithmetic skewness (method of moments)		S	In-house	um	8.49	6.32	7.01	6.07	6.52	6.96	7.14	-0.243	-0.724
arithmetic kurtosis (method of moments)		S	In-house	um	81.9	44.1	57.2	40.2	46.3	61.5	71.0	1.20	1.57
geometic mean (method of moments)		S	In-house	um	12.8	13.8	16.3	14.1	12.7	16.7	15.4	2100	9200
geometic sorting (method of moments)		S	In-house	um	3.56	3.64	7.64	3.72	3.74	4.24	4.31	42.7	35.8
geometic skewness (method of moments)		S	In-house	um	-0.171	0.175	1.14	0.144	0.098	-0.421	-0.397	-0.814	-1.44
geometic kurtosis (method of moments)		S	In-house	um	3.90	4.26	4.76	4.26	4.24	3.21	3.07	1.97	3.41
logarithmic mean (method of moments)		S	In-house	phi	6.29	6.18	5.94	6.15	6.30	5.90	6.02	-1.07	-3.20
logarithmic sorting (method of moments)		S	In-house	phi	1.83	1.87	2.93	1.90	1.90	2.08	2.11	5.42	5.16
logarithmic skewness (method of moments)		S	In-house	phi	0.171	-0.175	-1.14	-0.144	-0.098	0.421	0.397	0.814	1.44
logarithmic kurtosis (method of moments)		S	In-house	phi	3.90	4.26	4.76	4.26	4.24	3.21	3.07	1.97	3.41
mean (Folk and Ward method - um)		S	In-house	um	13.1	13.6	12.9	13.9	12.7	17.6	16.3	2350	5650
sorting (Folk and Ward method - um)		S	In-house	um	3.37	3.27	6.34	3.31	3.39	4.10	4.25	32.2	31.9
skewness (Folk and Ward method - um)		S	In-house	um	-0.096	-0.029	0.162	-0.056	-0.063	-0.158	-0.118	-0.905	-0.952
kurtosis (Folk and Ward method - um)		S	In-house	um	1.12	1.10	1.85	1.09	1.12	0.946	0.971	0.568	1.72
mean (Folk and Ward method - phi)		S	In-house	phi	6.26	6.20	6.28	6.17	6.29	5.83	5.94	-1.23	-2.50
sorting (Folk and Ward method - phi)		S	In-house	phi	1.76	1.71	2.67	1.73	1.76	2.04	2.09	5.01	5.00
skewness (Folk and Ward method - phi)		S	In-house	phi	0.096	0.029	-0.162	0.056	0.063	0.158	0.118	0.905	0.952
kurtosis (Folk and Ward method - phi)		S	In-house	phi	1.12	1.10	1.85	1.09	1.12	0.946	0.971	0.568	1.72
mean description (Folk and Ward method)		S	In-house		Medium Silt	Medium Silt	Medium Silt	Medium Silt	Medium Silt	Coarse Silt	Coarse Silt	Very Fine Gravel	Fine Gravel
sorting description (Folk and Ward method)		S	In-house		Poorly Sorted	Poorly Sorted	Very Poorly Sorted	Poorly Sorted	Poorly Sorted	Very Poorly Sorted	Very Poorly Sorted	Extremely Poorly Sorted	Extremely Poorly Sorted
skewness description (Folk and Ward method)		S	In-house		Symmetrical	Symmetrical	Coarse Skewed	Symmetrical	Symmetrical	Fine Skewed	Fine Skewed	Very Fine Skewed	Very Fine Skewed
kurtosis description (Folk and Ward method)		S	In-house		Leptokurtic	Mesokurtic	Very Leptokurtic	Mesokurtic	Leptokurtic	Mesokurtic	Mesokurtic	Very Platykurtic	Very Leptokurtic
MODE 1 - um		S	In-house	um	18.9	18.9	13.3	18.9	13.3	53.4	53.4	38300	76500
MODE 2 - um		S	In-house	um			1700	854		9.41	9.41		
MODE 3 - um		S	In-house	um			0.590				0.590		
MODE 1 - phi		S	In-house	phi	5.75	5.75	6.25	5.75	6.25	4.25	4.25	-5.24	-6.24
MODE 2 - phi		S	In-house	phi			-0.743	0.250		6.75	6.75		
MODE 3 - phi		S	In-house	phi			10.8				10.8		
D10 - um		S	In-house	um	2.8	3.1	2.2	3.0	2.8	2.8	2.6	6.1	10.2
D50 - um		S	In-house	um	13.6	14.0	12.4	14.5	13.0	19.0	16.8	27100	68700
D90 - um		S	In-house	um	55.9	58.9	243	60.6	56.1	86.0	85.4	41500	85300
(D90/D10) - um		S	In-house	um	19.9	19.2	109	20.0	20.0	30.4	33.0	6830	8360
(D90 - D10) - um		S	In-house	um	53.0	55.8	241	57.6	53.3	83.2	82.8	41500	85300
(D75/D25) - um		S	In-house	um	4.73	4.56	5.63	4.69	4.76	7.71	7.91	991	10.6
(D75 - D25) - um		S	In-house	um	22.5	22.7	24.3	23.7	22.0	43.4	41.1	36800	71200
D10 - phi		S	In-house	phi	4.16	4.09	2.04	4.04	4.16	3.54	3.55	-5.38	-6.41
D50 - phi		S	In-house	phi	6.20	6.16	6.33	6.10	6.27	5.72	5.89	-4.76	-6.10
D90 - phi		S	In-house	phi	8.48	8.35	8.81	8.36	8.48	8.47	8.60	7.36	6.62
(D90/D10) - phi		S	In-house	phi	2.04	2.04	4.32	2.07	2.04	2.39	2.42	-1.37	-1.03
(D90 - D10) - phi		S	In-house	phi	4.31	4.27	6.77	4.32	4.32	4.93	5.05	12.7	13.0
(D75/D25) - phi		S	In-house	phi	1.44	1.43	1.49	1.44	1.44	1.68	1.68	-0.913	0.460
(D75 - D25) - phi		S	In-house	phi	2.24	2.19	2.49	2.23	2.25	2.95	2.98	9.95	3.40
% gravel		S	In-house	%	0.00	0.00	4.66	0.00	0.00	0.00	0.00	65.0	78.4
% sand		S	In-house	%	8.17	9.07	8.79	9.50	8.32	18.2	17.2	6.29	3.01
% mud		S	In-house	%	91.8	90.9	86.6	90.5	91.7	81.8	82.8	28.8	18.6
% very coarse gravel (>32<64mm or <-5>-6phi)		S	In-house	%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	42.5	66.2
% coarse gravel (>16<32mm or <-4>-5phi)		S	In-house	%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	17.0	3.68
% medium gravel (>8<16mm or <-3>-4phi)		S	In-house	%	0.00	0.00	1.08	0.00	0.00	0.00	0.00	0.00	4.66
% fine gravel (>4<8mm or <-2>-3phi)		S	In-house	%	0.00	0.00	0.80	0.00	0.00	0.00	0.00	3.49	3.11
% very fine gravel (>2<4mm or <-1>-2phi)		S	In-house	%	0.00	0.00	2.78	0.00	0.00	0.00	0.00	2.00	0.72
% very coarse sand (>1<2mm or <0>-1phi)		S	In-house	%	0.00	0.00	3.95	0.00	0.00	0.00	0.00	2.13	1.09
% coarse sand (>0.5<1mm or <1>0phi)		S	In-house	%	0.95	1.82	1.28	2.08	1.81	0.90	0.51	0.53	0.15
% medium sand (>0.25<0.5mm or <2>1phi)		S	In-house	%	0.09	0.46	0.09	0.37	0.36	0.70	0.92	0.16	0.00
% fine sand (>0.125<0.25mm or <3>2phi)		S	In-house	%	1.54	1.72	0.90	1.32	1.00	2.32	2.81	0.57	0.28
% very fine sand (>0.0625<0.125mm or <4>3phi)		S	In-house	%	5.59	5.07	2.58	5.72	5.15	14.3	13.0	2.90	1.48
% very coarse silt (>0.03125<0.0625mm or <5>4phi		S	In-house	%	14.0	13.6	10.2	14.3	13.2	20.2	18.6	5.08	2.70
% coarse silt (>0.015625<0.03125mm or <6>5phi)		S	In-house	%	23.1	23.4	19.3	23.7	22.1	16.0	15.8	5.44	3.46
% medium silt (>0.007813<0.015625mm or <7>6phi)		S	In-house	%	22.9	23.5	21.4	22.4	23.2	16.3	16.7	6.03	4.11
% fine silt (>0.003906<0.007813mm or <8>7phi)		S	In-house	%	16.6	16.7	17.6	16.2	17.7	14.7	15.7	5.76	4.11
% very fine silt (>0.001953<0.003906mm or <9>8phi		S	In-house	%	8.69	8.38	9.49	8.26	8.95	7.77	8.41	3.30	2.31
% clay (<0.001953mm or >9phi)		S	In-house	%	6.56	5.39	8.64	5.58	6.55	6.85	7.54	3.15	1.92

RPS

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Results Summary - PSA Size Class & Statistics

Report No.: **17-63882**
Customer Reference: Not given
Order No: 9780

			Customer Sample No	**1**	**2**	**3**	**4**	**5**	**8**	**9**	**10**	**11**
			Customer Sample ID									
			RPS Sample No	335194	335195	335196	335197	335198	335199	335200	335201	335202
			Sample Type	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**
			Sample Location									
			Sample Depth (m)									
			Sampling Date	17/07/2017	17/07/2017	17/07/2017	17/07/2017	17/07/2017	17/07/2017	17/07/2017	17/07/2017	17/07/2017
			Sampling Time									
Sediment	**mm**	**phi ϕ**	**Units**									
Very coarse gravel	>32<64	<-5>-6	%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	42.50	66.20
Coarse gravel	>16<32	<-4>-5	%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	17.00	3.68
Medium gravel	>8<16	<-3>-4	%	0.00	0.00	1.08	0.00	0.00	0.00	0.00	0.00	4.66
Fine gravel	>4<8	<-2>-3	%	0.00	0.00	0.80	0.00	0.00	0.00	0.00	3.49	3.11
Very fine gravel	>2<4	<-1>-2	%	0.00	0.00	2.78	0.00	0.00	0.00	0.00	2.00	0.72
Very coarse sand	>1<2	<0>-1	%	0.00	0.00	3.95	0.00	0.00	0.00	0.00	2.13	1.09
Coarse sand	>0.5<1	<1>0	%	0.95	1.82	1.28	2.08	1.81	0.90	0.51	0.53	0.15
Medium sand	>0.25<0.5	<2>1	%	0.09	0.46	0.09	0.37	0.36	0.70	0.92	0.16	0.00
Fine sand	>0.125<0.25	<3>2	%	1.54	1.72	0.90	1.32	1.00	2.32	2.81	0.57	0.28
Very fine sand	>0.0625<0.125	<4>3	%	5.59	5.07	2.58	5.72	5.15	14.30	13.00	2.90	1.48
Very coarse silt	>0.03125<0.0625	<5>4	%	14.00	13.60	10.20	14.30	13.20	20.20	18.60	5.08	2.70
Coarse silt	>0.015625<0.03125	<6>5	%	23.10	23.40	19.30	23.70	22.10	16.00	15.80	5.44	3.46
Medium silt	>0.007813<0.015625	<7>6	%	22.90	23.50	21.40	22.40	23.20	16.30	16.70	6.03	4.11
Fine silt	>0.003906<0.007813	<8>7	%	16.60	16.70	17.60	16.20	17.70	14.70	15.70	5.76	4.11
Very fine silt	>0.001953<0.003906	<9>8	%	8.69	8.38	9.49	8.26	8.95	7.77	8.41	3.30	2.31
Clay	<0.001953	>9	%	6.56	5.39	8.64	5.58	6.55	6.85	7.54	3.15	1.92
Statistics*	Mean (phi)			6.26	6.20	6.28	6.17	6.29	5.83	5.94	-1.23	-2.50
	Sorting			1.76	1.71	2.67	1.73	1.76	2.04	2.09	5.01	5.00
	Skewness			0.096	0.029	-0.162	0.056	0.063	0.158	0.118	0.905	0.952
	Kurtosis			1.12	1.10	1.85	1.09	1.12	0.946	0.971	0.568	1.72
	% Silt/Clay		%	91.85	90.97	86.63	90.44	91.70	81.82	82.75	28.76	18.61
	Textural Group**			Mud	Mud	Slightly Gravelly Mud	Mud	Mud	Sandy Mud	Sandy Mud	Muddy Gravel	Muddy Gravel

* Folk & Ward
** GRADISTAT classification system (Blott, S. J. & Pye, K., 2001)

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Results Summary - PSA Wentworth Scale

Report No.: **17-63882**
Customer Reference: Not given
Order No: 9780

Customer Sample No		**1**	**2**	**3**	**4**	**5**	**8**	**9**	**10**	**11**
Customer Sample ID										
RPS Sample No		335194	335195	335196	335197	335198	335199	335200	335201	335202
Sample Type		**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**
Sample Location										
Sample Depth (m)										
Sampling Date		17/07/2017	17/07/2017	17/07/2017	17/07/2017	17/07/2017	17/07/2017	17/07/2017	17/07/2017	17/07/2017
Sampling Time										
Parameter	**Units**									
Pebble	%	0.00	0.00	1.88	0.00	0.00	0.00	0.00	62.99	77.65
Granule	%	0.00	0.00	2.78	0.00	0.00	0.00	0.00	2.00	0.72
Very coarse sand	%	0.00	0.00	3.95	0.00	0.00	0.00	0.00	2.13	1.09
Coarse sand	%	0.95	1.82	1.28	2.08	1.81	0.90	0.51	0.53	0.15
Medium sand	%	0.09	0.46	0.09	0.37	0.36	0.70	0.92	0.16	0.00
Fine sand	%	1.54	1.72	0.90	1.32	1.00	2.32	2.81	0.57	0.28
Very fine sand	%	5.59	5.07	2.58	5.72	5.15	14.30	13.00	2.90	1.48
Silt Clay	%	91.85	90.97	86.63	90.44	91.70	81.82	82.75	28.76	18.61
Total	%	100.0	100.0	100.1	99.9	100.0	100.0	100.0	100.0	100.0

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Report No.: **17-63882**
Customer Reference: Not given
Order No: 9780

Comments

Sample #	Job Comments
335194	Colour - dark grey sediment Texture - smooth, sand-like Odour - not abnormal Presence of Animals - No
335195	Colour - grey/brown sediment Texture - smooth, sand-like Odour - not abnormal Presence of Animals - No
335196	Colour - dark grey sediment Texture - gritty, sand-like Odour - not abnormal Presence of Animals - No
335197	Colour - grey/brown sediment Texture - smooth Odour - not abnormal Presence of Animals - No
335198	Colour - grey sediment Texture - gritty Odour - not abnormal Presence of Animals - No
335199	Colour - grey/black sediment Texture - smooth Odour - not abnormal Presence of Animals - No
335200	Colour - grey/brown sediment Texture - smooth, sand-like Odour - not abnormal Presence of Animals - No
335201	Colour - grey sediment Texture - gritty Odour - not abnormal Presence of Animals - Yes
335202	Colour - grey/black sediment Texture - gritty Odour - not abnormal Presence of Animals - No

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Report Information

Key to Report Codes

U	UKAS Accredited
M	MCERTS Accredited
N	Not Accredited
S	Subcontracted to approved laboratory
US	Subcontracted to approved laboratory UKAS Accredited for the test
MS	Subcontracted to approved laboratory MCERTS/UKAS Accredited for the test
SI	Subcontracted to internal RPS Group Laboratory
USI	Subcontracted to internal RPS Group Laboratory UKAS Accredited for the test
MSI	Subcontracted to internal RPS Group Laboratory MCERTS/UKAS Accredited for the test
I/S (in results)	Insufficient Sample
U/S (in results)	Unsuitable sample
Perishables, e.g. foodstuffs	1 month (if frozen) from the issue of this report
ND (in results)	Not Detected
DW (in units)	Results are expressed on a dry weight basis

Sample Retention and Disposal

Samples will generally* be retained for the following times prior to disposal:

Perishables, e.g. foodstuffs	1 month (if frozen) from the issue date of this report
Waters	2 weeks from the issue date of this report
Other Liquids	1 months from the issue date of this report
Solids (including Soils)	1 months from the issue date of this report

*Sample retention may be subject to agreement with the customer for particular projects

Analytical Methods

PAH's and PCB's	GCMS analysis following extraction of the wet sediment with hexane:acetone by ultrasonic and equlibrium extraction. Extract cleaned-up with alumina and activated copper.
Metals	ICP-MS analysis following microwave assisted digestion in hydrofluoric acid of the dried (<30°C) and ground sediment.
TOC	Combustion and infrared analysis following carbonate removal with hydrochloric acid.
PSA	Wet and dry sieving followed by laser diffraction analysis.
Density	Determination of density from the dry sediment by gravimetric analysis of a known volume of sediment.
Dry solids at 105°C	A portion of the wet sediment is dried at 105°C to constant weight.
TBT and DBT	GCMS analysis following the extraction of the wet sediment and subsequent derivatisation.
Please note:	**All testing carried out using the <2mm fraction**

Laboratories

RPS Letchworth	UKAS Test House 1663
RPS Manchester (Metals only)	UKAS Test House 0605
ESG Scientifics (TOC only)	UKAS Test House 0001
Thompson PSA only	

Profiency Testing (PT)

RPS Letchworth and Manchester Laboratories participate in the QUASIMEME Proficiency Testing Scheme

APPENDIX B: 2012 GEOCHEMICAL ANALYSIS RESULTS

Table C.1(I) Material Sampling - Physical Properties

Sampling Date: 12/06/2012	**Sampling Location:**	**DR-1**
Substance		**Result**
Fine Fraction Conc.: [1]		
<2 mm		7
<63µm		93
%Solids		49
	Units of Measurements	
Density/Specific Gravity	g/ml	1.4
TOC	%	2.13

Note 1: To be expressed as a percentage ot total sample

Sampling Date: 12/06/2012	**Sampling Location:**	**DR-2**
Substance		**Result**
Fine Fraction Conc.: [1]		
<2 mm		18
<63µm		82
%Solids		52
	Units of Measurements	
Density/Specific Gravity	g/ml	1.4
TOC	%	2.16

Note 1: To be expressed as a percentage ot total sample

Table C.1(I) Material Sampling - Physical Properties

Sampling Date: 12/06/2012		Sampling Location:	DR-3
Substance			**Result**
Fine Fraction Conc.: [1] <2 mm			9
<63µm			81
%Solids			51
	Units of Measurements		
Density/Specific Gravity	g/ml		1.4
TOC	%		1.92

Note 1: To be expressed as a percentage ot total sample

Sampling Date: 12/06/2012		Sampling Location:	DR-4
Substance			**Result**
Fine Fraction Conc.: [1] <2 mm			19
<63µm			81
%Solids			55
	Units of Measurements		
Density/Specific Gravity	g/ml		1.4
TOC	%		2.13

Note 1: To be expressed as a percentage ot total sample

Sampling Date: 12/06/2012		Sampling Location:	DR-5
Substance			**Result**
Fine Fraction Conc.: [1] <2 mm			17
<63µm			75
%Solids			55
	Units of Measurements		
Density/Specific Gravity	g/ml		1.5
TOC	%		1.51

Note 1: To be expressed as a percentage ot total sample

Table C.1(I) Material Sampling - Physical Properties

Sampling Date: 12/06/2012	Sampling Location:		DR-6
Substance			**Result**
Fine Fraction Conc.: [1]			
<2 mm			44
<63µm			56
%Solids			61
	Units of Measurements		
Density/Specific Gravity	g/ml		1.5
TOC	%		1.3

Note 1: To be expressed as a percentage ot total sample

Sampling Date: 12/06/2012	Sampling Location:		DR-7
Substance			**Result**
Fine Fraction Conc.: [1]			
<2 mm			33
<63µm			67
%Solids			70
	Units of Measurements		
Density/Specific Gravity	g/ml		1.5
TOC	%		1.38

Note 1: To be expressed as a percentage ot total sample

Table C.1(I) Material Sampling - Physical Properties

Sampling Date: 12/06/2012		**Sampling Location: DR-8**
Substance		**Result**
Fine Fraction Conc.: [1]		
<2 mm		21
<63µm		79
%Solids		53
	Units of Measurements	
Density/Specific Gravity	g/ml	1.5
TOC	%	2.44

Note 1: To be expressed as a percentage ot total sample

Sampling Date: 12/06/2012		**Sampling Location: DR-9**
Substance		**Result**
Fine Fraction Conc.: [1]		
<2 mm		33
<63µm		67
%Solids		54
	Units of Measurements	
Density/Specific Gravity	g/ml	1.5
TOC	%	1.57

Note 1: To be expressed as a percentage ot total sample

Table C.1(II) Material Sampling - Chemical Composition

Sampling Date: 12/06/2012	Sampling Location:	DR-1
Substance	**Units of Measurements**	**Result**
Arsenic	mg/kg	11.4
Copper	mg/kg	30.3
Cadmium	mg/kg	0.598
Chromium	mg/kg	34
Lead	mg/kg	64
Mercury	mg/kg	0.131
Nickel	mg/kg	26.7
Zinc	mg/kg	197
Aluminium	mg/kg	15100
Lithium	mg/kg	30.2
Organochlorine Pesticides		
Tributyltin (TBT) [1]	ug/kg	50
Dibutyltin (DBT) [1]	ug/kg	33.5
PCBs [1]	ug/kg	<1
PAHs [1]	ug/kg	
Total Extractable Hydrocarbons	mg/kg	228

Note 1: Only determined in certain Circumstances - see Application Note for further information

Sampling Date: 12/06/2012	Sampling Location:	DR-2
Substance	**Units of Measurements**	**Result**
Arsenic	mg/kg	12
Copper	mg/kg	34.6
Cadmium	mg/kg	0.852
Chromium	mg/kg	31.5
Lead	mg/kg	61.8
Mercury	mg/kg	0.127
Nickel	mg/kg	24.6
Zinc	mg/kg	188
Aluminium	mg/kg	11700
Lithium	mg/kg	25.9
Organochlorine Pesticides		
Tributyltin (TBT) [1]	ug/kg	60
Dibutyltin (DBT) [1]	ug/kg	20.7
PCBs [1]	ug/kg	
PAHs [1]	ug/kg	
Total Extractable Hydrocarbons	mg/kg	

Note 1: Only determined in certain Circumstances - see Application Note for further information

Table C.1(II) Material Sampling - Chemical Composition

Sampling Date: 12/06/2012	Sampling Location:	DR-3
Substance	**Units of Measurements**	**Result**
Arsenic	mg/kg	11.7
Copper	mg/kg	34.9
Cadmium	mg/kg	0.815
Chromium	mg/kg	29.7
Lead	mg/kg	61.7
Mercury	mg/kg	0.157
Nickel	mg/kg	23.5
Zinc	mg/kg	181
Aluminium	mg/kg	10800
Lithium	mg/kg	24.9
Organochlorine Pesticides		
Tributyltin (TBT) [1]	ug/kg	50
Dibutyltin (DBT) [1]	ug/kg	25.7
PCBs [1]	ug/kg	<1
PAHs [1]	ug/kg	
Total Extractable Hydrocarbons	mg/kg	142

Note 1: Only determined in certain Circumstances - see Application Note for further information

Sampling Date: 12/06/2012	Sampling Location:	DR-4
Substance	**Units of Measurements**	**Result**
Arsenic	mg/kg	7.07
Copper	mg/kg	10.1
Cadmium	mg/kg	0.311
Chromium	mg/kg	23.1
Lead	mg/kg	24.2
Mercury	mg/kg	0.062
Nickel	mg/kg	20.2
Zinc	mg/kg	85.2
Aluminium	mg/kg	105000
Lithium	mg/kg	21.7
Organochlorine Pesticides		
Tributyltin (TBT) [1]	ug/kg	<6
Dibutyltin (DBT) [1]	ug/kg	<6
PCBs [1]	ug/kg	<1
PAHs [1]	ug/kg	
Total Extractable Hydrocarbons	mg/kg	

Note 1: Only determined in certain Circumstances - see Application Note for further information

Sampling Date: 12/06/2012		Sampling Location: DR-5
Substance	**Units of Measurements**	**Result**
Arsenic	mg/kg	6.87
Copper	mg/kg	11.5
Cadmium	mg/kg	0.282
Chromium	mg/kg	22.5
Lead	mg/kg	23.8
Mercury	mg/kg	0.047
Nickel	mg/kg	19
Zinc	mg/kg	85.3
Aluminium	mg/kg	9090
Lithium	mg/kg	21.6
Organochlorine Pesticides		
Tributyltin (TBT) [1]	ug/kg	<9
Dibutyltin (DBT) [1]	ug/kg	<9
PCBs [1]	ug/kg	<0.1
PAHs [1]	ug/kg	
Total Extractable Hydrocarbons	mg/kg	4.4

Note 1: Only determined in certain Circumstances - see Application Note for further information

Table C.1(II) Material Sampling - Chemical Composition

Sampling Date: 12/06/2012	Sampling Location:	DR-6
Substance	**Units of Measurements**	**Result**
Arsenic	mg/kg	5.79
Copper	mg/kg	6.54
Cadmium	mg/kg	0.339
Chromium	mg/kg	16.6
Lead	mg/kg	16.8
Mercury	mg/kg	0.028
Nickel	mg/kg	13.4
Zinc	mg/kg	62.8
Aluminium	mg/kg	6130
Lithium	mg/kg	16.6
Organochlorine Pesticides		
Tributyltin (TBT) [1]	ug/kg	<5
Dibutyltin (DBT) [1]	ug/kg	<5
PCBs [1]	ug/kg	
PAHs [1]	ug/kg	
Total Extractable Hydrocarbons	mg/kg	

Note 1: Only determined in certain Circumstances - see Application Note for further information

Sampling Date: 12/06/2012	Sampling Location:	DR-7
Substance	**Units of Measurements**	**Result**
Arsenic	mg/kg	6.46
Copper	mg/kg	7.12
Cadmium	mg/kg	0.242
Chromium	mg/kg	18.3
Lead	mg/kg	18.1
Mercury	mg/kg	0.032
Nickel	mg/kg	14.6
Zinc	mg/kg	62.7
Aluminium	mg/kg	7400
Lithium	mg/kg	18.2
Organochlorine Pesticides		
Tributyltin (TBT) [1]	ug/kg	<5
Dibutyltin (DBT) [1]	ug/kg	<5
PCBs [1]	ug/kg	<0.1
PAHs [1]	ug/kg	
Total Extractable Hydrocarbons	mg/kg	1.86

Note 1: Only determined in certain Circumstances - see Application Note for further information

Table C.1(II) Material Sampling - Chemical Composition

Sampling Date: 12/06/2012	Sampling Location:	DR-8
Substance	**Units of Measurements**	**Result**
Arsenic	mg/kg	5.47
Copper	mg/kg	6.64
Cadmium	mg/kg	0.223
Chromium	mg/kg	20.1
Lead	mg/kg	19.4
Mercury	mg/kg	0.031
Nickel	mg/kg	16.3
Zinc	mg/kg	66.3
Aluminium	mg/kg	7910
Lithium	mg/kg	20.1
Organochlorine Pesticides		
Tributyltin (TBT) [1]	ug/kg	<6
Dibutyltin (DBT) [1]	ug/kg	<6
PCBs [1]	ug/kg	
PAHs [1]	ug/kg	
Total Extractable Hydrocarbons	mg/kg	

Note 1: Only determined in certain Circumstances - see Application Note for further information

Sampling Date: 12/06/2012	Sampling Location:	DR-9
Substance	**Units of Measurements**	**Result**
Arsenic	mg/kg	6.83
Copper	mg/kg	7.99
Cadmium	mg/kg	0.245
Chromium	mg/kg	21.2
Lead	mg/kg	21.8
Mercury	mg/kg	0.005
Nickel	mg/kg	17.2
Zinc	mg/kg	69
Aluminium	mg/kg	8390
Lithium	mg/kg	20.8
Organochlorine Pesticides		
Tributyltin (TBT) [1]	ug/kg	<5
Dibutyltin (DBT) [1]	ug/kg	<5
PCBs [1]	ug/kg	<0.1
PAHs [1]	ug/kg	
Total Extractable Hydrocarbons	mg/kg	4.16

Note 1: Only determined in certain Circumstances - see Application Note for further information

Attachment B.1 (III)

Sediment Chemistry Analysis with reference to Irish Action Levels

Table B.1 Results of sediment chemistry analysis of the material to be dumped at sea, with reference to Irish Action Levels Note 1

August 2017 Sampling Campaign- surface samples

Orange highlighted cells exceed the lower Irish Action Level.

Red highlighted cells exceed the upper Irish Action Level (none identified).

Parameter	Units (dry wt) Note 2	Sampling points								
		DR-1	DR-2	DR-3	DR-4	DR-5	DR-6	DR-7	DR-8	DR-9
Arsenic	mg kg^{-1}	10	12	15	12	12	9	10	13	10
Cadmium	mg kg^{-1}	0.5	0.5	1.1	0.5	0.8	0.4	0.4	0.4	0.4
Chromium	mg kg^{-1}	50	58	58	52	57	33	38	51	42
Copper	mg kg^{-1}	10	13	75	12	41	7	8	10	9
Lead	mg kg^{-1}	28	34	141	30	62	18	21	27	23
Mercury	mg kg^{-1}	0.1	0.1	0.2	0.1	0.2	0.0	0.0	0.0	0.0
Nickel	mg kg^{-1}	27	30	35	28	30	16	19	26	21
Zinc	mg kg^{-1}	81	100	242	97	209	57	61	79	67
Σ TBT & DBT Note 3	mg kg^{-1}	<0.02	<0.02	0.10	<0.02	0.08	<0.01	<0.01	<0.01	<0.01
γ-HCH (Lindane) Note 4	µg kg^{-1}	<2.34	<2.77	<2.52	<2.58	<2.06	<1.00	<1.00	<1.00	<2.08
HCB Note 5	µg kg^{-1}	<2.34	<2.77	<2.52	<2.58	<2.06	<1.00	<1.00	<1.00	<2.08
PCB 028	µg kg^{-1}									
PCB 052	µg kg^{-1}									
PCB 101	µg kg^{-1}									
PCB 138	µg kg^{-1}									
PCB 153	µg kg^{-1}									
PCB 180	µg kg^{-1}									
PCB 118	µg kg^{-1}									
PCB (Σ ICES 7) Note 6	µg kg^{-1}	1	36	10	17	1	<1	<1	<1	1
PAH (Σ 16) Note 7	µg kg^{-1}	348	n/a	5888	n/a	827	n/a	246	n/a	207
Total Extractable Hydrocarbons	g kg^{-1}	<23.37	n/a	<25.15	n/a	72.10	n/a	<10.0	n/a	<20.82

Note 1: Applicants should highlight in Table B.1 any results which exceed either the upper or lower Irish action levels. Action levels are published in: *Cronin et al. 2006. Guidelines for the Assessment of Dredge Material for Disposal in Irish Waters. Marine Environment & Health Series, No. 24. Marine Institute.*
Note 2: Total sediment <2 mm
Note 3: Sum of tributyl tin and dibutyl tin
Note 4: 1α,2α,3β,4α,5α,6β-hexachlorocyclohexane
Note 5: Hexachlorobenzene
Note 6: ICES 7 polychlorinated biphenyls: PCB 028, 052, 101, 118, 138, 153, 180.
Note 7: Polyaromatic hydrocarbons (measured as individual compounds): Naphthalene, Acenaphthylene, Acenaphthene, Fluorene, Phenanthrene, Anthracene, Fluoranthene, Pyrene, Benzo(a)anthracene, Chrysene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Benzo(a)pyrene, Dibenzo(ah)anthracene, Benzo(ghi)perylene, Indeno(123-cd)pyrene.

———————————————————————————

2012 Sampling Campaign- surface samples

Orange highlighted cells exceed the lower Irish Action Level.

Red highlighted cells exceed the upper Irish Action Level (none identified).

Parameter	Units (dry wt) Note 2	Sampling points								
		DR-1	DR-2	DR-3	DR-4	DR-5	DR-6	DR-7	DR-8	DR-9
Arsenic	mg kg^{-1}	11	12	12	7	7	6	6	5	7
Cadmium	mg kg^{-1}	0.6	0.9	0.8	0.3	0.3	0.3	0.2	0.2	0.2
Chromium	mg kg^{-1}	34	32	30	23	23	17	18	20	21
Copper	mg kg^{-1}	30	35	35	10	12	7	7	7	8
Lead	mg kg^{-1}	64	62	62	24	24	17	18	19	22
Mercury	mg kg^{-1}	0.1	0.1	0.2	0.1	0.0	0.0	0.0	0.0	0.0
Nickel	mg kg^{-1}	27	25	24	20	19	13	15	16	17
Zinc	mg kg^{-1}	197	188	181	85	85	63	63	66	69
Σ TBT & DBT Note 3	mg kg^{-1}	0.1	0.1	0.1	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
γ-HCH (Lindane) Note 4	µg kg^{-1}	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
HCB Note 5	µg kg^{-1}	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
PCB 028	µg kg^{-1}									
PCB 052	µg kg^{-1}									
PCB 101	µg kg^{-1}									
PCB 138	µg kg^{-1}									
PCB 153	µg kg^{-1}									
PCB 180	µg kg^{-1}									
PCB 118	µg kg^{-1}									
PCB (Σ ICES 7) Note 6	µg kg^{-1}	<1.0	n/a	<1.0	<1.0	<0.1	n/a	<0.1	n/a	<0.1
PAH (Σ 16) Note 7	µg kg^{-1}	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Total Extractable Hydrocarbons	g kg^{-1}	228	n/a	142	n/a	4.4	n/a	1.9	n/a	4.2

Note 1: Applicants should highlight in Table B.1 any results which exceed either the upper or lower Irish action levels. Action levels are published in: *Cronin et al. 2006. Guidelines for the Assessment of Dredge Material for Disposal in Irish Waters. Marine Environment & Health Series, No. 24. Marine Institute.*

Note 2: Total sediment <2 mm

Note 3: Sum of tributyl tin and dibutyl tin

Note 4: 1α,2α,3β,4α,5α,6β-hexachlorocyclohexane

Note 5: Hexachlorobenzene

Note 6: ICES 7 polychlorinated biphenyls: PCB 028, 052, 101, 118, 138, 153, 180.

Note 7: Polyaromatic hydrocarbons (measured as individual compounds): Naphthalene, Acenaphthylene, Acenaphthene, Fluorene, Phenanthrene, Anthracene, Fluoranthene, Pyrene, Benzo(a)anthracene, Chrysene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Benzo(a)pyrene, Dibenzo(ah)anthracene, Benzo(ghi)perylene, Indeno(123-cd)pyrene.

———————————————————————————

Attachment B.2

Characteristics and Composition of the Material for Disposal

Refer to Foynes and Limerick Dock Sampling Survey Report (Hydrographic Surveys Ltd- August 2017) - contained in Attachment B.1 (II).

Also refer to previous Radiological testing report in Attachment G.1 and email dated 12.09.17 confirming ongoing testing was no longer a requirement.

From: Ciara Maxwell [mailto:c.maxwell@epa.ie]
Sent: 12 September 2017 13:50
To: John Carlton <jcarlton@sfpc.ie>
Subject: Radiological Analysis - Foynes Harbour & Limerick Dock

John,

As discussed in our pre-application meeting today, I contacted my colleague in the Office of Radiation Protection and Environmental Monitoring (ORM) who advised that samples were taken in the Shannon Foynes Port area in 2008 and 2012. In accordance *with IAEA-TEC-DOC-1375, Determining the suitability of materials for disposal at sea under the London Convention 1972: A radiological assessment procedure t*he measurements made on the samples were found to be *de minimis*, indicating that the dumping of these materials at sea will not result in a radiological hazard.

So based on previous measurements there is no requirement to analyse samples on this occasion as the samples analysed previously are sufficient to cover the area of the intended dredging operation.

Regards,
Ciara

Ciara Maxwell
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Environmental Protection Agency
Regional Inspectorate
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Ireland

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Email: c.maxwell@epa.ie

http://www.youtube.com/user/epaireland
http://twitter.com/EPAIreland

Attachment C.1

Alternatives to Dumping at Sea

ALTERNATIVE MEANS OF DISPOSAL OF DREDGE SPOIL

Dumping at sea is regulated under the Dumping at Sea Act, 1996 (No 14). This Act implements the OSPAR Convention adopted in 1992 and entered into force in 1998. Shannon Foynes Port Company is aware of the necessity to consider and explore alternatives to sea disposal and in particular to consider the practicable availability of land-based methods, treatment, disposal or elimination as set out in the First Schedule of the Dumping at Sea Act, 1996.

In the mid 1950's the Limerick Harbour Commissioners, (predecessors of Shannon Foynes Port Company) carried out a capital dredging contract, which entailed the deepening of the navigation channel by 1.2 metres between Limerick Dock and Battle Island, a distance of 6.5 miles. The dredged spoil from this contract was pumped ashore at Corcanree, a low-lying area of 65 acres owned by the Port Company.

The spoil was used to partly fill the low-lying area and was later covered with stone and aggregate fill. See Photograph C.1-1.

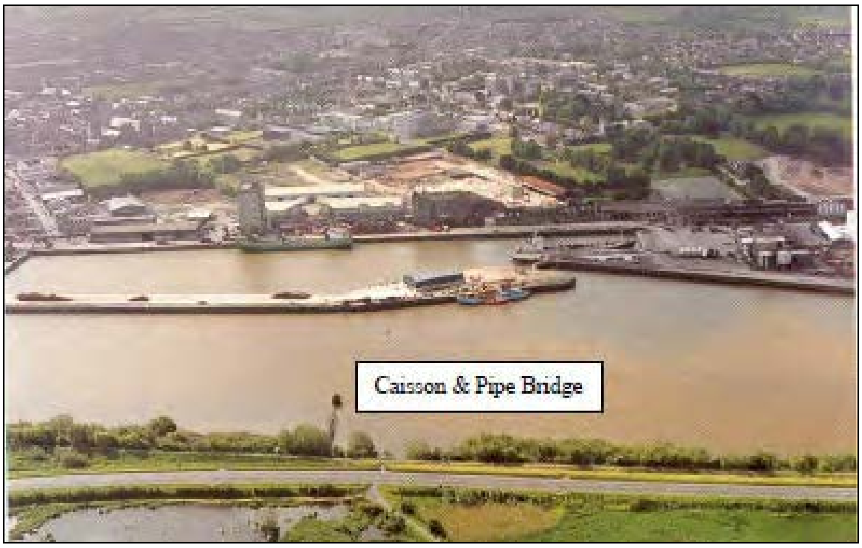
The dredged material at that time contained gravel and stone, as it was a deepening of the natural riverbed as opposed to clearing a build-up of silt. An area of land West of the Dock was also reclaimed and filled with silt.

However this land had to be piled to support buildings which have been constructed on it.

Photograph C.1-1- Dredged Spoil being pumped ashore 1956

In the early 1970's a structure was erected North of Ted Russell Dock in Limerick to pump the dredged silt ashore rather than dumping it downriver. This was a joint venture between the Port Company and Limerick Corporation. The plan was to fill in a pond area owned by Limerick Corporation and turn it into a Public Park.

However there were serious objections to the plan from local residents and it was never implemented. As a result of representations made to the Port Company the structure was finally removed in 1993 without ever having been used. See Photograph C.1-2.



Photograph C.1-2- Structure intended to be used to pump dredged spoil ashore

The Shannon Foynes Port Company continues to explore alternative disposal options, but to date practical alternatives have not been possible due to:

(a) The high percentage (60%) of silt that is involved is unsuitable as a fill material or for other engineering purposes
(b) The lack of availability of suitable land based sites in the vicinity of the areas to be dredged, along with planning and environmental issues relating to filling land
(c) The costs associated with the dredging and transport of material to sites remote from the areas to be dredged.

None of the Port Company owned land is suitable for disposal as it is developed and Limerick Corporation has no suitable land available in Limerick. Limerick City and County Council has no land available for the disposal of dredged spoil.

Shannon Foynes Port Company has invested in a Multicat Vessel “SHANNON 1” acquired in 2009, at a cost of €2.6m. This vessel has the capability of bed levelling and also injection pumping of silt from deposited areas over a short distance in to the current stream, where it is dispersed naturally by the tides and currents. This helps to reduce the quantities of silt that are required to be loaded in the dredge sites and subsequently dumped at the approved dump sites. This vessel also has a computerised system which monitors the progress of the bed levelling and can carry out bathymetric surveys also to monitor water depths on a regular basis; this ties in with the Company’s Quality and Maintenance procedures.

As a further measure, the Marine Operations Department co-ordinate closely with Shipping Agents regarding best time windows to fix larger deeper draughted vessels by taking into account tidal patterns (best done in Neap Tidal Periods). Vessels then arrive at High Tide. The Port Services Department also provide flexible operating hours, to enable deeper vessels to commence discharge at high tide, thus reducing the draft as the water depth reduces on the ebbing tide. This makes best use of the depths available.

Chemical and Radiological tests previously carried out on silt samples indicate that the material is not deleterious to the receiving environment. There is an Anti-Pollution Team based at Foynes Port, which can be deployed quickly with all the resources available to contain any pollution that may occur in the Estuary. There are strict regimes involved in Limerick and Foynes for cleaning the Quays and Jetties. A roadsweeper is deployed to sweep up cargo residue, which in turn is deposited in a registered Waste Intake Facility on a regular basis.

There are also on-going improvement works being carried out with regard to Surface Water runoff and Foul Waste in the Port areas. This includes interceptors and waste water treatment systems. This is being carried out in conjunction with Limerick City and County Council. The ultimate aim is to improve the Water Quality in the Shannon Estuary.

Attachment D.1

Purpose of the Operation

HISTORY OF THE PORT

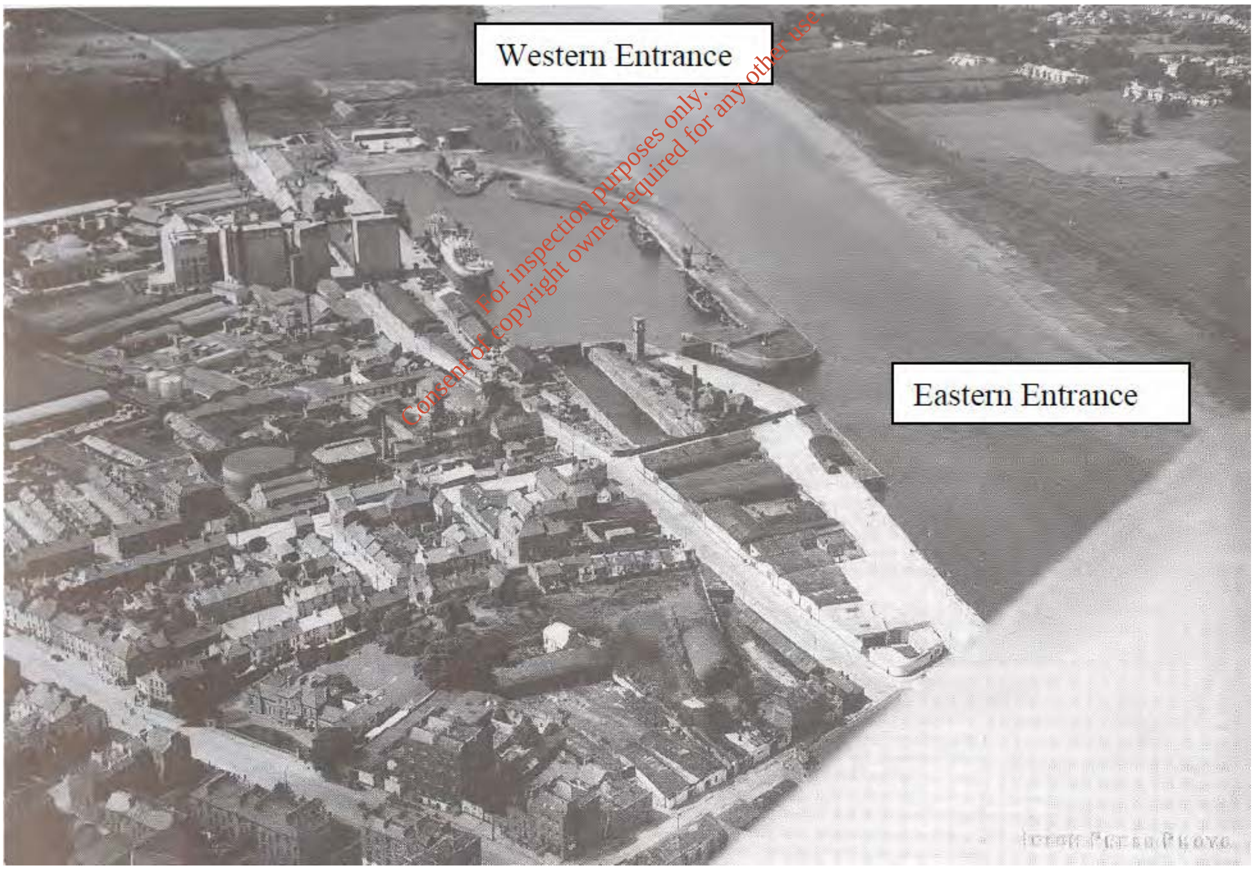
Limerick:

Limerick has been used as a trading port for more than 1000 years from the Viking times in the 9th century when they founded a fortified settlement. It became a major trading port and 500 years ago flourished in times when other ports struggled.

In 1823 following representations by prominent merchants in the Limerick area, an Act of Parliament was passed enabling the then Limerick Bridge Commissioners to construct a bridge and quays to accommodate the increased number of ships using the port.

In 1847 again following representations by prominent merchants in the Limerick area, an Act of Parliament was passed enabling the then Limerick Harbour Commissioners to construct a Floating Dock to accommodate larger ships arriving in Limerick.

This new Dock was opened in 1853 with a Lock Gate located on the Eastern end, which allowed ships to enter and leave at high water. The Dock was extended in area in 1933 to accommodate the increased number and size of ships using the Port. This remained unchanged until in 1955 the new Western entrance was opened and the old Eastern one closed up and filled in see Photograph D.1-1.



Photograph D.1-1- Ted Russell Docks looking downstream showing old Eastern Entrance and the cut for the now used Western Entrance

Docks today are shown in Photograph D.1-2.

Photograph D.1-2- Ted Russell Docks today looking upstream showing the enclosed Dock and the Approach Channel

The shape of Limerick Dock has not changed since 1955.

Limerick Harbour Commissioners were changed to Shannon Estuary Ports under the 1996 Harbours Act.

The port amalgamated with Foynes Port Company under the Harbours Act 2000 and the company is now called Shannon Foynes Port Company.

Foynes

Foynes Harbour came to prominence in the early 1800's and the first pier was constructed in 1846 now known as the West Quay.

Due to increased activity the Foynes Harbour Trustees were formed in 1890 and they constructed a timber jetty adjacent to the West Pier. In 1936 this was replaced by the West Jetty.

In 1968 the East Jetty was constructed and this Jetty was extended in 1984.

The dolphin system catering for oil products and chemicals was constructed in 1992.

The extension to the West Jetty and upgrading of the West Quay was completed in 2000. See Photograph D.1-3.

The Foynes Harbour Trustees were changed to Foynes Port Company under the 1996 Harbour Act.

The port amalgamated with Shannon Estuary Ports under the Harbours Act 2000 and the company is now called Shannon Foynes Port Company.

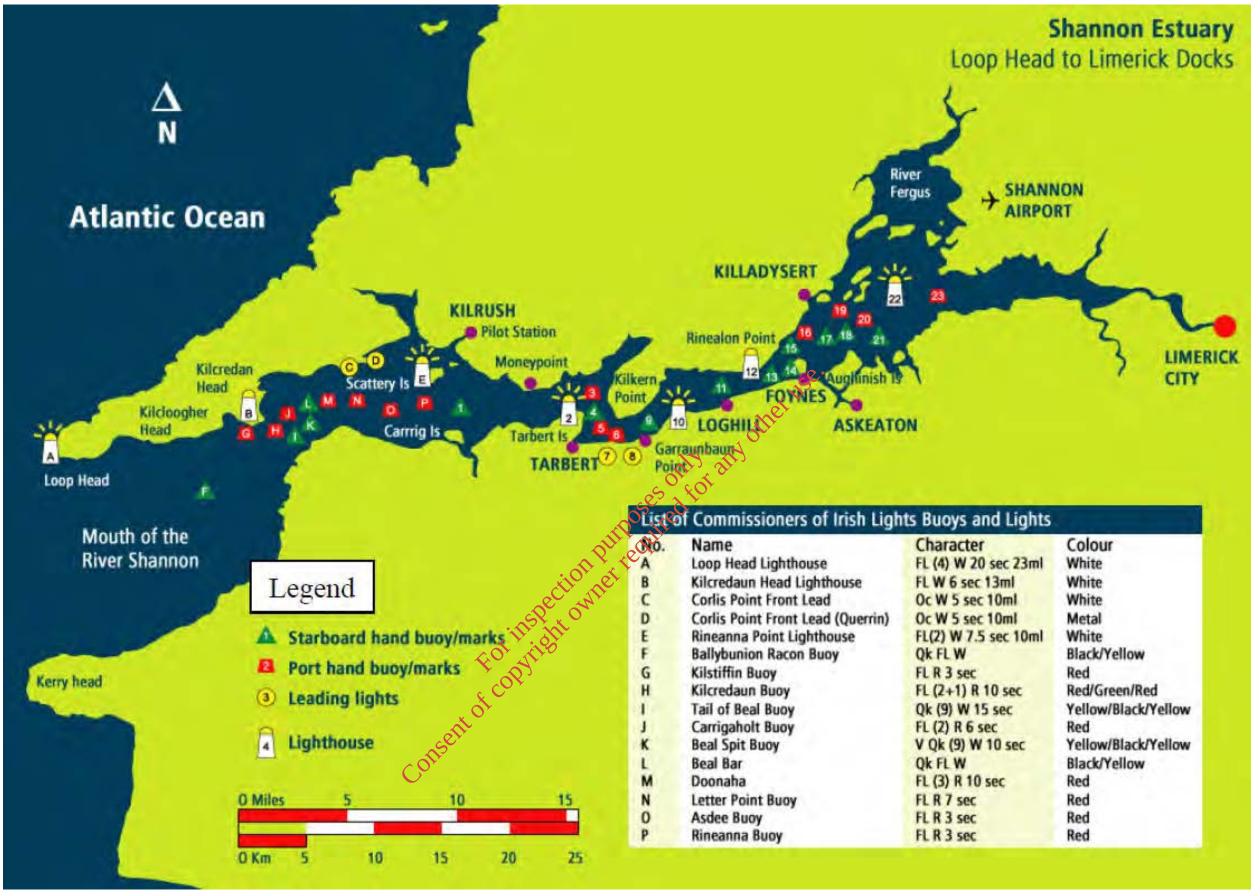
Photograph D.1-3- An Aerial View of Foynes Harbour

PORT FACILITIES

Navigation Channel

The navigation channel which runs from the Sea to Foynes Harbour and further on to Limerick, is a natural deep water channel which is clearly marked by a large number of Lighted Buoys and Beacons see Photograph D.1-4.

Photograph D.1-4- Navigation Channel



Limerick

The Port facilities at Limerick consist of an enclosed Dock with a water area of 4.5 hectares operating 11 separate ship berthing facilities with a total quay length of 914 metres. The enclosed Dock is maintained to a minimum depth of 5.5 metres but it can be much deeper depending on the Tide levels.

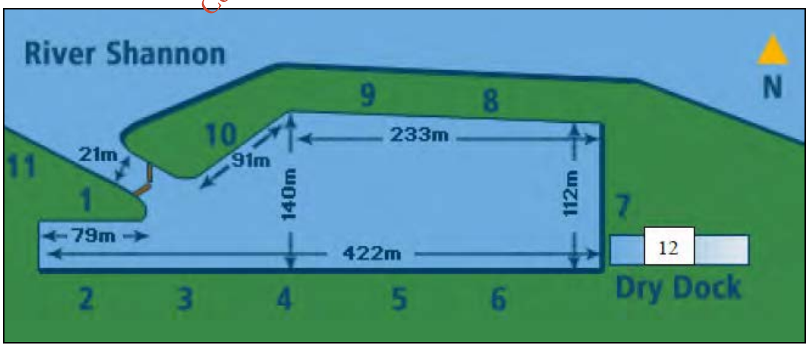
The maximum size of ship catered for in Ted Russell Dock is:

- Maximum Length 152 metres
- Maximum Beam 19.8 metres
- Tidal Draft 0.5 metre clearance (normally)
- 0.6 metre clearance – Tankers

Access to the Dock is through the Dock Gates which generally open 2 hours before High Water and close at High Water, see Photograph D.1-5.

Photograph D.1-5- Dock Access

All depths are relative to 0.00m on the Limerick Dock Tide Gauge which is –1.67m Ordnance Datum (Poolbeg). Details of the Berths are shown on Photograph D.1-6.



Photograph D.1-6- Limerick Berthing Facilities

Limerick Dock berthing facilities:

1: Cement Berth	7: Clock Berth
2: Shell Berth	8: North East Berth
3: Stone Berth	9: North Berth
4: Garryowen Berth	10: North West Berth
5: Clyde Berth	11: Long Wall (NAABSA) Not Always Afloat But Safe Aground
6: Liverpool Berth	12: Graving (Dry) Dock

Foynes

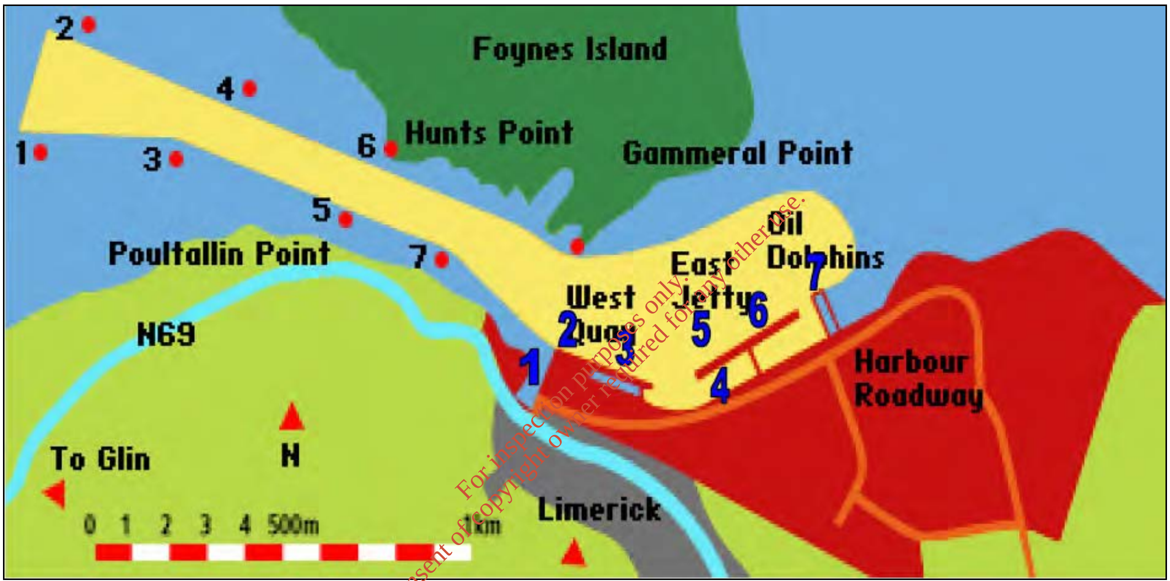
Foynes is an open natural harbour located between the Southern Bank of the Shannon and Foynes Island on the North. Seven separate ship berthing facilities which comprise of a West Quay and East Jetty for handling general/bulk cargoes and one purpose built dolphin jetty for handling liquid products.

The maximum size of ship catered for is:

- Maximum Length 229 metres
- Maximum Draft 10.5 metres

All depths are relative to Chart Datum –0.3m Ordnance Datum (Poolbeg).

Details of Berthing facilities are shown on Photograph D.1-7.



Photograph D.1-7- Foynes Berthing Facilities

Foynes berthing facilities:

- **Berth 1:** NAABSA (Not Always Afloat But Safe Aground)
- **Berth 2:** 271m in length
- **Berth 3:** 295m in length
- **Berth 4:** 271m in length
- **Berth 5:** 142m in length
- **Berth 6:** 295m in length
- **Berth 7:** Two Dolphins - 35m length with mooring at each end

PURPOSE OF THE OPERATION

The proposed work is maintenance dredging, to maintain water depths for ships navigating to and from and berthing at Limerick Dock and Foynes Port. This is necessary due to a natural build-up of silt deposited at the dredge areas, as detailed below.

SEDIMENTATION AND ACCRETION:

At Ted Russell Dock:
The upper Shannon catchment area is subjected to varying degrees of runoff and soil erosion, which contributes to silt accretion throughout the estuary. In the estuarine area of the river vast quantities of sediment are eroded, held in suspension by the velocity of the tide and then deposited during slack water periods at high and low tide times.

The pattern of silt accretion at Ted Russell Dock is further compounded during a dry Summer and Autumn as the amount of fresh water released from the upper Shannon into the estuary is vastly reduced to maintain the head of water required to power the Hydroelectric Station at Ardnacrusha see Map D.1-1.

This reduces the volume of water required to scour the silt from the vicinity of Ted Russell Dock. This can lead to vast deposits of silt at the approach channel to the Docks (up to 3 metres above the required datum) where the river widens and can be so large that it can be clearly seen at low water see Photograph D.1-8.

This explains the necessity to seek permits for 120,000 tonnes annually which include a contingency amount to cover exceptionally dry periods.

Attached is a copy of Permit No. S0009-02 in 2013 which permitted the dumping of 120,000 tonnes (refer to Attachment A.7). This figure would be the absolute maximum quantity dredged at Ted Russell Dock and approach channel in any year.

Photograph D.1-8- Picture showing large build of silt at the Entrance Channel to Limerick Dock where the river widens

At Foynes Harbour:

As in the case of Ted Russell Dock huge quantities of silt are eroded from the river banks and riverbed, held in suspension during tidal flows and deposited at the end of the tide. However this is further added to during ebb tides by the eroded silt from the tributaries feeding into the Estuary East of Foynes i.e. the Maigue, the Deel and the Fergus, in particular during a wet Summer and Autumn when the volume of runoff water is suddenly increased see Map D.1-2.

Since the Capital Dredging works carried out in 1999/2000, the regime of the harbour has changed due to the deepening of the Berths and inner harbour area and also by the lengthening of the West Quay. This has led to a significant increase in the volume of silt building up on the river bed. H R Wallingford have said that this is common following major capital dredging works and tends to settle down over time as the new regime takes effect. The rate of siltation is likely to reduce in the longer term. They go on to say that it is likely that a new regime would be established within 5 to 7 years after the capital dredging.

This explains the necessity to seek permits for 156,000 tonnes annually which include a contingency amount to cover exceptional periods.

Attached is a copy of Permit No. S0009-02 in 2013 which permits the dumping of 156,000 tonnes Attachment A.7.

This figure would be the absolute maximum quantity dredged at Foynes Harbour in any year.

HISTORY OF MAINTENANCE DREDGING:

At Ted Russell Dock:

Since the opening of Ted Russell Dock in 1853 there has always been some level of dredging carried out to maintain the approach channel and to a lesser extent the enclosed Dock itself to accommodate the vessels using it.

In the latter half of the 1800's improvements were made to the channel with the removal of rock from the cock rock at Tervoe and foul ground from Spillanes and Barringtons. Following these works maintenance dredging was required to maintain the improved channel. In 1872 the Port Company acquired a steam dredger to carry out dredging works. In 1894 a hopper dredger was acquired which carried out dredging until 1959 when the hopper dredger "Curraghgour II" was acquired.

Shannon Foynes Port Company have acquired a new state of the art Multi-Purpose vessel "SHANNON 1" and this has the ability to operate bed levelling as well as water injection methods of dredging.

In 1933 the Dock was extended in area to cater for increased levels of shipping and in 1955 the new Western entrance to the Dock was opened to cater for the increasing size of ships which could steam directly into the Dock without altering course which made entering the Docks much safer. As a result of the changed configuration of the river and the increased drafts of the larger vessels the dredging requirement increased dramatically.

As already stated to service the navigation of ships into Ted Russell Dock two areas require dredging, the approach channel and the floor of the enclosed Dock. In general the amounts dredged from the enclosed Dock, is in the region of 5,000 tonnes every year. The records each year up to 2018 show a combined total for the volumes dredged from the channel and the Dock.

The following table shows the volumes of dredged materials from 1990 to 2018 inclusive at Limerick.

Table D.1-1- Volumes Dredged at Limerick

Year	Quantity (tonnes)
1990	83,710
1991	71,460
1992	53,900
1993	27,600
1994	29,900
1995	97,250
1996	79,700
1997	65,650
1998	1,350
1999	10,950
2000	9,000
2001	14,850
2002	11,700
2003	19,350
2004	24,050
2005	15,900
2006	12,150
2007	0
2008	0
2009	0
2010	0
2011	0
2012	0
2013	0
2014	0
2015	5,750
2016	0
2017	0
2018	0

The figures highlight the variations in quantity from a dry Summer (high quantity) to that of a wet Summer (low quantity).

The maximum quantity requested on the permit application is 120,000 tonnes for the approach channel annually, which includes a maximum of 6,000 tonnes from the enclosed dock annually.

At Foynes:

Prior to the year 2000 maintenance dredging at Foynes has traditionally been carried out every two to three years. A major capital dredging program was carried out in 1999/2000 to provide a new berth and accommodate larger and deeper drafted vessels. To maintain the advertised depths required maintenance dredging is required annually.

While the feasibility studies carried out by HR Wallingford, Marine Consultants prior to the capital dredging works indicated that maintenance dredging would not increase significantly due to the increased depths it is now apparent that the annual quantity will be substantially more than that required prior to the capital works.

To maximise the benefit of the capital works it is also planned that maintenance dredging will be carried out every three to four months in order to avoid the application of draft restrictions throughout the year if dredging is only carried out once a year. The maximum amount to be dredged annually at Foynes Harbour would be 156,000 tonnes.

The following is a table showing the quantities dredged in Foynes from 1993 to 2018 inclusive:

Table D.1-2- Volumes Dredged at Foynes

Year	Quantity (tonnes)
1993	85,200
1995	67,500
1996	39,000
1997	45,000
1999/2000	Capital works 412,500 plus 120,000 of rock & clay
2001	134,200
2002	98,000
2003	0
2004	50,310
2005	31,987
2006	44,290
2007	40,130
2008	54,120
2009	0
2010	143,651
2011	0
2012	0
2013	128,494
2014	0
2015	0
2016	201,488
2017	0
2018	157,517

The maximum quantity requested on the permit application is for 156,000 tonnes annually to allow for contingencies.

MAP D.1-1 ARDNACRUSHA POWER STATION RELATIVE TO LIMERICK DOCKS

MAP D.1- 2 NAVIGATION CHANNEL FROM LIMERICK TO FOYNES

Attachment D.2

Loading Areas

Refer to the following drawings in Appendix A which show the location and co-ordinates of the Loading Areas in Foynes and Limerick:

- M0742-RPS-XX-DS-DR-C-0001 Location of Dredge Site A
- M0742-RPS-XX-DS-DR-C-0002 Location of Dredge Site B
- M0742-RPS-XX-DS-DR-C-0003 Location of Dredge Site C
- M0742-RPS-XX-DS-DR-C-0004 Location of Dredge Site D

Loading Area "A"- Dredge Site "A" (Ted Russell Dock)

Loading Area "A" consists of dredge site A as shown on Figure D.2-1 below and Drawing M0742-RPS-XX-DS-DR-C-0001 in Appendix A.

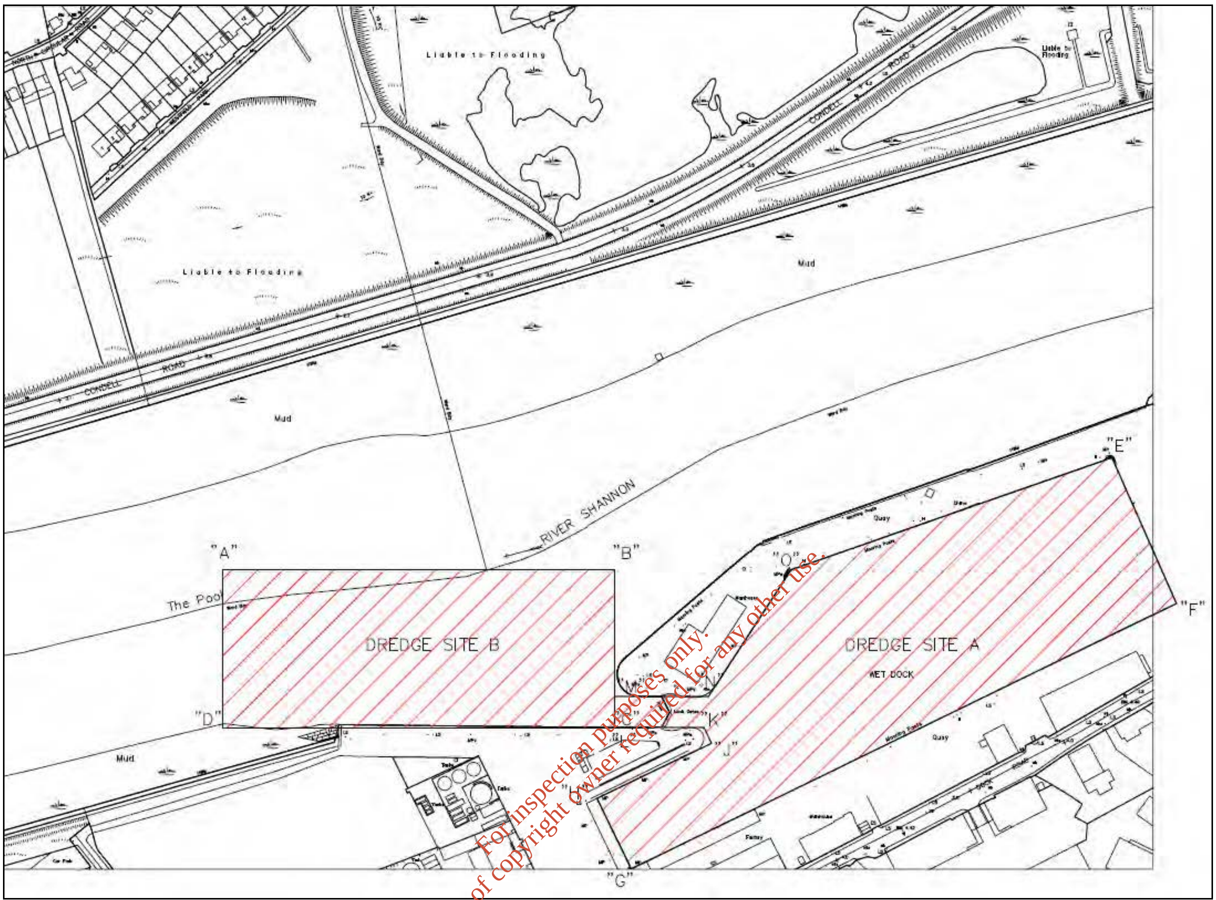


Figure D.2-1- Extents of Dredge Sites "A" & "B"

The co-ordinates of the loading area are shown in Table D.2-1 below.

	WGS84						ITM	
	Latitude			Longitude				
Point	**Degrees**	**Minutes**	**Seconds**	**Degrees**	**Minutes**	**Seconds**	**Easting**	**Northing**
A	52	39	36.128	-8	38	22.162	556738	656731
B	52	39	29.391	-8	38	19.773	556782	656630
C	52	39	26.778	-8	38	39.799	556404	656445
D	52	39	28.357	-8	38	41.099	556830	656494
E	52	39	29.609	-8	38	36.860	556460	656532
F	52	39	29.964	-8	38	37.132	556455	656543
G	52	39	29.978	-8	38	40.431	556393	656544
H	52	39	30.657	-8	38	40.441	556393	656565
J	52	39	30.676	-8	38	36.982	556458	656565
K	52	39	33.540	-8	38	33.991	556515	656653

Table D.2-1 Dredge Site "A" Co-ordinates

Loading Area "B"- Dredge Site "B" (Approach to Ted Russell Dock)

Loading Area "B" consists of dredge site B as shown on Figure D.2-1 above and Drawing M0742-RPS-XX-DS-DR-C-0002 in Appendix A.

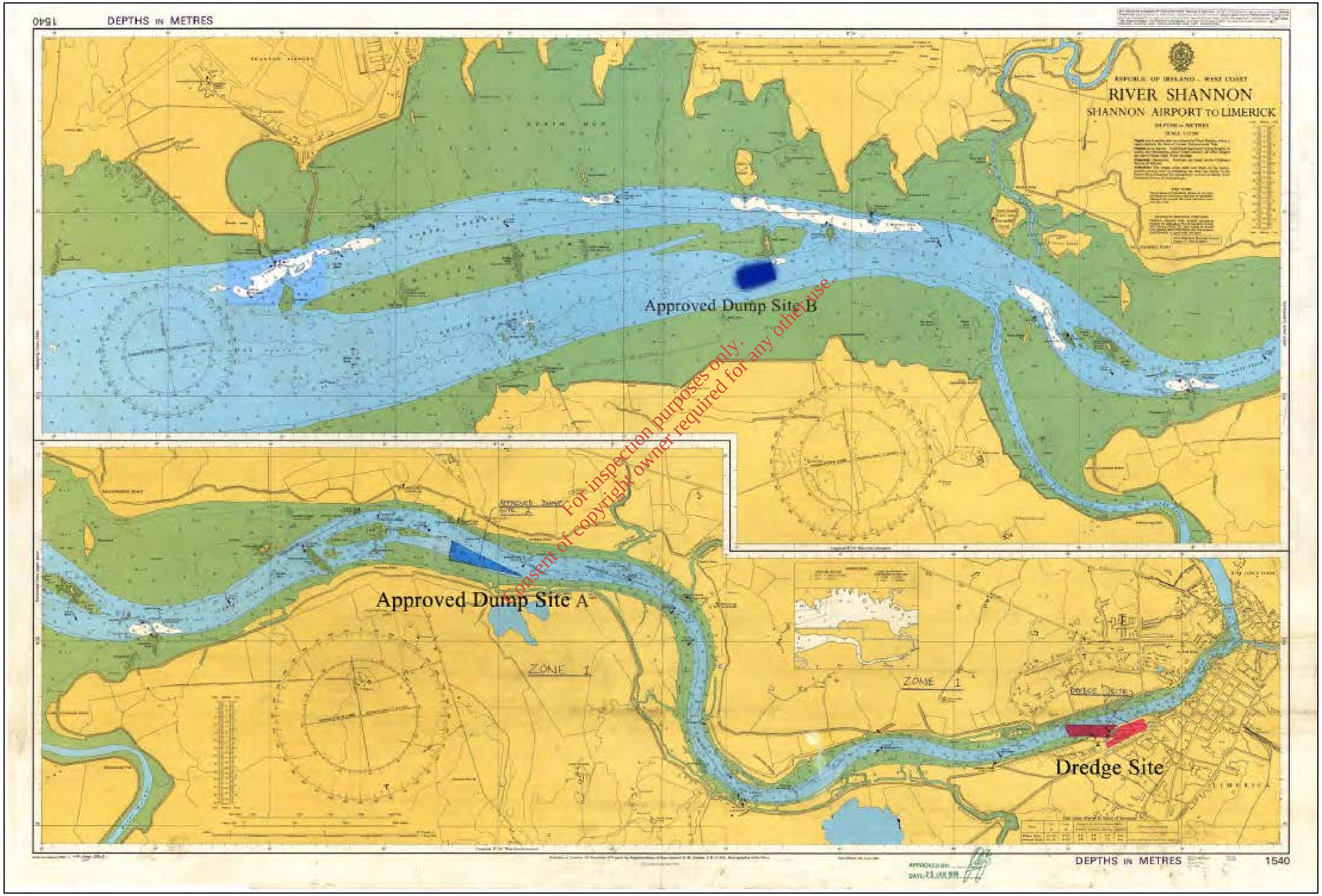
The co-ordinates of the loading area are shown in Table D.2-2 below.

	WGS84						ITM	
	Latitude			Longitude				
Point	**Degrees**	**Minutes**	**Seconds**	**Degrees**	**Minutes**	**Seconds**	**Easting**	**Northing**
A	52	39	33.426	-8	38	54.956	556121	656653
B	52	39	33.505	-8	38	40.483	556393	656653
C	52	39	29.978	-8	38	40.431	556393	656544
D	52	39	29.867	-8	38	54.903	556121	656543

Table D.2-2 Dredge Site "B" Co-ordinates

Map D.2-1 below shows the Dredge Site and Approved Dump Sites for Limerick

MAP D.2-1 DREDGE SITES "A" & "B" AND APPROVED DUMP SITES FOR LIMERICK



Loading Area "C"- Dredge Site "C" (Foynes Harbour)

Loading Area "C" consists of dredge site C as shown on Figure D.2-2 below and Drawing M0742-RPS-XX-DS-DR-C-0003 in Appendix A.

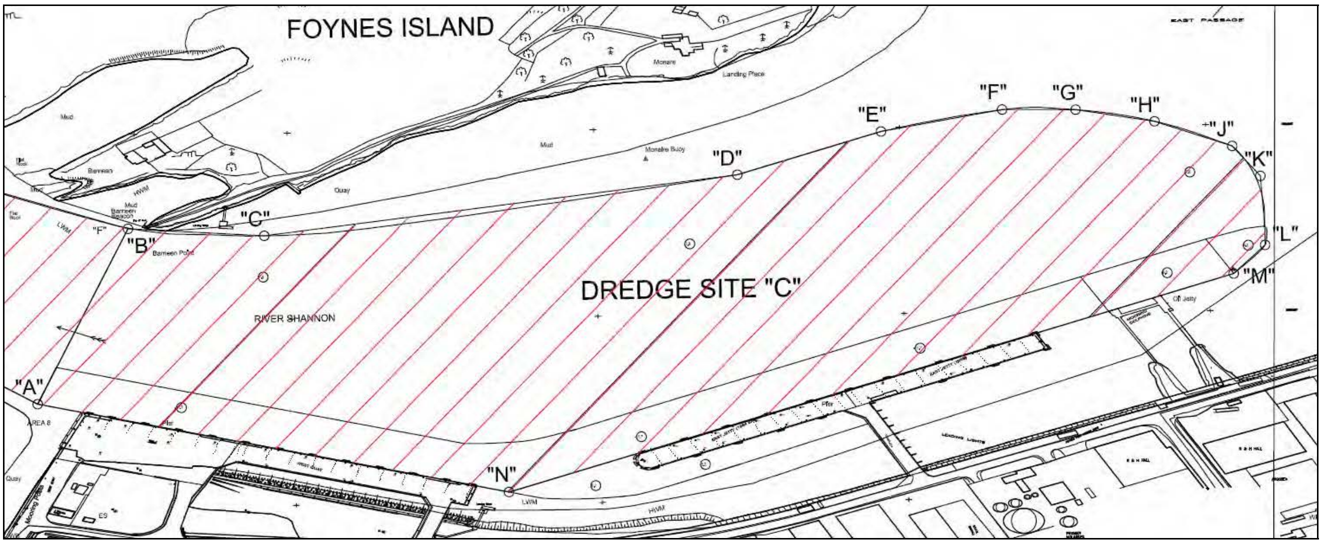


Figure D.2-2 Extents of Dredge Site "C"

The co-ordinates of the loading area are shown in Table D.2-3 below.

	WGS84						ITM	
	Latitude			Longitude				
Point	Degrees	Minutes	Seconds	Degrees	Minutes	Seconds	Easting	Northing
A	52	36	49.099	-9	6	37.590	524799	651956
B	52	36	55.211	-9	6	34.449	524861	652144
C	52	36	54.965	-9	6	29.711	524950	652135
D	52	36	57.092	-9	6	13.284	525260	652196
E	52	36	58.595	-9	6	8.271	525355	652241
F	52	36	59.345	-9	6	4.090	525434	652263
G	52	36	59.337	-9	6	1.538	525482	652262
H	52	36	58.941	-9	6	58.817	525533	652249
J	52	36	58.093	-9	6	56.084	525584	652222
K	52	36	57.034	-9	6	55.101	525602	652189
L	52	36	54.641	-9	6	54.935	525604	652115
M	52	36	53.661	-9	6	56.026	525583	652085
N	52	36	46.049	-9	6	21.193	525106	651857

Table D.2-3 Dredge Site "C" Co-ordinates

Loading Area "D"- Dredge Site "D" (Foynes Harbour Approach Channel)

Loading Area "D" consists of dredge site D as shown on Figure D.2-3 below and Drawing M0742-RPS-XX-DS-DR-C-0004 in Appendix A.

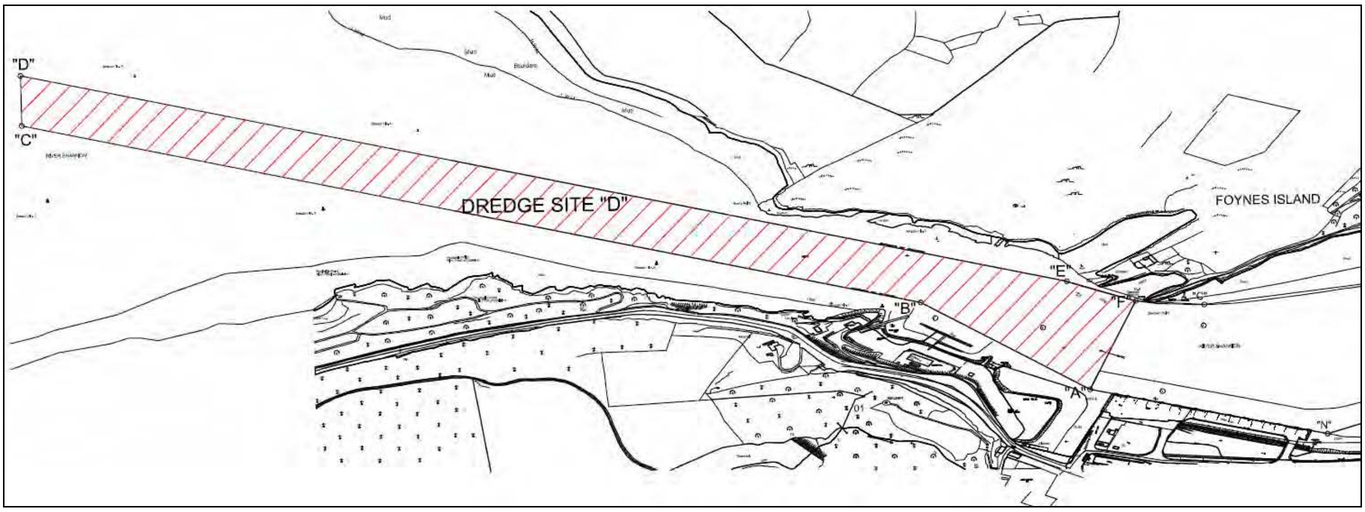


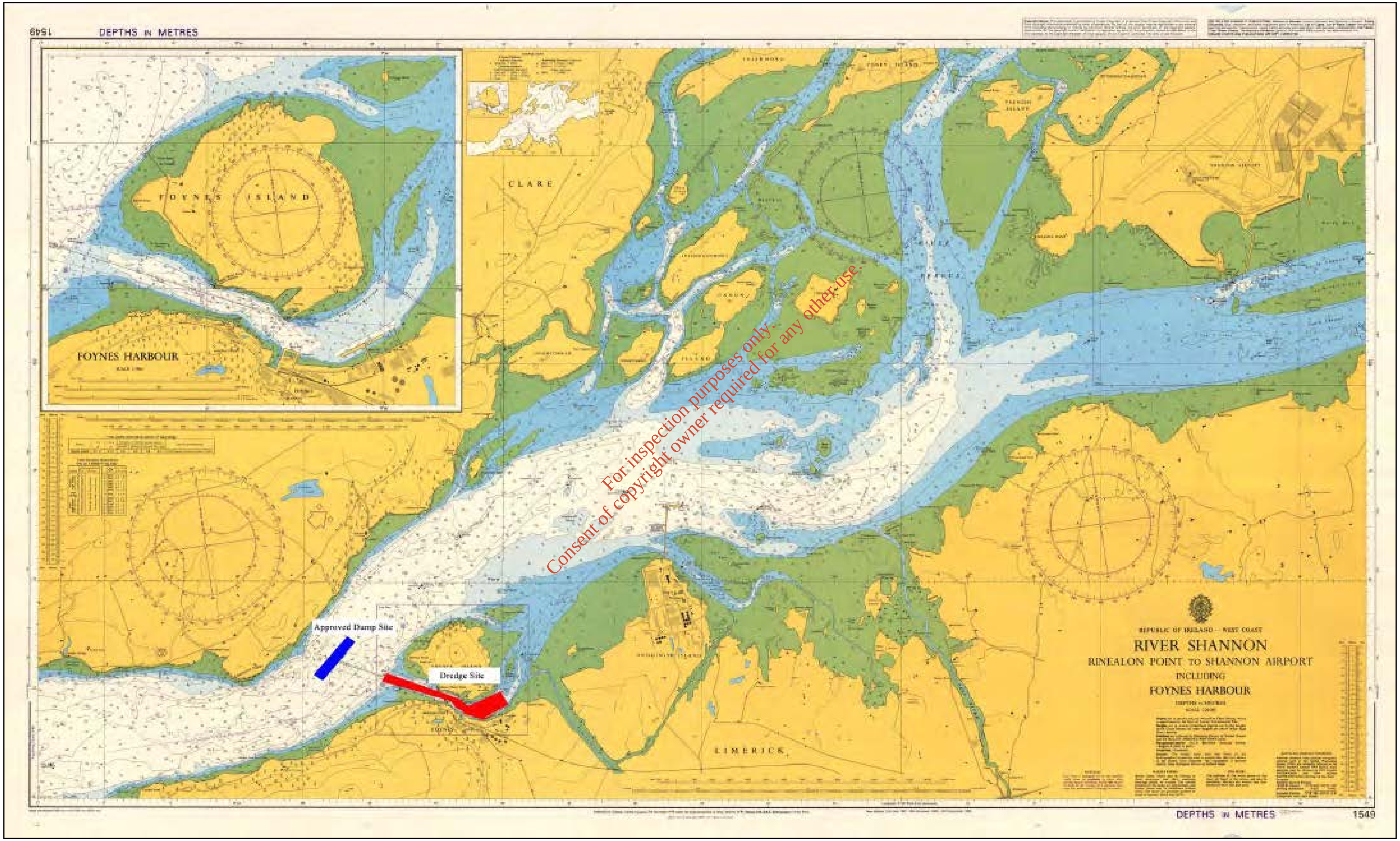
Figure D.2-3- Extents of Dredge Site "D"

The co-ordinates of the loading area are shown in Table D.2-4 below.

	WGS84						ITM	
	Latitude			Longitude				
Point	**Degrees**	**Minutes**	**Seconds**	**Degrees**	**Minutes**	**Seconds**	**Easting**	**Northing**
A	52	36	49.099	-9	6	37.590	524799	651956
B	52	36	55.105	-9	6	49.225	524583	652145
C	52	37	7.268	-9	7	51.154	523424	652539
D	52	37	10.697	-9	7	51.242	523424	652645
E	52	36	56.559	-9	6	39.161	524773	652187
F	52	36	55.211	-9	6	34.449	524861	652144

Table D.2-4- Dredge Site "D" Co-ordinates

MAP D.2-2 DREDGE SITES "C" & "D" AND APPROVED DUMP SITES FOR FOYNES



Attachment D.3

Details of the Loading Operation

DREDGING PROGRAMME

Maintenance Dredging

Over the next eight years, the proposed quantities of material to be dredged as part of the dredging programme of Shannon Foynes Port Company are set out in Table D.3-1. Dredging will be carried out on an as-required basis, with a degree of overdredging to provide buffer depths to allow sedimentation and maintain minimum depths.

The areas and quantities of materials to be dredged are tabulated in Table D.3-1. The dredge quantities include for an overdredge of approximately 0.5m at Foynes and approximately 0.3m at Limerick to ensure that the advertised depth at berths will be achieved.

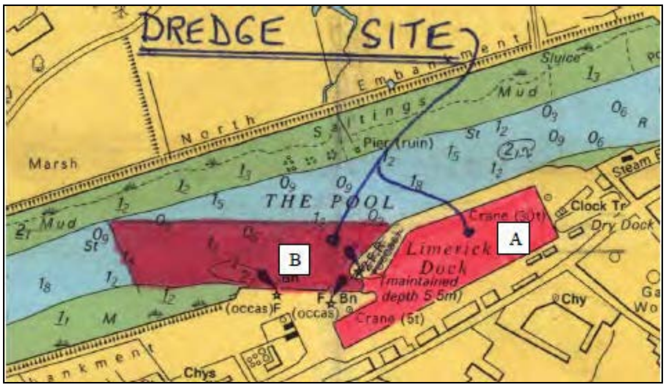
As already stated, quantities can vary considerably depending on the weather and in particular rainfall. The quantities outlined in Table D.3-1 are based on experience over a number of years in the Port. These quantities are expected to be the absolute maximum and include contingency amounts.

Location	Dredge Method	2019 Tonnes	2020 Tonnes	2021 Tonnes	2022 Tonnes	2023 Tonnes	2024 Tonnes	2025 Tonnes	2026 Tonnes	Total Tonnes
Ted Russell Dock, Limerick	Grab/ T.S.H.D/ Bed Levelling	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	**48,000**
Approach Channel to Ted Russell Dock	Grab/ T.S.H.D/ Bed Levelling	114,000	114,000	114,000	114,000	114,000	114,000	114,000	114,000	**912,000**
Foynes Harbour	Grab/ T.S.H.D/ Bed Levelling	156,000	156,000	156,000	156,000	156,000	156,000	156,000	156,000	**1,248,000**
Totals		**276,000**	**276,000**	**276,000**	**276,000**	**276,000**	**276,000**	**276,000**	**276,000**	**2,208,000**

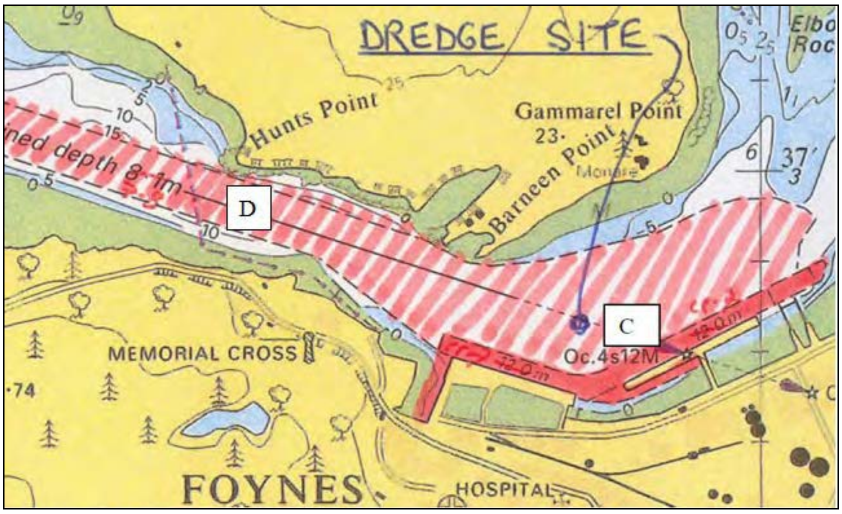
Table D.3-1 Maximum Quantities of Mud/Silt to be Dredged

The areas to be dredged at Limerick are shown Photograph D.3-1, on Map D.2-1, and on Drawings M0742-RPS-XX-DS-DR-C-0001 & 0002 in Appendix A, and the areas to be dredged at Foynes are shown in Photograph D.3-2, Drawings M0742-RPS-XX-DS-DR-C-0003 & 0004 in Appendix A and on Map D.2-2.

Photograph D.3-1- Areas to be Dredged at Limerick



Photograph D.3-2- Areas to be Dredged at Foynes



DUMP SITES

Dump Sites Limerick

There are two approved dump sites for silt/mud dredged from Limerick which have been used since 1999 and 2005 shown on Map D.2-1 and on Drawings M0742-RPS-XX-DS-DR-C-0005 & 0006 in Appendix A, and the co-ordinates are as follows:

Approved Dump Site A

(i) Latitude 52°40.54’ North and longitude 08°44.40’ West,

(ii) Latitude 52°40.44’ North and longitude 08°44.43’ West,

(iii) Latitude 52°40.35’ North and longitude 08°43.80’ West.

Approved Dump Site B

(i) Latitude 52°40.67’ North and longitude 08°51.14’ West,

(ii) Latitude 52°40.72’ North and longitude 08°50.69’ West,

(iii) Latitude 52°40.57’ North and longitude 08°51.11’ West,

(iv) Latitude 52°40.62’ North and longitude 08°50.66’ West.

Dump Site Foynes

There is one approved dump site for silt/mud dredged from Foynes Harbour which has been used since 1999 located in the centre of the main channel of the River Shannon West of Foynes Island as shown on Map D.2-1 and Photograph D.3-3 and drawing M0742-RPS-XX-DS-DR-C-0007 in Appendix A, , and the co-ordinates are as follows:

Approved Dump Site C

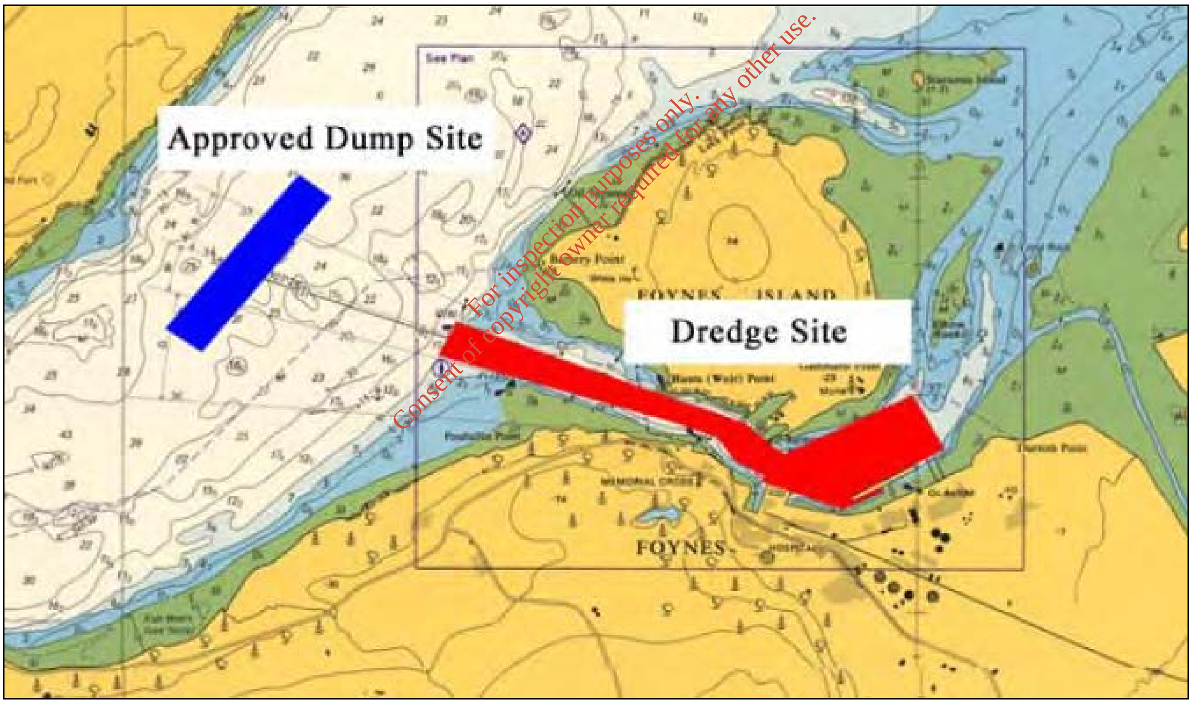
(i) Latitude 52°37.17' North and longitude 09°08.33' West,

(ii) Latitude 52°37.52' North and longitude 09°08.45' West,

(iii) Latitude 52°37.44' North and longitude 09°08.29' West,

(iv) Latitude 52°37.10' North and longitude 09°08.65' West.

Photograph D.3-3 Approved Dump Site "C" Foynes



Photograph D.3-1 Multicat M.V. "Shannon 1" to be used for plough dredging at Limerick and also part of Foynes Port

Photograph D.3-2 Typical Trailing Suction Hopper Dredger used on Contract for Dredging Foynes Harbour and smaller model in Limerick

DREDGING METHODS

It is anticipated that the berths in Foynes will be ploughed on a regular basis to an area of deep water on the West Side of the Harbour. This material will settle here and when SFPC contract a Trailing Suction Hopper Dredger on an annual basis this material will be loaded and dumped at the Approved Dump Site "C" as shown on Map D.2-2 and Drawing M0742-RPS-XX-DS-DR-C-0007 in Appendix A.

When the Annual Dredge campaign is under way, it is anticipated that it will take up to two weeks to carry out and this will involve a typical load of approximately 1,000 tonnes up to a maximum of 30,000 tonnes per day.

It is anticipated that in Limerick there will be ploughing on occasion to the middle of the River off the Approach Channel. This material will settle here and some will disperse over time and also during the Annual Campaign will be loaded on a Trailing Suction Hopper Dredger and dumped at the Approved Dump Sites "A", "B" & ""C" in rotation, as shown on Maps D.2-1 & D.2-2, and Drawings M0742-RPS-XX-DS-DR-C-0005, 0006 & 0007 in Appendix A, so as to minimise the effect. The typical loads will be approximately 900 tonnes and a maximum of two loads or 1,800 tonnes per day.

The area within the enclosed Dock will be ploughed to a holding area on the North West corner awaiting loading on to a Trailing Suction Hopper Dredger and then dumped at the Approved Dump Sites "A", "B" & "C" in rotation so as to minimise the effect.

Attachment E.1

Dumping Site Selection

The Dump Sites were carefully selected by taking into account the following:

- The distance from the Loading Site, the effect on Navigation of Shipping and the minimal impact they would have on the Environmental.
- The two Approved Dump Sites A and B used for Dumping Dredge Spoil from Limerick are close to the area and are not located in the Shipping Channel. There were Environmental Assessments carried out on both, which concluded that although there would be a short term effect, this would recover quickly. These reports are contained in Attachment F.1.
- Dump Site A is close to the "Whelps", an area within a Special Protection Area under Council Directive No. 74/409/EEC of 2nd April, 1979 (the "Birds Directive"). Shannon Foynes Port Company shall ensure that there is no impact from the dumping hereby permitted on the activity of bird-life in the "Whelps" area and that there is no interference with water flow around the "Whelps".
- Dump Site A is also close to a fish trap located at O'Brien's Point on the Clare shore. The Dumping has not had a negative effect on this, as it has been monitored in 2002 and 2008 with no adverse effects found. This Site has been used since 1999.
- The material to be dumped has been tested and is deemed not to be deleterious to the Environment.
- The Dump Site C off Foynes Island is close to the Dredge Site and is not going to affect shipping as there is a water depth of 37m, the Dumping Operations have been assessed by Aqua fact in 2003 and although there would be a short term effect, this would recover quickly. This report is contained in Attachment F.1.
- Dump Site C has been used since 1999 also and has been used to dump spoil from Capital Dredging and Maintenance Dredging.
- The material to be dumped has been tested and is deemed not to be deleterious to the Environment.

All three Dump Sites have been Archeologically Assessed, as requested by Duchas and at Dump Sites B and C there have been no features of significance found. As already mentioned the Dump Site A is located close to a Fish trap and is being monitored every five years or so. These reports are contained Attachment F.1.

Attachment E.2 (I)

Characteristics of the Dumping Sites

Distance of dump site from nearest shore:

- Dump Site "A" = 0.2km
- Dump Site "B" = 1.0km
- Dump Site "C" = 1.25km

Average, minimum and maximum water depths (referenced to OD Malin)

- Dump Site "A"
    - Average Depth = -0.9mCD [-3.865mOD Malin]
    - Minimum Depth = -0.5mCD [-3.465mOD Malin]
    - Maximum Depth = -1.3mCD [-4.265mOD Malin]
- Dump Site "B"
    - Average Depth = -2.5mCD [-5.465mOD Malin]
    - Minimum Depth = -1.2mCD [-4.165mOD Malin]
    - Maximum Depth = -3.7mCD [-6.665mOD Malin]
- Dump Site "C"
    - Average Depth = -34.0mCD [-36.965mOD Malin]
    - Minimum Depth = -29.0mCD [-31.965mOD Malin]
    - Maximum Depth = -39.0mCD [-41.965mOD Malin]

Sediment Characteristics

Refer to Aqua Fact reports contained in Attachment F.1 for details on the sediment characteristics of the Dump Sites.

Nature of seabed habitats

Refer to Aqua Fact reports contained in Attachment F.1 for details on the sediment characteristics of the Dump Sites.

Current/flow/tidal regime

Refer to Aqua Fact reports contained in Attachment F.1 for details on the sediment characteristics of the Dump Sites.

Previous use of Dump Sites

Dump Site A has been used since 1999 and the quantities dumped there are detailed in Table E.2(I)-1 below.

Table E.2(I)-1 Quantities Disposed at Dump Site "A"

Year	Quantity (tonnes)
1999	10,950
2000	9,000
2001	14,850
2002	11,700
2003	19,350
2004	24,050
2005	7,900
2006	6,150
2007	0
2008	0
2009	0
2010	0
2011	0
2012	0
2013	0
2014	0
2015	2,875
2016	0
2017	0
2018	0

Dump Site B approved in 2005 has only had a small quantity dumped there as detailed in Table E.2(I)-2.

Table E.2(I)-2 Quantities Disposed at Dump Site "B"

Year	Quantity (tonnes)
2005	8,000
2006	6,000
2007	0
2008	0
2009	0
2010	0
2011	0
2012	0
2013	0
2014	0
2015	2,875
2016	0
2017	0
2018	0

Dump Site C has been used since 1999 and the quantities dumped are detailed in Table E.2(I)-3.

Table E.2(I)-3 Quantities Disposed at Dump Site "C"

Year	Quantity (tonnes)
1999/2000	Capital Works 412,500 plus 120,000 of rock & clay
2001	134,200
2002	98,000
2003	0
2004	50,310
2005	31,987
2006	44,290
2007	40,130
2008	54,120
2009	0
2010	143,651
2011	0
2012	0
2013	128,494
2014	0
2015	0
2016	201,488
2017	0
2018	157,517

Dump Sites A, B and C have had independent Bathymetric Surveys conducted on them. The results of these are contained in Appendix A.

As outlined in Attachment F.1 they have been environmentally assessed, with no long term adverse impacts the conclusion.

Details of the most recent previous Permit are contained in Attachment A.7.

There have been Permits issued for all years from 1999 to 2012 and a six year Permit in 2013 to date.

Attachment E.2 (II)

Location of the Dumping Sites

Refer to the following drawings in Appendix A which show the location and co-ordinates of the Dumping Sites:

- M0742-RPS-XX-DS-DR-C-0005 Location of Dump Site A
- M0742-RPS-XX-DS-DR-C-0006 Location of Dump Site B
- M0742-RPS-XX-DS-DR-C-0007 Location of Dump Site C

Approved Dump Site "A"

The co-ordinates of Dump Site "A" are shown in Table E.2 (II)-1 below.

	WGS84						ITM	
	Latitude			Longitude				
Point	Degrees	Minutes	Seconds	Degrees	Minutes	Seconds	Easting	Northing
A	52	40	32.461	-8	44	23.700	549962	658537
B	52	40	21.036	-8	43	47.682	550635	658177
C	52	40	26.464	-8	44	25.515	549926	658352

Table E.2 (II)-1 Dump Site "A" Co-ordinates

Refer to Map E.2 (II)-1 and Drawing M0742-RPS-XX-DS-DR-C-0005 for location of approved Dump Site "A".

Approved Dump Site "B"

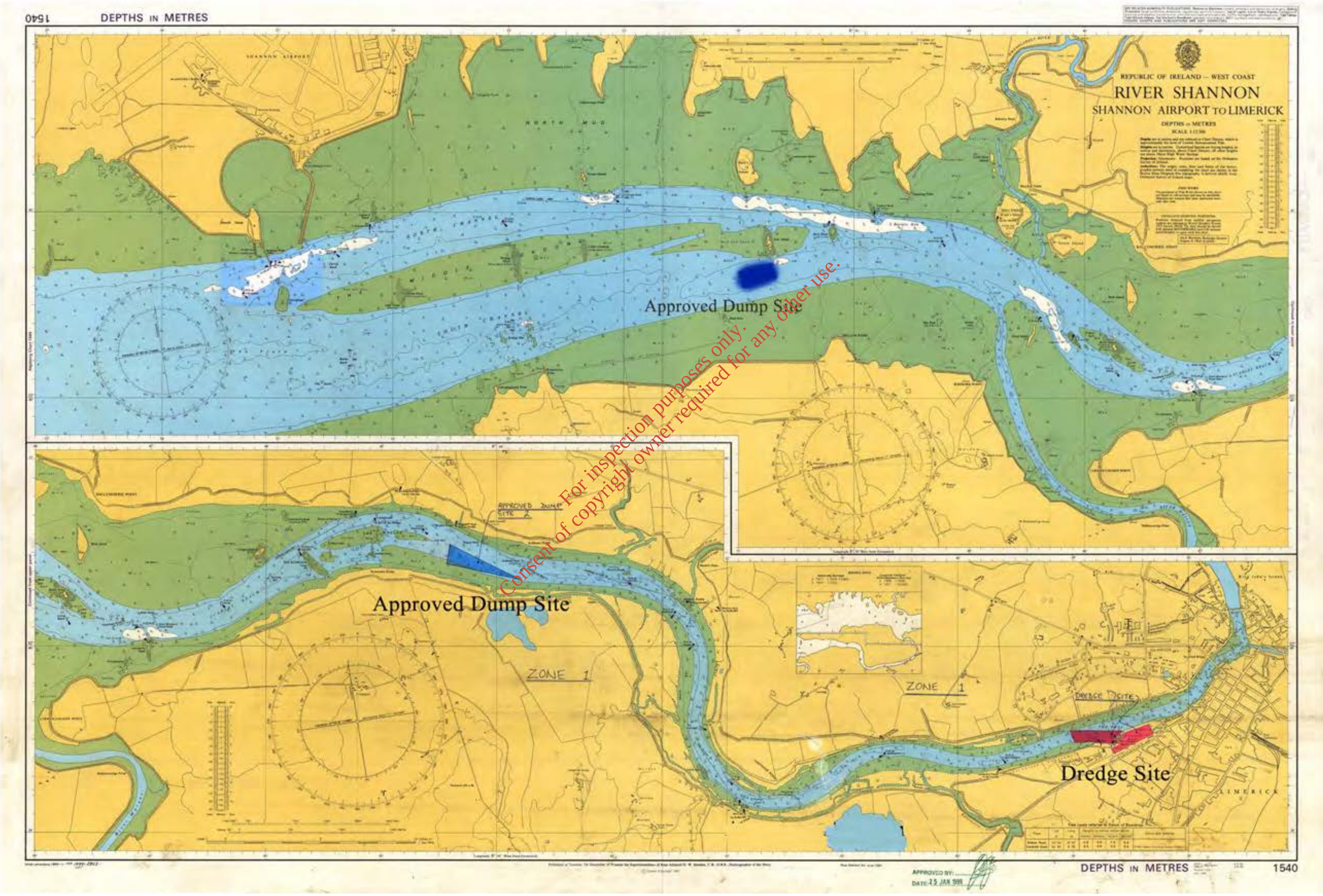
The co-ordinates of Dump Site "B" are shown in Table E.2 (II)-2 below.

	WGS84						ITM	
	Latitude			Longitude				
Point	Degrees	Minutes	Seconds	Degrees	Minutes	Seconds	Easting	Northing
A	52	40	40.238	-8	51	11.361	542307	658862
B	52	40	43.269	-8	50	41.181	542875	658949
C	52	40	37.264	-8	50	39.361	542907	658763
D	52	40	34.225	-8	51	6.400	542398	658676

Table E.2 (II)-2 Dump Site "B" Co-ordinates

Refer to Map E.2 (II)-1 and Drawing M0742-RPS-XX-DS-DR-C-0006 for locations of approved Dump Site "B".

MAP E.2(II)-1 DREDGE SITE AND APPROVED DUMP SITES “A” AND “B” FOR LIMERICK



Approved Dump Site "C"

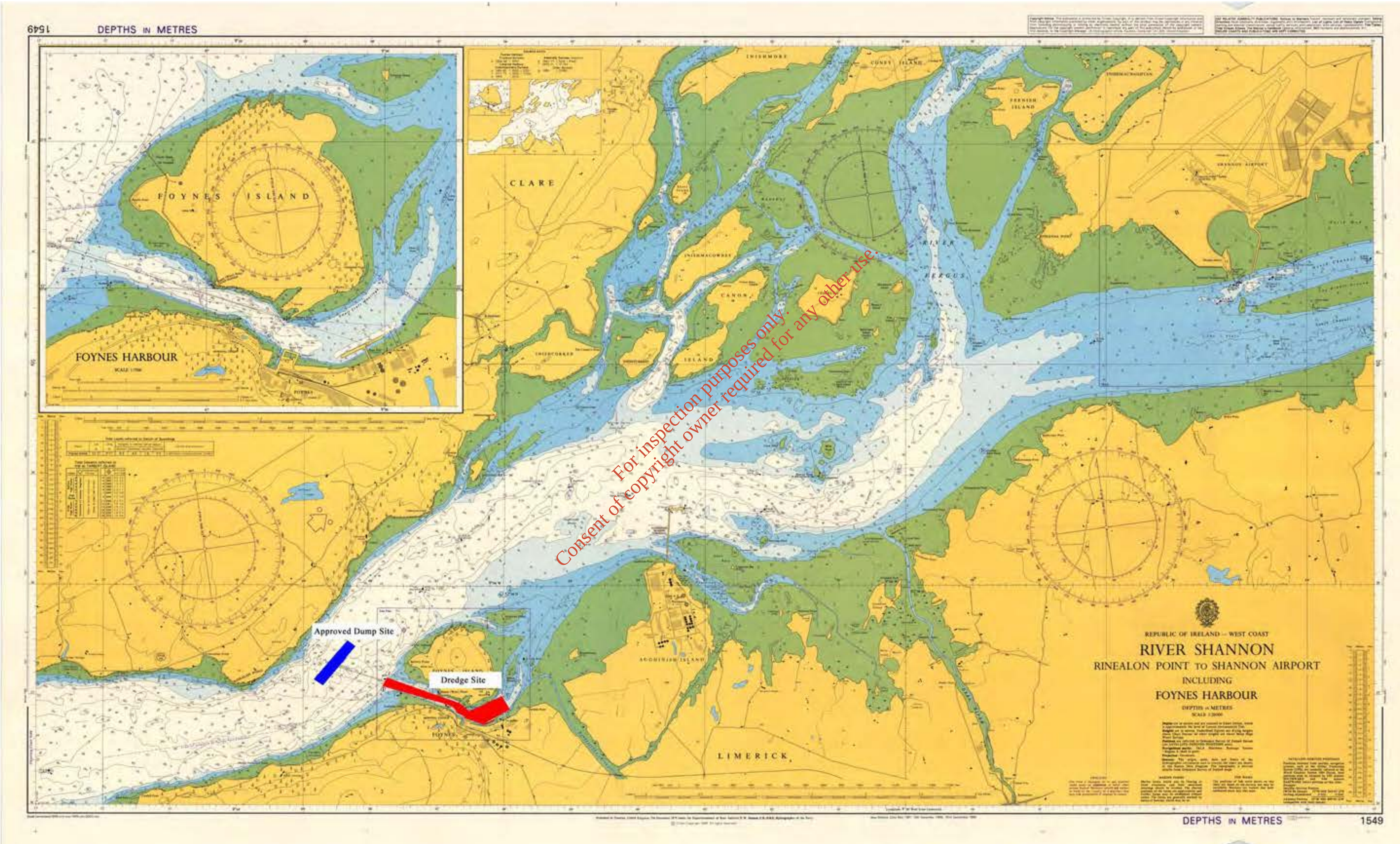
The co-ordinates of Dump Site "C" are shown in Table E.2 (II)-3 below.

	WGS84						ITM	
	Latitude			Longitude				
Point	**Degrees**	**Minutes**	**Seconds**	**Degrees**	**Minutes**	**Seconds**	**Easting**	**Northing**
A	52	37	11.643	-9	8	50.975	522301	652692
B	52	37	32.337	-9	8	29.129	522722	653325
C	52	37	27.543	-9	8	19.540	522900	653174
D	52	37	7.144	-9	8	41.127	522484	652550

Table E.2 (II)-3 Dump Site "C" Co-ordinates

Refer to Map E.2 (II)-2 and Drawing M0742-RPS-XX-DS-DR-C-0007 for location of approved Dump Site "C".

MAP E.2 (II)-2 DREDGE SITE AND APPROVED DUMP SITE "C" FOR FOYNES



Attachment E.3

Details of the Dumping Operation

Also refer to Attachment D.2, which outlines details of the loading operation and dredging methods.

E.3 (I) Date of Commencement and duration of dumping operations

SFPC anticipate commencement of maintenance dredging works as soon as possible after the Permit is granted.

Proposed duration of dumping operations as below:

- Limerick (Areas A&B)- Typically 1 TSHD campaign every two years, with plough dredging late summer and winter (to avoid closed period of 1st February- 20th June as stated in previous permit S0009-02)
- Foynes dredging (Areas C&D) - Typically 1 or two weeks per annum for TSHD campaign, plough dredging typically carried out every 2 weeks during Spring tides

E.3 (II) Name and address of operator contracted to carry out the dumping at sea

Not yet known.

E.3 (III) & (IV) Location and method of dumping and total quantity to be dumped per day/week

Locations of dump site as detailed in Attachment E.2 (II).

Methods for disposal as detailed in Attachment D.3.

Anticipated rates of dumping as outlined below:

- Dump Site “A” 900T/day (4,500T/week) - through vessels bottom
- Dump Site “B” 900T/day (4,500T/week) - through vessels bottom
- Dump Site “C” 30,000T/day (150,000T/week)- through vessels bottom

Attachment F.1

Assessment of Impact on the Environment

IMPACT ASSESSMENT STUDIES

Shannon Foynes Port Company employed Aqua Fact Limited, in Galway, to carry out three Environmental Assessment and Sediment Transport Modelling for the three Approved Dump Sites used for the disposal of dredged spoil.

The first was in 2003 and assessed two dump Sites in the upper Estuary at Newtown Point and Coonagh Point. The Dump Site at Coonagh Point was later decommissioned as a result of the construction of the Tunnel Crossing at this point.

The second assessment undertaken also in 2003 was for the Dump Site off Foynes Island.

The third assessment was carried out in 2005 at a Dump Site South of Sod Island; this was as a result of decommissioning the Dump Site at Coonagh Point.

Sediment transport analysis and modelling was undertaken for all three sites and the results indicated that all three were suitable for the disposal of dredge material, with careful management of the dumping operation.

The titles of the three reports are noted below, and are contained in sub-sections 1-3 below.

- Impact Assessment Study of Two Dredge Disposal Sites in the Shannon Estuary (Aqua-Fact International Services Ltd)
- Impact Assessment Study of a Dredge Disposal Site in the Shannon Estuary at Foynes, Co. Limerick (Aqua-Fact International Services Ltd)
- Environmental Survey and Sediment Transport Model for a Proposed Dump Site in Shannon Estuary (Aqua-Fact International Services Ltd)

In addition, a number of Archaeological surveys were undertaken for all three sites also, as noted below and the results of these are contained in sub-sections 4-6 below.

- Archaeological Inspection, 2016 Wooden Fishtrap Structures, O'Brien's Point, River Shannon, Co. Clare (Donal Boland- Maritime Archaeologist)
- Archaeological Assessment, Proposed Marine Dump Site, Sod Island, Shannon Estuary, Co. Limerick (Donal Boland & Ciara Herron- Maritime Archaeologists)
- Foynes Harbour and Approaches, Proposed Dredging and Disposal- Archaeological Diving Inspection (Wessex Archaeology)
- Foynes Harbour and Approaches, Capital Dredging and Disposal, Archaeological Monitoring (Wessex Archaeology)
- Archaeological Monitoring, Maintenance Dredging, Foynes Port, Co. Limerick (Boland Archaeological Services Ltd)

Furthermore, a Screening for Appropriate Assessment was carried out and a Natura Impact Statement was prepared by RPS and this is contained in sub-section 7 below.

Attachment F.1

Sub-Section 1

Impact Assessment Studies

Impact Assessment Study of Two Dredge Disposal Sites in the Shannon Estuary (Aqua-Fact International Services Ltd)

IMPACT ASSESSMENT STUDY OF TWO DREDGE DISPOSAL SITES IN THE SHANNON ESTUARY.

For: Shannon Foynes Port Company,
Mill House,
Foynes,
Co. Limerick.

By: Aqua-Fact International Services Ltd.,
12 Kilkerrin Park,
Liosbaun,
Galway.
www.aquafact.ie

TABLE OF CONTENTS

CHAPTER 1
INTRODUCTION

Aqua-Fact International Services Ltd. were commissioned by Shannon-Foynes Port Company to carry out an impact assessment study of the environmental effects caused by maintenance dredging in the Shannon Estuary and subsequent disposal of the dredged material within the estuary at two proposed sites. Maintenance dredging is carried out to maintain the natural chart datum within the estuary as published on British Admiralty Charts for the area.

The purpose of the study was to model the transport and deposition of the disposed material in order to assess its impacts on water quality and the sea bed in the area surrounding the disposal sites. This was achieved with the use of the U.S. Army Corps of Engineers' Open Water Disposal Model (STFATE), which accounts for the physical processes determining the short-term fate of the dredged material disposed at open water sites. The model provides estimates of water column concentrations of suspended sediment and the initial deposition of material on the sea bed.

A description of the location and bathymetry of each of the disposal sites is presented in Chapter 2. All the relevant environmental and hydrodynamic data required as input to the model are also described in Chapter 2. The theory, development and application of the model to analyse the short-term fate of the disposed material at each of the dump sites is detailed in Chapter 3. Chapter 4 and Chapter 5, respectively, present and discuss the results obtained from the model simulations. Finally, in Chapter 6, the summary and conclusions of the project are presented and some recommendations are provided based on the study's conclusions.

CHAPTER 2
MODEL DATA INPUT

2.1 Disposal Sites

This report deals with inner area of the Shannon Estuary located between Limerick and Shannon Airport Jetty. Table 2.1 details the extent of the dredging operations that are expected to be required in order to maintain Chart Datum at this site (Shannon-Foynes Port Company, 1999).

Location	Material	Quantity
Limerick Dock	Mud/Silt	150,000 m^3

Table 2.1: *Details of proposed dredging operation.*

It is proposed that the dredged material will be dumped at two disposal sites, the locations of which are shown in Figure 2.1. Their coordinates are as follows:

- **Site 1:** Near Newtown Point – (52° 40’ 26.4’’ N, 8° 44’ 19.2’’ W)
- **Site 2:** Near Coonagh Point – (52° 39’ 13.2’’ N, 8° 41’ 10.2’’ W)

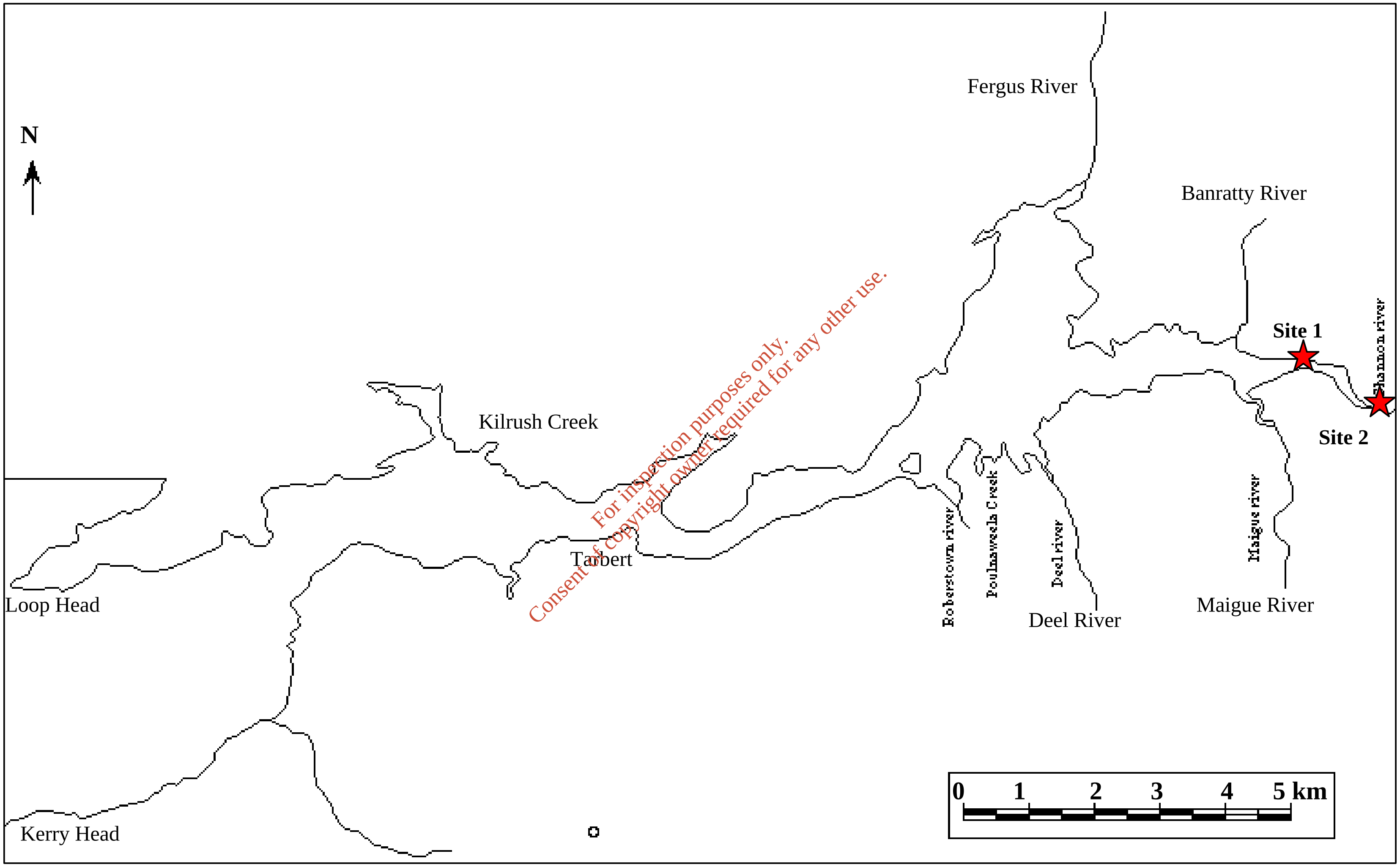


Figure 2.1: *Plan view of the Shannon Estuary showing the locations of the two proposed Dump Sites.*

The bathymetric profiles at each of the sites as taken from the respective Admiralty Charts are shown in Figures 2.2 – 2.3. In each case, the boundary of the dump site is highlighted in red.

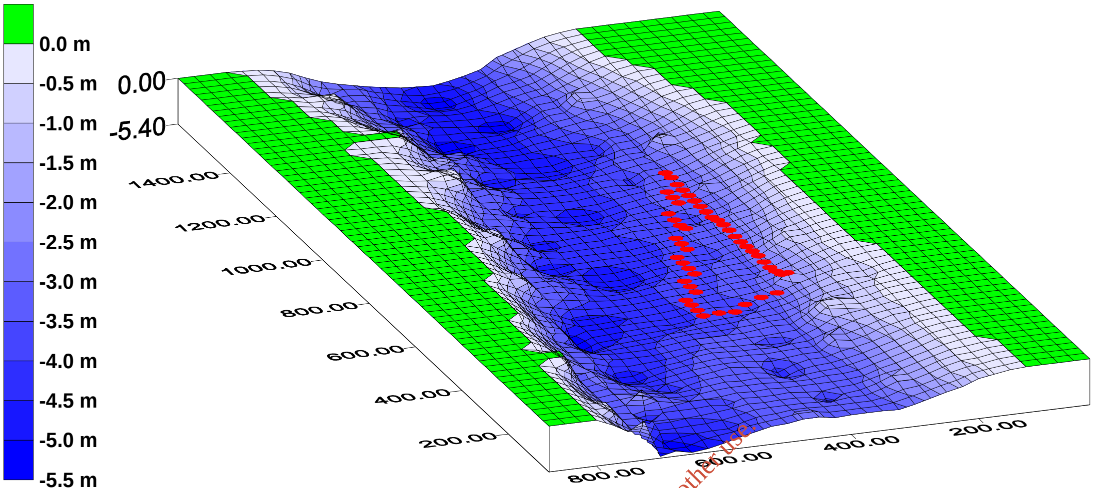


Figure 2.2: *Study area incorporating Dump Site 1, depths in metres below MWL.*

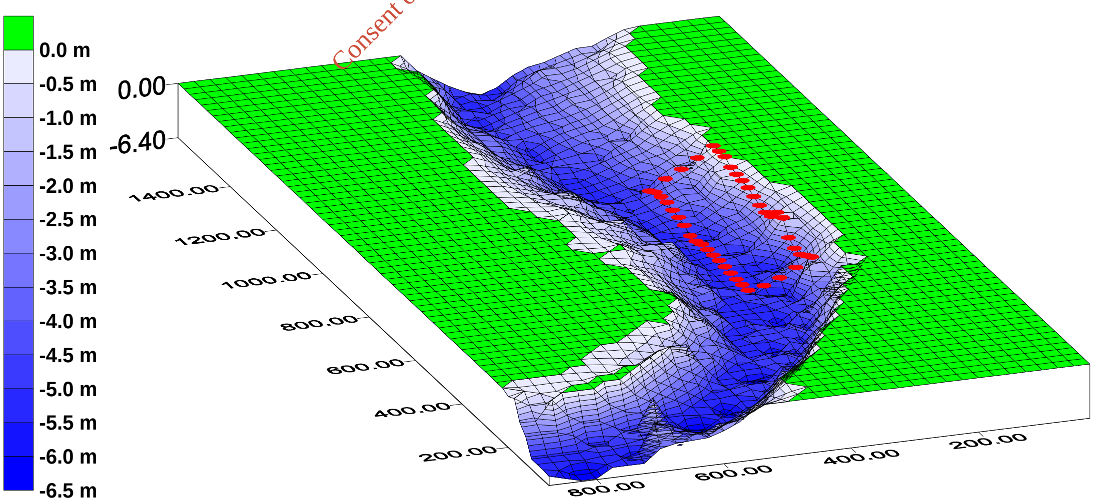


Figure 2.3: *Study area incorporating Dump Site 2, depths in metres below MWL.*

The STFATE model can only be run using a flat bed surface or one with a constant slope. Therefore, an average water depth was calculated for the extent of each of the study areas shown in the diagrams above for use in the model simulations.

2.2 Hydrodynamic Data

In studies investigating the impact of the disposal of dredged material there are two important considerations to take into account:

a) Whether the dredged material will be transported outside the boundary of the disposal site by the prevailing currents, which is most likely to occur when the currents are at a maximum.
b) Whether the build-up of dredged material on the sea bottom will significantly reduce the depth of water at the disposal site, which is most likely to occur when the currents are at a minimum.

With these considerations in mind, it was decided to analyse the disposal of the dredged material using two different hydrodynamic regimes, namely the maximum current velocity and minimum current velocity at each of the sites.

The current velocity data at each of the dump sites were obtained from the Shannon Estuary Hydrodynamic Model which is already in existence and is owned by Shannon-Foynes Port Company. The model was executed and the current velocities and directions were computed and output at each of the proposed dump site locations for both spring and neap tidal conditions. From these plots of current velocity the maximum, average and minimum velocities were then calculated. The current data for spring tidal conditions were used in the model as current velocities reach their maximum during a spring tide. All of the current data input to the STFATE model are presented in Table 2.2.

Analysis	Description	Current Speed (m/s)	Current Direction (degrees from N)
1	Maximum Velocity - Site 1	0.700	91.390
2	Minimum Velocity - Site 1	0.020	29.600
3	Maximum Velocity - Site 2	0.280	92.890
4	Minimum Velocity - Site 2	0.009	179.375

Table 2.2: *Current data used in STFATE model simulations.*

2.3 Dredged Material Data

The Environmental Services section of Enterprise Ireland analysed sediment samples taken from the approach to Limerick Dock on the 28th June, 2002 and at the 'Wet Dock' on 17th October, 2002. The reports from both sediment studies show that the dredged material is composed predominantly of a mixture of sand and silt. However, the 'Wet Dock' area also contains relatively high proportions of gravel material (~20-30%). The properties of the material as specified to the model are presented in Table 2.3.

Type	Spec. Gravity [mg/m^3]	Volumetric Conc.	Fall Vel. [m/s]	Deposited Void Ratio	Character
Sand	2.70	0.1918	3.05×10^{-2}	0.6	Noncohesive
Silt	2.65	0.3265	3.05×10^{-3}	4.5	Cohesive

Table 2.3: *Properties of dredged material input to model.*

The data on the properties of the dredged material used for the model refers to a site investigation carried out in the Shannon Estuary by The Environmental Services section of Enterprise Ireland in 1998 (Report ref.: 98078). From this report the material to be dredged consists of a mixture of sand and silt and does not include fractions of coarser gravel material (>2mm), such as that recorded from the 'Wet Dock' in 2002. In comparison to fine sediments coarser material such as gravel will not be transported away from the dump site to the same extent or be re-suspended once it settles on the bottom.

2.4 Disposal Operation Data

The disposal of dredged material will take place from a grab dredger with bottom opening doors for disposal. Although the dumping operation is considered to be instantaneous, it is assumed that the time to completely empty the dredging vessel will be approximately 3 ½ minutes. The input data specified to the model regarding the disposal operation are presented in Table 2.4 (Shannon-Foynes Port Company, 2000).

Disposal Operation Detail	Value Input to Model
Mass of dredged material held in vessel	450 tonnes
Vessel length and width	43.6 x 9.9 m
Pre-disposal draft of vessel	3.2 m
Post-disposal draft of vessel	2.9 m
Angle of discharge	vertical
Time to empty vessel	210 s
Vessel velocity	stopped

Table 2.4: *Details of dredging operation data input to the model.*

CHAPTER 3
MODEL THEORY AND DEVELOPMENT

3.1 Introduction

The objective of this study is to determine the impacts on the water column and the sea bed of the disposal of dredged material at each of the proposed dump sites. The initial phase of deposition of dredged material follows immediately upon release from the disposal vessel. Accurate representation of the initial mixing process of the dredged material is required to determine estimates of water column concentrations of suspended sediment and the initial deposition of the material on the bottom. In order to accurately represent the physics of the disposal, the mathematical model STFATE was employed to determine the characteristics of the initial mixing phase.

3.2 Theory

In the STFATE model, the behaviour of the material is assumed to be separated into three phases: **1)** ***convective descent***, during which the dump cloud or discharge jet falls under the influence of gravity and the initial momentum of the discharge; **2)** ***dynamic collapse***, occurring when the descending cloud or jet impacts the bottom or arrives at a level of neutral buoyancy where descent is retarded and horizontal spreading dominates; **3)** ***passive transport-diffusion***, commencing when the material transport and spreading are determined more by ambient currents and turbulence than by the dynamics of the disposal operation (U.S. EPA & U.S. Army Corps of Engineers, 1995). Figure 3.1 illustrates these three phases of material behaviour. The passive transport and diffusion phase in the model is handled by allowing the material settling from the descent and collapse phases to be stored in small Gaussian clouds. These clouds are then diffused and transported at the end of each time step.

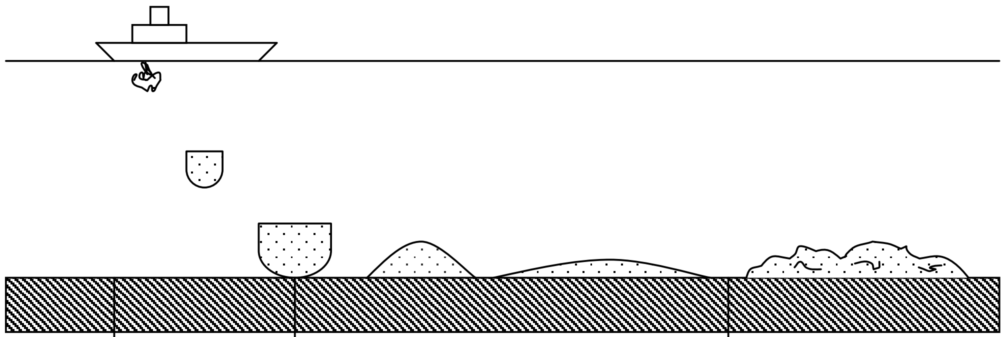


Figure 3.1: *The three stages of material behaviour as assumed in STFATE model (U.S. EPA & US Army Corps of Engineers, 1995).*

3.3 STFATE Model Development

The study areas were declared to the model in the form of a rectangular grid of equal cell spacings. Each grid cell was then assigned the average depth that had been calculated for the associated study area. Table 3.1 gives the grid sizes and spacings and the average depth used to simulate each of the dump site study areas. It should be noted that the average depths used in the models were calculated using water depths at mean water level.

Dump Site	Grid Area [km^2]	Grid Spacing [m]	No. of Rows	No. of Columns	Depth [m]
Site 1	0.75 x 0.75	100	30	30	2.88
Site 2	0.75 x 0.75	100	30	30	3.16

Table 3.1: *Grid sizes, spacings and depths used in model simulations.*

3.4 STFATE Model Analyses

A total of four model simulations, two for each dump site, were performed using the STFATE model in order to predict the initial deposition of dredged material resulting from a single disposal operation under two different current velocity conditions. The simulation times varied between 1 hour and 2 hours for the model runs depending on model output constraints. However, in all cases the times were of sufficient duration to allow the majority of the dredged material to settle to the bed surface and, hence, determine the maximum thickness of the deposited material. The execution timestep used during the model runs for the long-term transport-dispersion calculations was 100 seconds, which is the minimum timestep allowable in the model. The two STFATE analyses at each site for the two different velocity conditions were described in Chapter 2 and are reproduced in Table 3.2.

Analysis	Description	Current Speed (m/s)	Current Direction (degrees from N)
1	Maximum Velocity - Site 1	0.700	91.390
2	Minimum Velocity - Site 1	0.020	29.60
3	Maximum Velocity - Site 2	0.280	92.890
4	Minimum Velocity - Site 2	0.009	179.375

Table 3.2: *Current data used in STFATE model simulations.*

In each case the current velocities were assumed to be uniform over the entire water depth and were input to the model as depth averaged velocities. The velocities and directions were also assumed to be constant over the whole of the study area and for the full duration of the simulations.

The model was unable to simulate the required disposal scenarios. This was due to the volume of material to be dumped during each operation being too large compared to the shallow water depths in the vicinity of the disposal sites. However, following experimentation, it was found that when hydrodynamic conditions were kept constant an approximate linear relationship could be developed relating the volume of dredge material to be dumped to the predicted maximum thickness of deposited material on the estuary bed following a disposal operation. This relationship was then used to calculate the predicted maximum thickness of deposited material following the disposal of the correct volume of dredge material.

3.5 STFATE Model Results

Results from the STFATE model may be presented using the following five formats:

1) Graphs showing the development of the plume and its extent during the convective descent and cloud collapse phases.
2) Graphs showing the extent and movement of the plume of suspended material during the long-term transport-dispersion phase.
3) Graphs of suspended solids concentrations within the water column over the period of simulation.
4) Concentration contours of each material solid fraction at various depths and times chosen by the user.
5) Three dimensional deposition plots of material on the sea bed at the end of the simulation period.

Formats 2-5 are produced for each of the solid fractions simulated, which in the case of this study were sand and silt. Therefore, for each of these result formats there are two sets of results for a single simulation.

Since the model could not simulate the required scenarios, the only results presented are the graphs showing the linear relationships developed for the volume of dredge material and the maximum thickness of the resulting deposited layer.

CHAPTER 4
MODEL RESULTS AND DISCUSSION

In this chapter, the results of the STFATE model simulations for the two different hydrodynamic regimes are presented and discussed. Results are presented for each of the three physical processes represented in the model and described in Chapter 3 (convective descent, cloud collapse and long-term transport-diffusion). A discussion of these results is presented in Chapter 5 while conclusions drawn from them are presented in Chapter 6.

4.1 Dump Site 1 – Near Newtown Point

The average water depth calculated for Dump Site 1 at mean water level was 2.88 m. However, the pre-disposal draft of the disposal vessel when fully loaded is approximately 3.2 m. Because of this, an analysis of the disposal of dredged material was carried out at Dump Site 1 during spring high tide conditions only.

As described in Chapter 3, it was discovered from the results of numerous model simulations that under constant hydrodynamic conditions, an approximate linear relationship existed between the volume of dredge material being dumped and the maximum thickness of the resulting layer of deposited material. Therefore, for Analyses 1, the maximum velocity condition at Dump Site 1, and Analyse 2, the minimum velocity condition at Dump Site 1, a number of simulations were executed using different volumes of dredge material ranging from 19 m^3 to the maximum volume allowed by the model constraints. A ‘material volume versus deposited layer thickness’ relationship was then developed for each analysis based on the results of these simulations and a prediction of the maximum thickness of the deposited layer resulting from the disposal of the correct volume of material was then calculated.

Figure 4.1 shows the relationship between the volume of dredge material and the maximum thickness of the resulting deposited layer obtained for maximum current velocity conditions at Site 1. As can be seen, the regression coefficient for the linear approximation of the model results has a value of 0.9955 indicating that the relationship is almost exactly a linear one. Using the relationship shown on the graph, a maximum thickness of deposited material of approximately 44.7 mm was calculated for the actual volume of dredge material, 293.6 m^3, to be dumped at the site. The calculation is as follows:

Maximum thickness = 0.1551(Volume of material) - 0.7922

$\Rightarrow$ Maximum Thickness = 0.1551(293.6) – 0.7922)

$\Rightarrow$ Maximum Thickness = 44.7 mm

Figure 4.2 shows the relationship between the volume of dredge material and the maximum thickness of the resulting deposited layer obtained for minimum current velocity conditions at Site 1. As can be seen, the regression coefficient for the linear approximation of the model results has a value of 0.9998 indicating, as before, that the relationship is almost exactly a linear one. Using the relationship shown on the graph (y = 0.2104x - 0.4266) a maximum thickness of deposited material of approximately 61.3 mm was calculated for the actual volume of dredge material, 293.6 m^3, to be dumped at the site.

It should be noted that in both cases the maximum layer thicknesses will occur within the grid cell directly below the point of discharge and will cover the entire grid square.

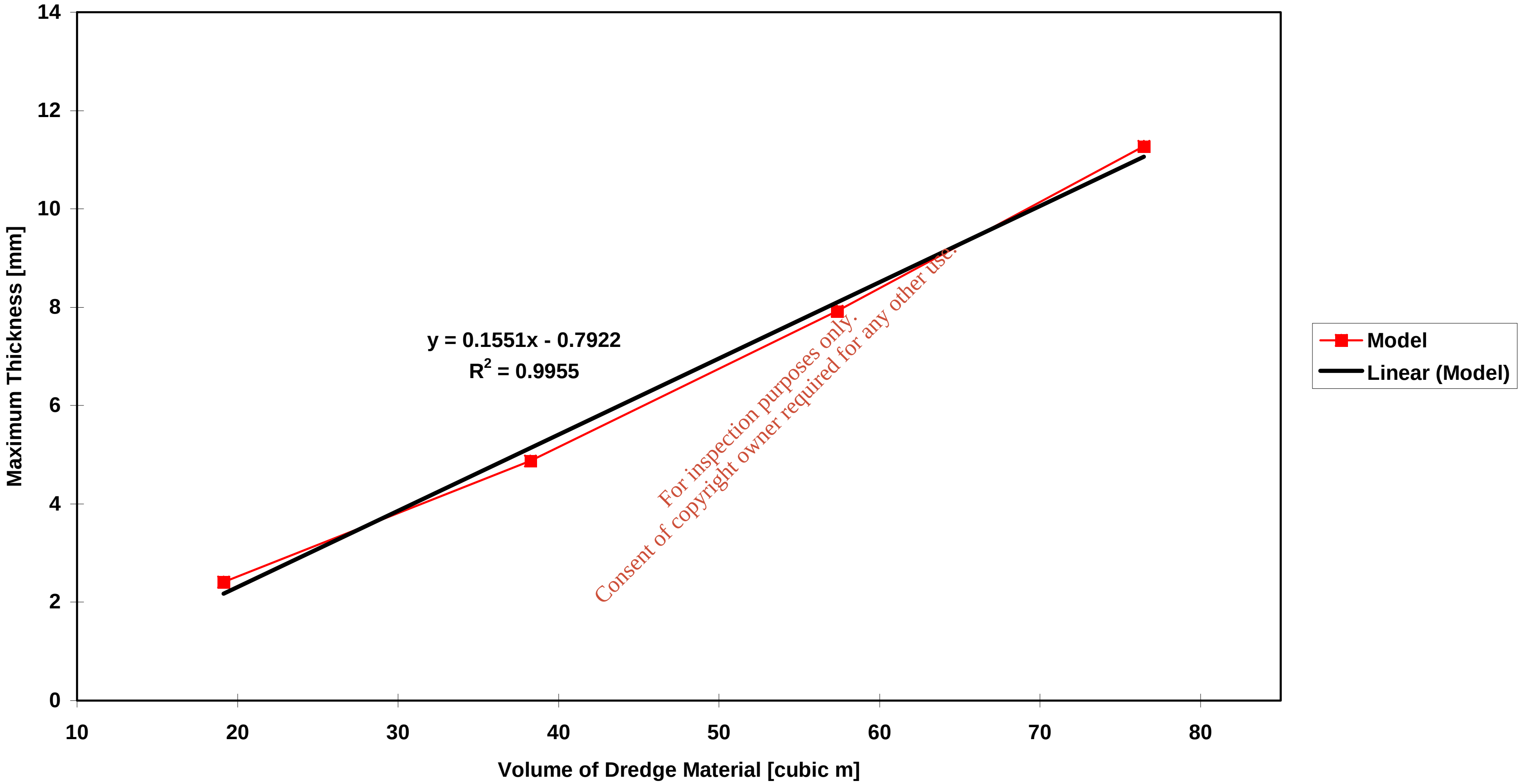


Figure 4.1: *Relationship between volume of dredged material and maximum deposited layer thickness for Analysis 1.*

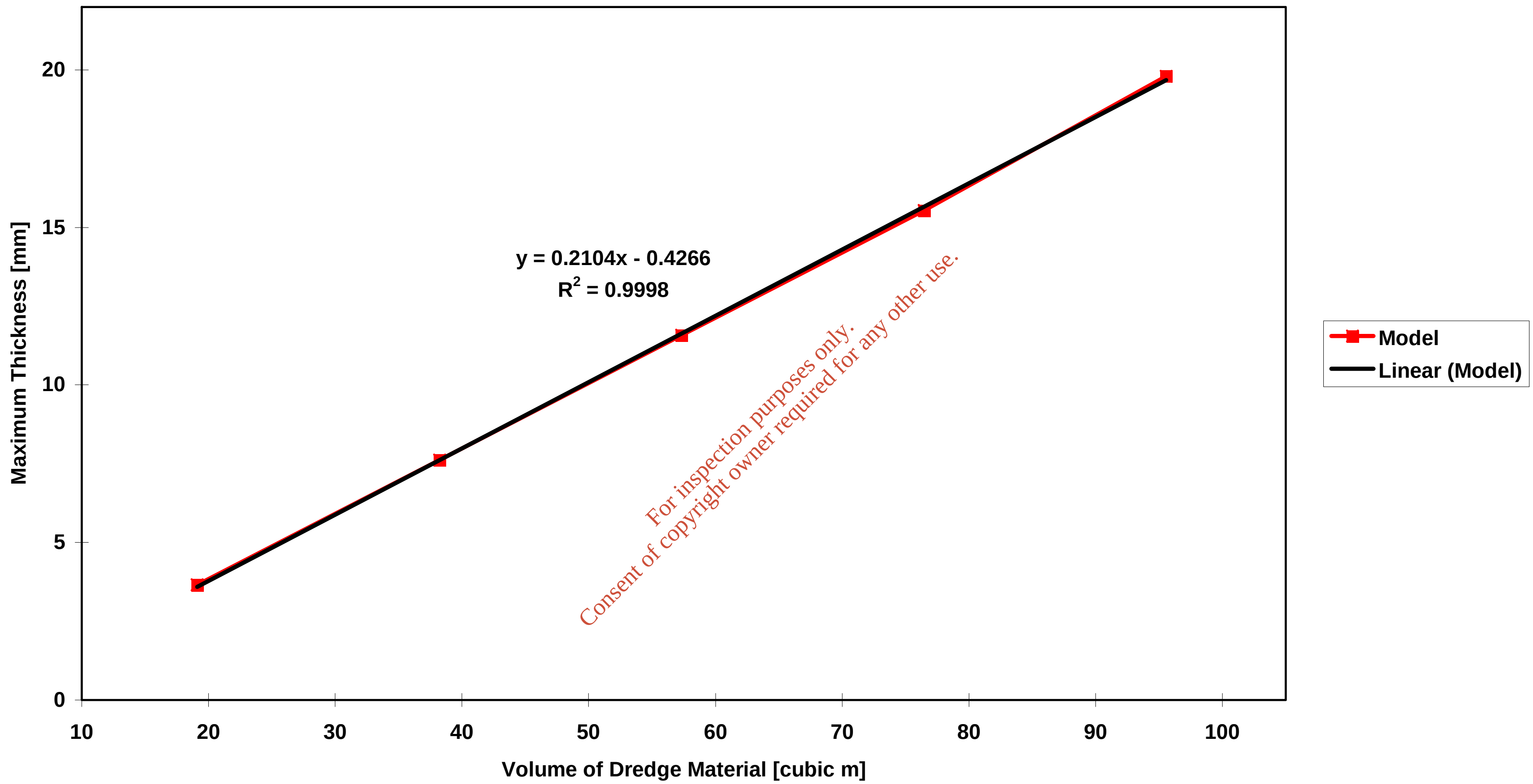


Figure 4.2: *Relationship between volume of dredged material and maximum deposited layer thickness for Analysis 2.*

4.2 Dump Site 2 – Near Coonagh Point

The average water depth calculated for Dump Site 2 at mean water level was 3.16 m. However, as stated previously, the pre-disposal draft of the disposal vessel when fully loaded is approximately 3.2 m. Therefore, as for Dump Site 1, an analysis of the disposal of dredged material was carried out at Dump Site 2 during spring high tide conditions only.

A number of simulations were executed for Analyses 3, the maximum velocity condition at Dump Site 2, and Analyse 4, the minimum velocity condition at Dump Site 2, using different volumes of dredge material ranging from 19 m^3 to the maximum volume allowed by the model constraints. The ‘material volume versus deposited layer thickness’ relationships were then developed for both hydrodynamic conditions based on the results of these simulations allowing the calculation of the predicted maximum thickness of the deposited layer resulting from the disposal of the correct volume of material.

Figure 4.3 and Figure 4.4 show the relationship between the volume of dredge material and the maximum thickness of the resulting deposited layer obtained for maximum and minimum current velocity conditions at Site 2, respectively. As can be seen, the regression coefficient for the linear approximation of the model results has a value of 0.9912 for Analysis 3 indicating that the relationship is almost exactly linear and a value of 1 for Analysis 4 indicating a perfect linear relationship. Using the relationship shown on the graph for Analysis 3 (y = 0.1176x - 1.2249), a maximum thickness of deposited material of approximately 33.3 mm was calculated for the actual volume of dredge material, 293.6 m^3, to be dumped at the site, while using that shown for Analysis 4 (y = 0.2072x - 0.3047), a maximum thickness of 60.5 mm was calculated. The maximum thicknesses will occur within the grid cell directly below the dredge vessel and will cover the entire cell.

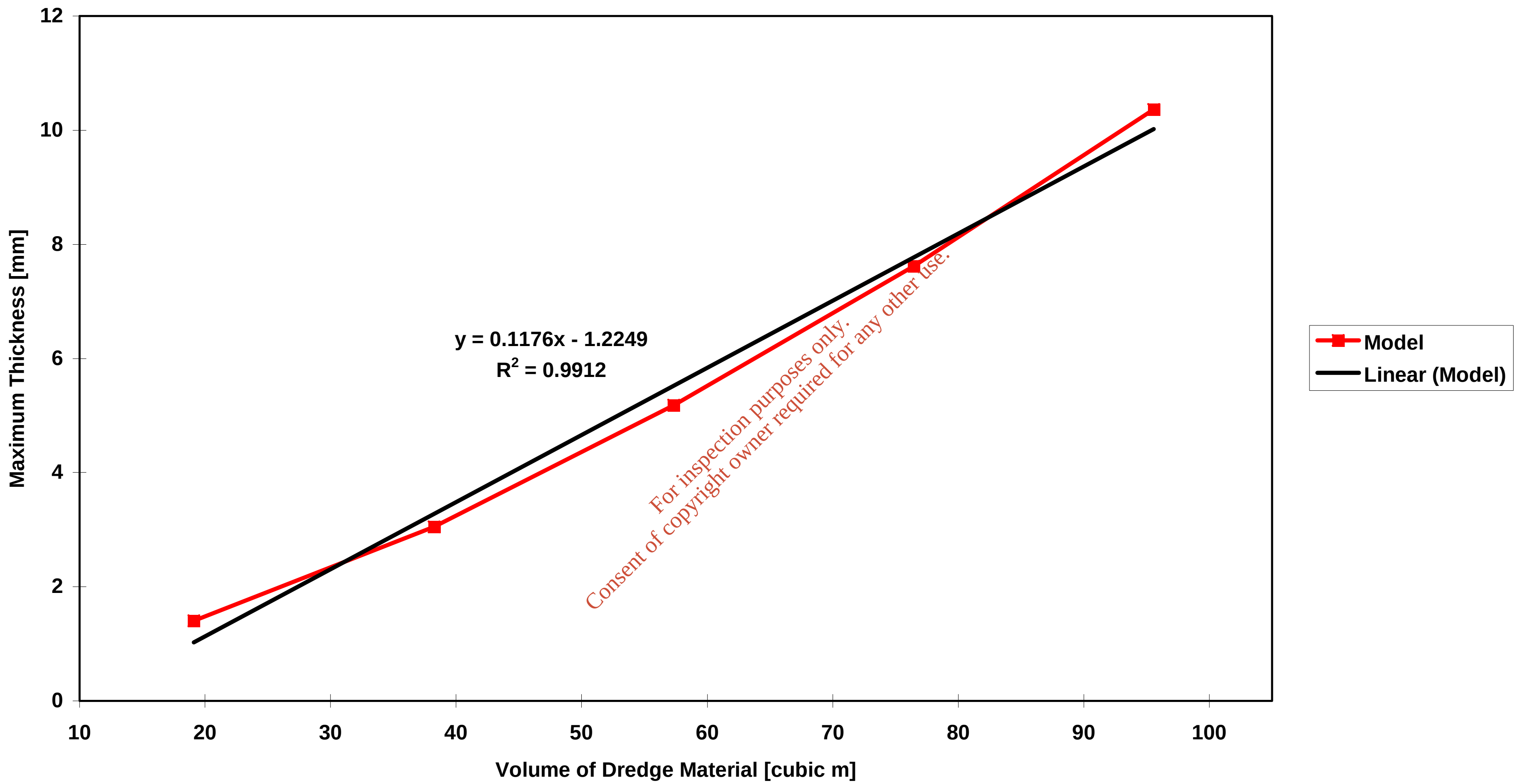


Figure 4.3: *Relationship between volume of dredged material and maximum deposited layer thickness for Analysis 3.*

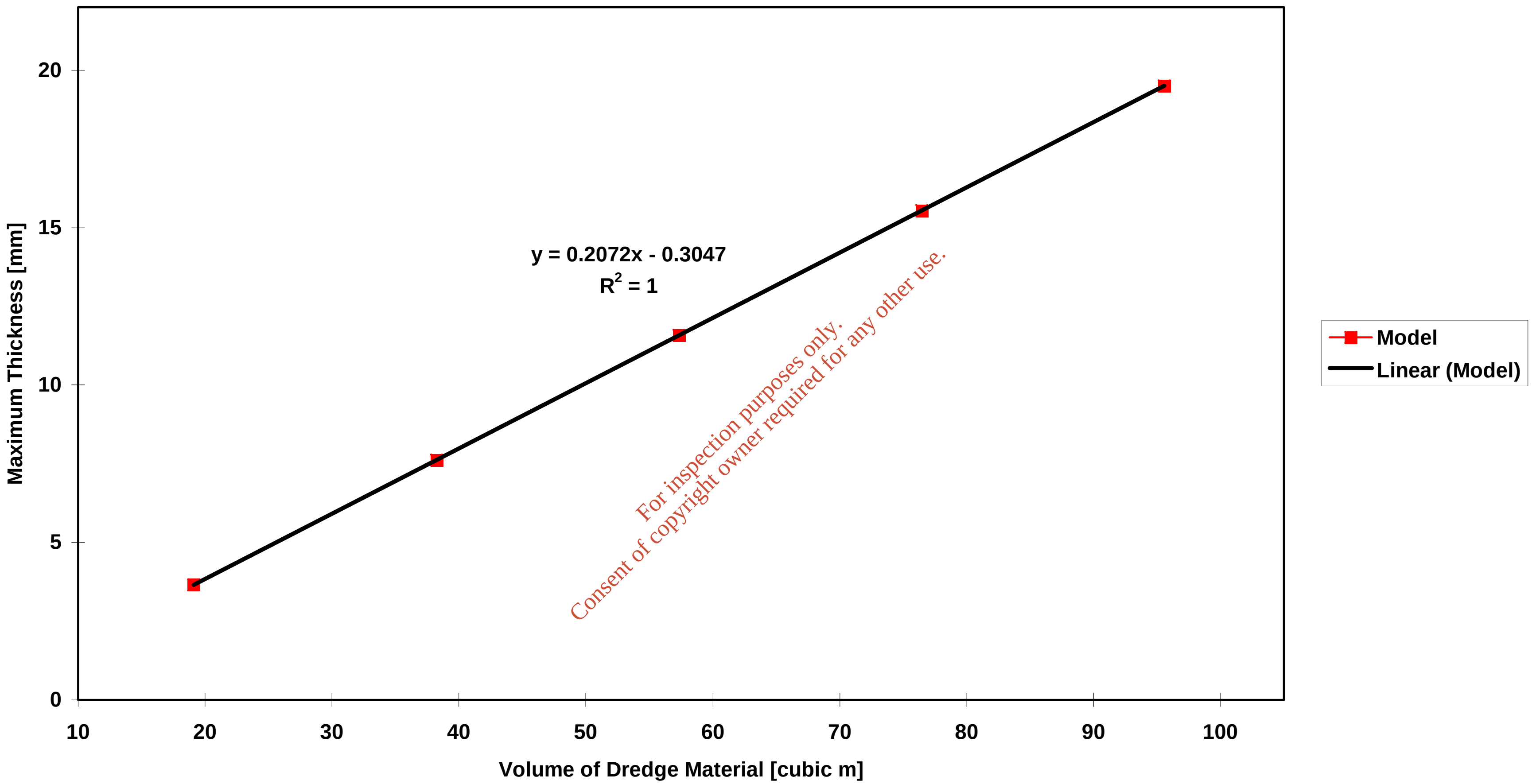


Figure 4.4: *Relationship between volume of dredged material and maximum deposited layer thickness for Analysis 4.*

CHAPTER 5
DISCUSSION OF RESULTS

The results of the model simulations carried out for the two proposed dump sites are discussed in this chapter. The results were analysed in such a way as to ascertain the possible impacts of the disposal of dredge material on water quality and the sea bed in the area surrounding the disposal sites. The following sections deal with the effects of water depths and current velocities on the transport and deposition of dredge material following its disposal, the comparison of model results between the disposal sites, and the ecological impacts of the disposal of dredge material within the Shannon Estuary.

5.1 Effects of Water Depths

The greater depth of water allows a greater proportion of material to be transported away from the dump site resulting in a reduction in deposited layer thickness close to the site. Therefore, the deeper the depth of water at the disposal site, the smaller the localised accumulations of dredged material. This fact is highlighted by the large increases in the maximum deposited layer thickness calculated at both sites due to the shallowness of the areas.

5.2 Effects of Current Velocities

In general, it would be expected that the peak thicknesses recorded during a single dumping operation carried out under maximum current velocity conditions, would all be lower than the maximum thicknesses recorded under minimum velocity conditions at the same sites. This is due to the fact that a greater proportion of material is transported away from the dump site prior to reaching the bed surface as a result of the stronger currents. The stronger currents, make for a more even distribution of settled dredged material on the bed surface. Although the plume of suspended material does travel much further from the dump site at maximum current speeds than at the lower current speeds, the vast majority of the material settles to the bed within the immediate vicinity of the dump site and the remaining suspended material will, therefore, have a negligible impact on the water depth when it does eventually settle. This would suggest that the optimum time for disposal of the dredged material is at the time of maximum current speeds at each of the dump sites.

5.3 Comparison of Sites

From the results provided for Dump Sites 1 and 2, located downstream of Limerick Docks at Newtown Pt. and Coonagh Pt. respectively, it is apparent that while both of these proposed disposal sites are suitable for the dumping of dredged material, due to the shallow depth of water at the sites and the relatively slow ambient current speeds, the volume of material which may be dumped there without major adverse effects on the surrounding environment will be limited.

With regard to Site 1, the maximum thickness of material accumulated on the estuary bed after a single disposal operation was predicted to be 61.3 mm and it occurred over a single grid square when the material was disposed under minimum current velocity conditions. This compares with a maximum layer thickness of 44.7 mm when the material was disposed under maximum current velocity conditions. In the case of Site 2, the maximum thickness of material accumulated on the bed after a single dump was also found to occur under minimum velocity conditions with a thickness of 60.5 mm spread over a single grid square while a peak thickness of 33.3 mm was recorded under maximum current velocity conditions. It should also be noted that due to the shallow nature of Sites 1 and 2 the client will only access the sites at high water, thereby, maximising the depth of water within which dispersion and diffusion of the dumped material can occur.

5.4 Operational Considerations

Finally, in order to ascertain the effects of the full dredge disposal operation on the dump sites and their immediate surroundings, an attempt was made to estimate the likely maximum thicknesses of deposited material on the estuary bed following the disposal of the total volume of material expected to be dredged in a single year. The quantities of material arising from the dredging operations are presented in Table 5.1 and may be summarised as follows:

- Limerick Dock - 150,000 m^3

To calculate the likely maximum deposition at each site the approximate number of equivalent grid cells was calculated for each site based on the area of the site and the area of the grid cells used in the respective model simulations. The number of dumping operations required at each disposal site was then calculated based on the volume of material dumped during a single operation and the total volume to be dumped. It is assumed that the dumping operations will be spread evenly within the dump site in order to minimise the accumulation of dredge material. Therefore, using the equivalent number of grid cells for each site and the number of disposal operations required, an estimation of the likely maximum thickness of the deposited layer of dredge material was calculated for each disposal site based on the maximum thicknesses calculated by the model simulations for a single dumping operation. The results of these calculations are summarised in Table 5.1. The calculations were carried out for disposal of the dredge material under maximum current velocity conditions when the least amount of accumulation will occur.

Dump Site	Area of Site [m^2]	Area of Cell [m^2]	Equiv. No. of Cells	Total Volume [m^3]	Single Volume [m^3]	No. of Dumps	Thickness after 1 Dump [m]	Maximum Thickness [m]
Site 1	52,500	10,000	5	75,000	294	255	0.04470	2.280
Site 2	45,000	10,000	5	75,000	294	255	0.03330	1.698

Table 5.1: *Summary of calculations to estimate the likely maximum thickness of deposited dredge material following disposal of total volume.*

From the table, it can be seen that extremely large accumulations of disposed material will occur on the estuary bed at both Dump Site 1 and 2, with maximum layer thicknesses predicted of 2.28 m and 1.698 m respectively. Given that the average water depths at Sites 1 and 2 are 2.88 m and 3.16 m respectively, at mean water level, the results indicate that the deposited layers of dredge material will become exposed at low water. These significant variations in bathymetry would also cause changes in the hydrodynamic regimes within the respective regions. The layer of deposited material is also thick enough to have major adverse effects on the flora and fauna within the respective areas. These adverse effects are discussed in a later section. These extremely large accumulations of dredge material are due to the shallow depths of water at the sites, the low current velocities and the large volume of material to be dumped there.

From the results discussed, it is readily apparent that Dump Sites 1 and 2 and their immediate vicinities will be affected by the dumping of dredge material. With careful management the total volume of dredge material to be disposed of could be distributed between the dump sites based on the predicted thickness of the deposited layers at each site for a single dumping operation.

5.5 Ecological Impacts of Dredge Material Disposal

Regarding the biological implications of the disposal of the dredge spoil material, the deposition of 2 cm of material on top of a biologically active seabed will smother the benthic infauna. It is evident, therefore, that one of the results of the maintenance dredging activities in the Shannon will be to destroy any infauna at the dump sites. Due, however, to the fluctuating salinities which Sites 1 and 2 experience in response to freshwater flows from the River Shannon it is very likely that infauna at these sites is only present in small numbers. Also, given that there are extensive areas of seabed close by both dump sites which are colonised by the same types of species, it is expected that re-colonisation of the freshly deposited sediments will occur quite quickly.

With regard to the water column, it is clear that the dumping exercise will increase turbidity levels in the River Shannon. However, the zone of measurable impact will be limited to circa 100 m downstream of the dumpsite. Monitoring of suspended solids at other dredge disposal / extraction sites in Ireland has shown that levels fall to below background outside such a distance. Turbidity levels in the River Shannon can be high (McMahon & Quirke, 1992) especially in the vicinity of the upper estuary ca.

from Limerick City to 40km westwards. They record levels of ca 80 mg/l in the vicinity of the area closest to Limerick City. In the lower part of the estuary, i.e. 40km west of Limerick City, the authors record ≤ 80 mg/l for suspended solids. Given the overall naturally high levels of suspended solids throughout the estuary, it is unlikely that the additional load contributed to the River Shannon during dredge disposal operations will have a significant negative impact on the biological communities in the water column.

CHAPTER 6
SUMMARY AND CONCLUSIONS

6.1 Summary

In order to investigate the environmental effects caused by the proposed dredging of the Shannon Estuary and subsequent disposal of the dredged material within the estuary, two separate mathematical models were developed which simulated the transport and deposition of the disposed material at each of the proposed dump sites. These proposed sites are as follows:

- Dump Site 1 - Newtown Point
- Dump Site 2 - Coonagh Point

The mathematical model used for the study was the U.S. Army Corps of Engineers' Open Water Disposal Model (STFATE), which accounts for the physical processes determining the short-term fate of the dredged material disposed at open water sites.

In the case of each dump site, the bathymetry, the current velocity conditions and the characteristics of the dredged material were input to the models. For each site, the STFATE model was executed using two different hydrodynamic conditions, namely, maximum current velocities and minimum current velocities. The current velocity data at each of the dump sites were obtained from the Shannon Estuary Hydrodynamic Model which is already in existence and is owned by Shannon-Foynes Port Company.

Finally, the model simulations were executed and the following conclusions were drawn based on the analysis of the results.

6.2 Conclusions

- Due to the shallow water depths at Dump Sites 1 and 2, execution of the models developed for the sites was not possible as a result of computational restrictions. This was true for water depths calculated at both mean water level and at spring high tide. However at spring high tide it was possible to execute the models using smaller volumes of dredge material than the volumetric capacity of the dredger. From these simulations a linear relationship was determined between the volume of material dumped and the resulting maximum thickness of the deposited material allowing the calculation of the peak thickness of accumulated material for the correct volume of dredge material.

- At Dump Site 1, under maximum velocity conditions, the maximum thickness of settled material after a single dump was calculated at 44.7 mm and occurred directly below the point of discharge. Under minimum velocity conditions, the maximum thickness of settled material after a single dump was calculated at 61.3 mm and also occurred directly below the point of discharge.

- At Dump Site 2, under maximum velocity conditions, the maximum thickness of settled material after a single dump was calculated at 33.3 mm and occurred directly below the point of discharge. Under minimum velocity conditions, the maximum thickness of settled material after a single dump was calculated at 60.5 mm and also occurred directly below the point of discharge.

- The likely maximum thicknesses of deposited dredge material at each of the Dump Sites, as predicted by the model simulations after a single dumping operation, are summarised in Table 6.1.

Model Simulation	Maximum Thickness [mm]
Dump Site 1 - Maximum Velocity Simulation - Minimum Velocity Simulation	 44.7 61.3
Dump Site 2 - Maximum Velocity Simulation - Minimum Velocity Simulation	 33.3 60.5

Table 6.1: *Summary of model results for two proposed dump sites.*

- The deposition of 2 cm of material on top of a biologically active seabed will smother the benthic infauna, therefore, the maintenance dredging activities in the Shannon Estuary will destroy any infauna at all of the dump sites. However, re-colonisation of the freshly deposited sediments will occur quite quickly as there are extensive areas of seabed in the vicinity of both sites which are colonised by the same types of species.

- The dumping exercise will increase turbidity levels in the River Shannon. However, given the overall naturally high levels of suspended solids throughout the estuary and the limited zone of measurable impact (circa 100 m downstream of the dump site) it is unlikely that the additional turbidity resulting from the dredge disposal operations will have a significant negative impact on the biological communities in the water column.

6.3 Recommendations

- Since the proposed dredging operations will require the re-use of the disposal sites, it is necessary to vary the dump location within the dump site area in order to ensure localised accumulations on the estuary bed are kept to a minimum. If this is adhered to then the likely maximum thickness of deposited material at each of the sites following the disposal of a year's worth of dredging operations is 2.28m at Site 1, 1.698 m at Site 2.

- It may be concluded, that careful management of the proposed dredge disposal operations within the Shannon Estuary will be extremely important in minimising the adverse effects of the dumping on both the hydrodynamic regimes and the flora and fauna within the proposed dump sites and their surrounding vicinities.

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2. Shannon-Foynes Port Company, 1999. *"Shannon Estuary planned maintenance dredging – Five year plan 1999-2004."* Shannon-Foynes Port Company, Mill House, Foynes, Co. Limerick.

3. Shannon-Foynes Port Company, 2000. As per communication.

4. U.S. EPA & U.S. Army Corps of Engineers, 1995. *"Evaluation of dredged material proposed for discharge in waters off the U.S. – Testing Manual."* Environmental Protection Agency, Office of Water, Office of Science and Technology, Washington D.C. and Department of the Army, United States Army Corps of Engineers, Washington D.C..

Attachment F.1

Sub-Section 2

Impact Assessment Studies

Impact Assessment Study of a Dredge Disposal Site in the Shannon Estuary at Foynes, Co. Limerick (Aqua-Fact International Services Ltd)

IMPACT ASSESSMENT STUDY OF A

DREDGE DISPOSAL SITE

IN THE SHANNON ESTUARY

AT FOYNES, CO. LIMERICK

For: Shannon Foynes Port Company,
Mill House,
Foynes,
Co. Limerick.

By: Aqua-Fact International Services Ltd.,
12 Kilkerrin Park,
Liosbaun,
Galway.
www.aquafact.ie

TABLE OF CONTENTS

CHAPTER 1
INTRODUCTION

Aqua-Fact International Services Ltd. were commissioned by Shannon Foynes Port Company to carry out an impact assessment study of the environmental effects caused by maintenance dredging in the Shannon Estuary and subsequent disposal of the dredged material within the estuary at a proposed site near Foynes Island. Maintenance dredging is carried out to maintain the natural chart datum within the estuary as published on British Admiralty Charts for the area.

The purpose of the study was to model the transport and deposition of the disposed material in order to assess its impact on water quality and the estuary bed in the area surrounding the disposal site. This was achieved with the use of the U.S. Army Corps of Engineers' Open Water Disposal Model (STFATE) which accounts for the physical processes determining the short-term fate of the dredged material disposed at open water sites. The model provides estimates of water column concentrations of suspended sediment and the initial deposition of material on the estuary bed.

All the relevant environmental and hydrodynamic data required as input to the model are described in Chapter 2. The theory, development and application of the model to analyse the short-term fate of the disposed material at the dump site is detailed in Chapter 3. Chapter 4 and Chapter 5, respectively, present and discuss the results obtained from the model simulations. Finally, in Chapter 6, the summary and conclusions of the project are presented and some recommendations are provided based on the study's conclusions.

CHAPTER 2
MODEL DATA INPUT

2.1 Disposal Site

In order to keep the channels surrounding Foynes Island free of sediment built up, it is necessary to periodically carry out dredging operations. Table 2.1 details the amount of material which is required to be removed to maintain Chart Datum at the aforementioned locations (Shannon Foynes Port Company).

Location	Material	Quantity
Foynes Island	Mud/Silt	150,000 m^3

Table 2.1: *Details of proposed dredging operation.*

It is proposed that the dredged material will be dumped at the disposal site shown in Figure 2.1. The coordinates of the site are 52° 37' 19.8'' N and 9° 08' 33.2'' W.

The bathymetric profile at the site was taken from the Admiralty Chart shown in Figure 2.2. The boundary of the dump site is highlighted in red. Part of the study area modelled using STFATE is indicated in Figure 2.2. The entire study area measures 7500m x 1500m and extends a further 5km downstream.

The STFATE model can only be run using a flat bed surface or one with a constant slope. Therefore, an average water depth was calculated for the extent of the study area. This figure was then used in model simulations.

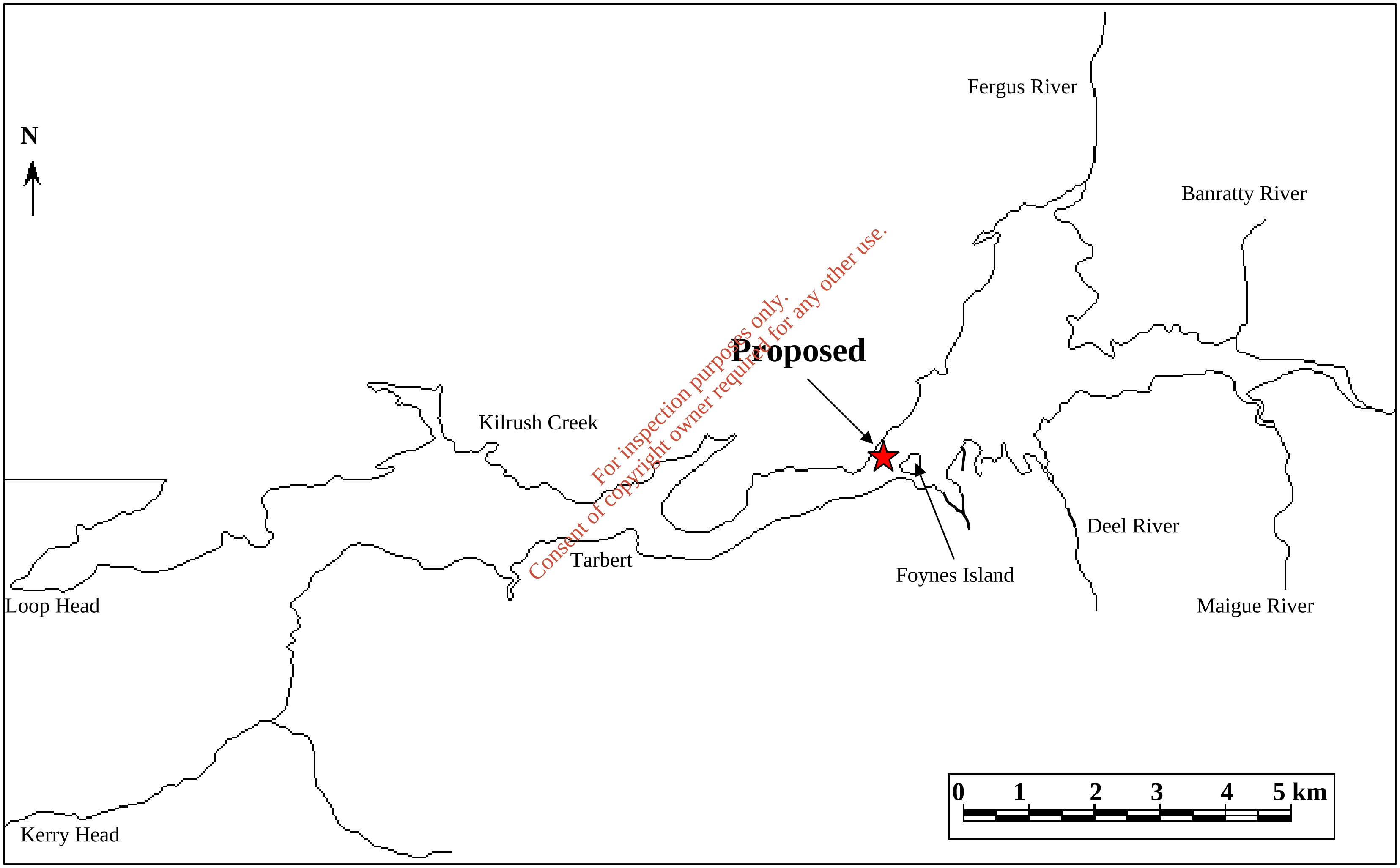

Figure 2.1: *Plan view of the Shannon Estuary showing the location of the proposed dump site.*

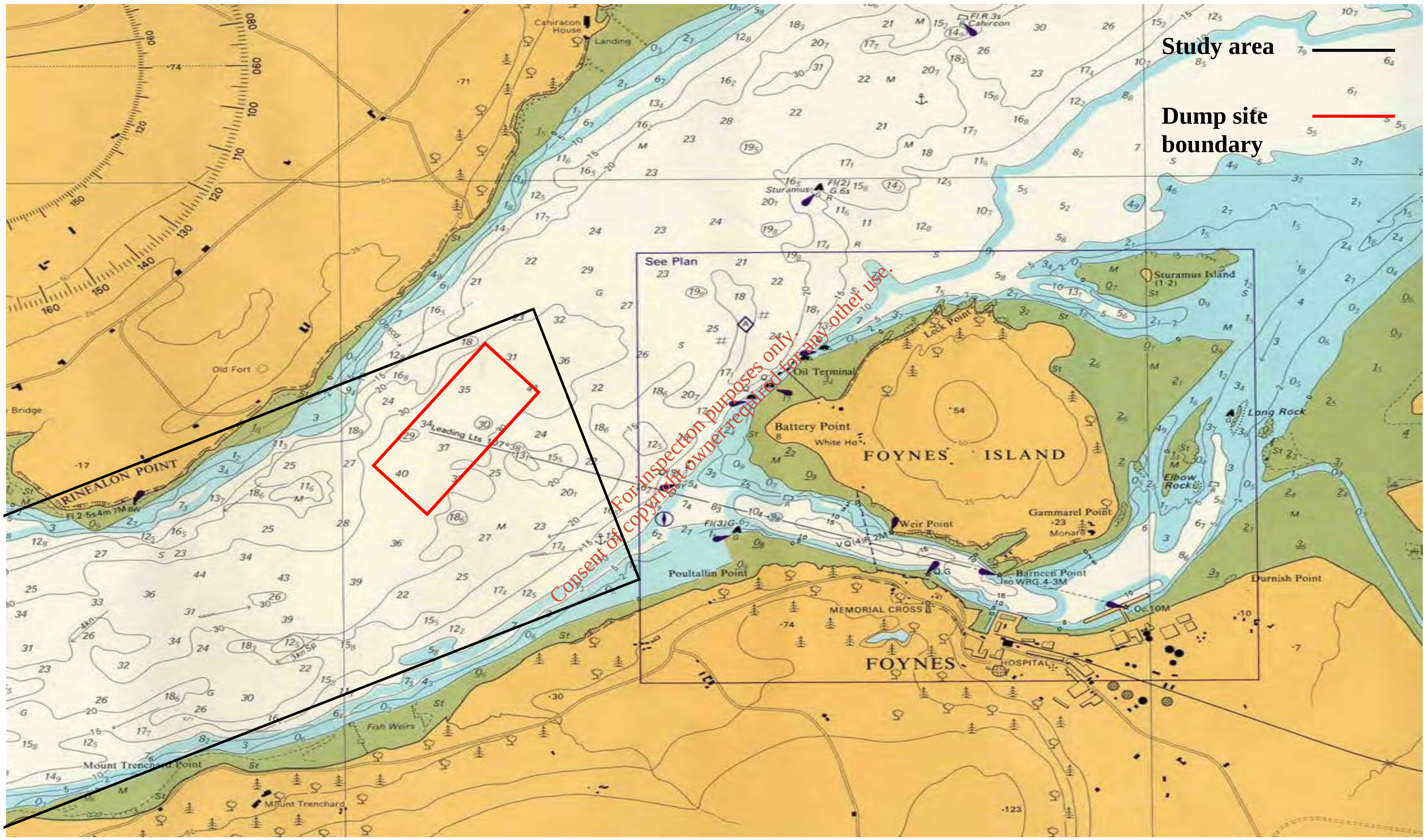

Figure 2.2 Admiralty Chart of section of Shannon estuary illustrating proposed dump site and study area modelled using STFATE

2.2 Hydrodynamic Data

In studies investigating the impact of the disposal of dredged material there are two important considerations to take into account:

a) Whether the dredged material will be transported outside the boundary of the disposal site by the prevailing currents, which is most likely to occur when the currents are at a maximum.
b) Whether the build-up of dredged material on the sea bottom will significantly reduce the depth of water at the disposal site, which is most likely to occur when the currents are at a minimum.

With these considerations in mind, it was decided to analyse the disposal of the dredged material using two different hydrodynamic regimes, namely the maximum current velocity and minimum current velocity at each of the sites.

The current velocity data at the dump site was obtained from the Shannon Estuary Hydrodynamic Model which is already in existence and is owned by Shannon Foynes Port Company. The model was executed and the current velocities and directions were computed and output at the proposed dump site for both spring and neap tidal conditions. From these plots of current velocity the maximum and minimum velocities were then calculated. The current data for spring tidal conditions were used in the model as current velocities reach their maximum during a spring tide. The current data input to the STFATE model are presented in Table 2.2.

Analysis	Description	Current Speed (m/s)	Current Direction (degrees from N)
1	Maximum Velocity	1.572	219.545
2	Minimum Velocity	0.019	163.600

Table 2.2: *Current data used in STFATE model simulations.*

2.3 Dredged Material Data

Information on the properties of the dredged material to be disposed of was obtained from a site investigation carried out at Foynes. Shannon Foynes Port Company requested Enterprise Ireland's Shannon Laboratory to collect sediment samples and have them analysed for a range of specific parameters. In total, three samples were taken from Foynes on 15th August 2002. Analysis showed that the dredged material is composed of a mixture of sand and silt. The properties of the material (average of the three samples), as specified to the model, are presented in Table 2.3.

Location	Type	Spec. Gravity [mg/m^3]	Volumetric Conc.	Fall Vel. [m/s]	Deposited Void Ratio	Character
Foynes	Sand	2.70	0.1800	$3.05x10^{-2}$	0.6	Noncohesive
	Silt	2.65	0.3723	$3.05x10^{-3}$	4.5	Cohesive

Table 2.3: *Properties of dredged material input to model.*

2.4 Disposal Operation Data

The disposal of dredged material will take place from a grab dredger with bottom opening doors for disposal. Although the dumping operation is considered to be instantaneous, it is assumed that the time to completely empty the dredging vessel will be approximately 3 ½ minutes. The input data specified to the model regarding the disposal operation are presented in Table 2.4 (Shannon Foynes Port Company, 2000).

Disposal Operation Detail	Value Input to Model
Mass of dredged material held in vessel ⇒ Volume of material	450 tonnes 234.3 m^3
Vessel length and width	43.6 x 9.9 m
Pre-disposal draft of vessel	3.2 m
Post-disposal draft of vessel	2.9 m
Angle of discharge	Vertical
Time to empty vessel	210 s
Vessel velocity	Stopped

Table 2.4: *Details of dredging operation data input to the model.*

CHAPTER 3
MODEL THEORY AND DEVELOPMENT

3.1 Introduction

The objective of this study is to determine the impacts on the water column and the seabed of the disposal of dredged material at the proposed dump site. The initial phase of deposition of dredged material follows immediately upon release from the disposal vessel. Accurate representation of the initial mixing process of the dredged material is required to determine estimates of water column concentrations of suspended sediment and the initial deposition of the material on the bottom. In order to accurately represent the physics of the disposal, the mathematical model STFATE was employed to determine the characteristics of the initial mixing phase.

3.2 Theory

In the STFATE model, the behaviour of the material is assumed to be separated into three phases:

1) ***convective descent***, during which the dump cloud or discharge jet falls under the influence of gravity and the initial momentum of the discharge;
2) ***dynamic collapse***, occurring when the descending cloud or jet impacts the bottom or arrives at a level of neutral buoyancy where descent is retarded and horizontal spreading dominates;
3) ***passive transport-diffusion***, commencing when the material transport and spreading are determined more by ambient currents and turbulence than by the dynamics of the disposal operation (U.S. EPA & U.S. Army Corps of Engineers, 1995). Figure 3.1 illustrates these three phases of material behaviour. The passive transport and diffusion phase in the model is handled by allowing the material settling from the descent and collapse phases to be stored in small Gaussian clouds. These clouds are then diffused and transported at the end of each time step.

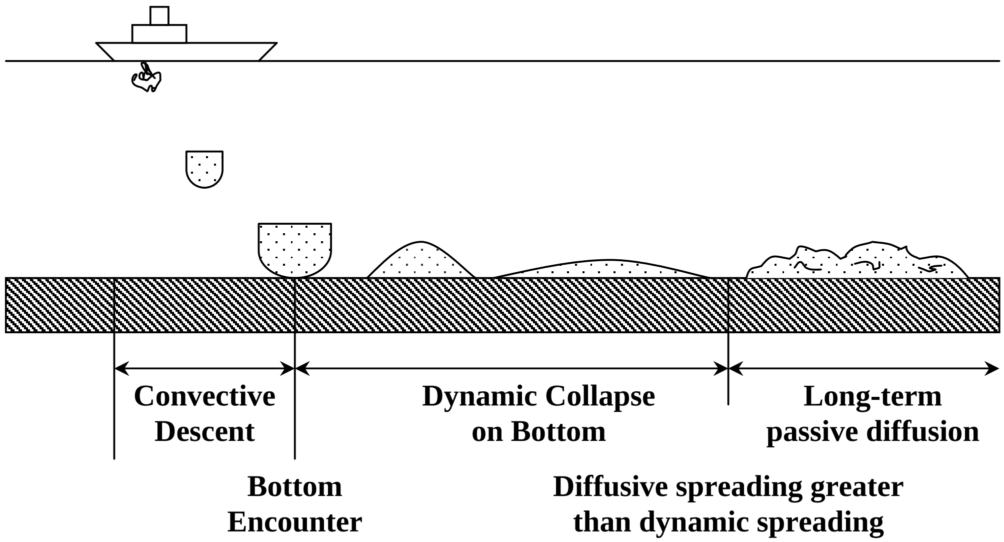

Figure 3.1: *The three stages of material behaviour as assumed in STFATE model (U.S. EPA & US Army Corps of Engineers, 1995).*

3.3 STFATE Model Development

The study area was declared to the model in the form of a rectangular grid, details of which are given in Table 3.1. Each grid cell was then assigned the average depth that had been calculated for the entire study area. It should be noted that the average depth used in the models was calculated using a water depth at mean water level.

Dump Site	Grid Area [km^2]	Grid Spacing [m]	No. of Rows	No. of Columns	Depth [m]
Foynes	7.50 x 1.50	250 x 100	15	30	28.08

Table 3.1: *Grid size, spacing and depth used in model simulations.*

3.4 STFATE Model Analyses

Two different simulations were performed using the velocity conditions listed in Table 2.2. Each simulation predicted the initial deposition of dredged material resulting from a single disposal operation. The simulation time was equal to 1 hour for each model run. A period of 1 hour was chosen for simulations because it was observed that there was very little change in the amount of material settling on the seabed with time after this period had elapsed. The execution time step used during the model runs for the long-term transport-dispersion calculations was 100 seconds, which is the minimum timestep allowable in the model.

In each case the current velocities were assumed to be uniform over the entire water depth and were input to the model as depth averaged velocities. The velocities and directions were also assumed to be constant over the whole of the study area and for the full duration of the simulations.

3.5 STFATE Model Results

Results from the STFATE model are presented using the following formats:

1) Graphs showing the development of the plume and its extent during the convective descent and cloud collapse phases.
2) Graphs showing the extent and movement of the plume of suspended material during the long-term transport-dispersion phase.
3) Three dimensional deposition plots of material on the seabed at the end of the simulation period.

With reference to the graphs presented in the following section, the x-direction corresponds to East-West, the y-direction corresponds to North-South and the z-direction represents water depth. The usual Cartesian convention applies with North and East corresponding to the positive y and x directions, respectively.

CHAPTER 4
MODEL RESULTS AND DISCUSSION

In this chapter, the results of the STFATE model simulations for the two different hydrodynamic regimes are presented and discussed. Results are presented for each of the three physical processes represented in the model and described in Chapter 3 (convective descent, cloud collapse and long-term transport-diffusion). A discussion of these results is presented in Chapter 5 while conclusions drawn from them are presented in Chapter 6.

4.1 Foynes dump site

Convective Descent Results:

Analysis 1 – Maximum Velocity Condition: The duration of the convective descent phase was 5.27 seconds. At the end of this phase the plume centroid had moved 0.77m in the negative y-direction (southwards) and 4.39m from the barge in the negative x-direction (westward), while the downward velocity was 4.50m/s. The maximum radius of the plume achieved during this phase was 9.56m which can be compared to the initial plume radius of 5m.

Analysis 2 – Minimum Velocity Condition: The duration of the convective descent phase was 5.18 seconds. At the end of this phase the plume centroid was 0.048 m from the barge in the negative y-direction and 0.015 m in the negative x-direction, while the downward velocity was 4.58m/s. The maximum radius of the plume achieved during this phase was 13.961m which can be compared to the initial plume radius of 5m.

Cloud Collapse Results:

Analysis 1 – Maximum Velocity Condition: The cloud collapse phase terminated 35.77 seconds after dumping. At the end of this phase the plume centroid was 7.60m from the barge in the negative y-direction and 42.83m in the negative x-direction. The plume had a vertical thickness of 1.21 m and a diameter of 86.11 m. Figure 4.1 shows the radial extent and position relative to the barge of the plume as it sinks to the estuary bed.

Analysis 2 – Minimum Velocity Condition: The cloud collapse phase terminated 33.98 seconds after dumping. At the end of this phase, the plume centroid was located 0.063m from the barge in the negative y-direction and 0.018 m in the negative x-direction while the cloud had a thickness of 1.19m and a diameter of 84.44m. Figure 4.2 shows the radial extent and position relative to the barge of the plume as it sinks to the estuary bed.

From these results it can be seen that the speed of the ambient current has very little effect on both the downward velocity of the plume and its radius. Similarly, it has a negligible effect on the distance over which the plume will be transported during convective descent and dynamic collapse with the plume only moving a further 42.5 metres (approximately) in the negative x-direction for the increase in current speed from minimum to maximum conditions.

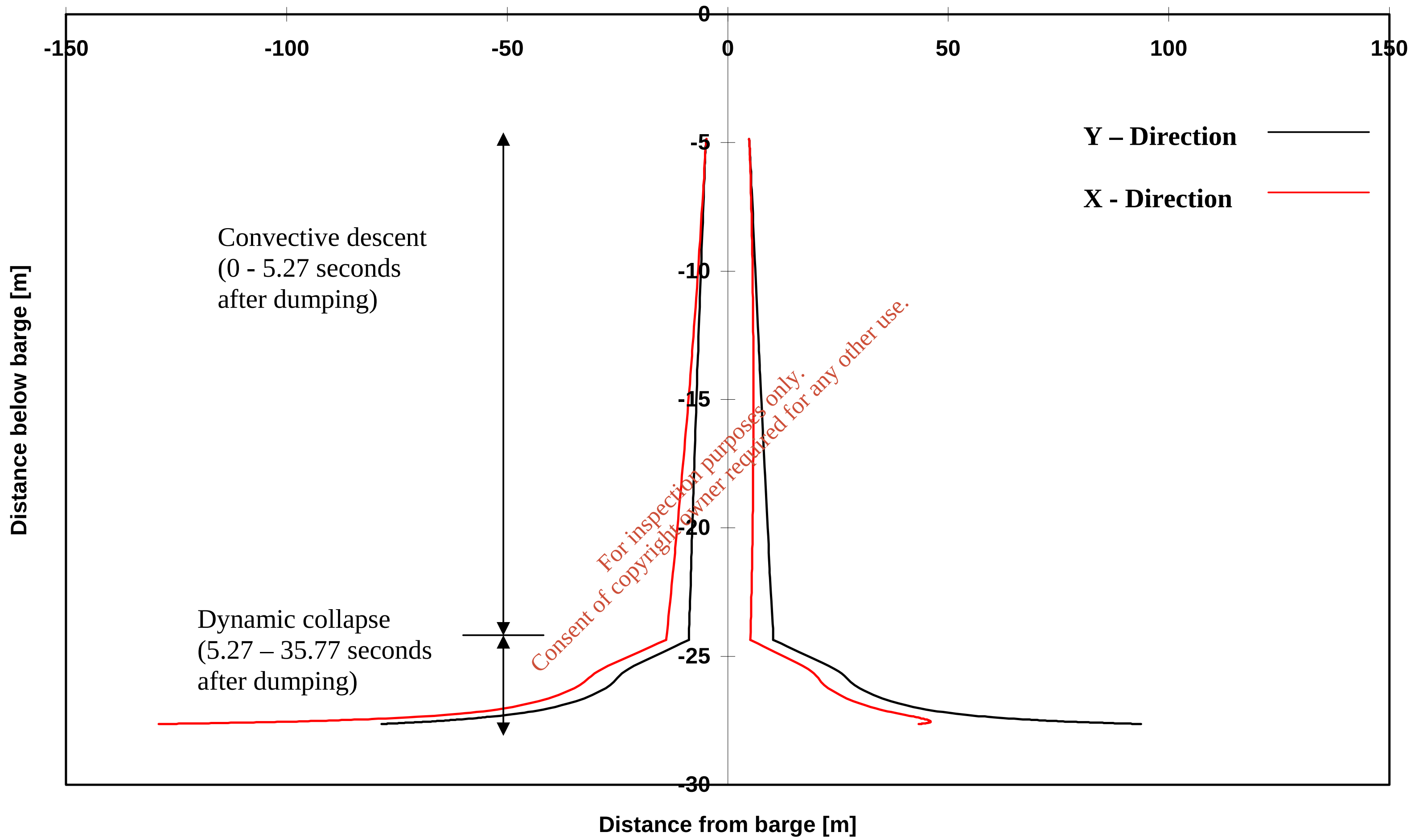

Figure 4.1: *Development of plume extent during convective descent and cloud collapse phases – Analysis 1.*

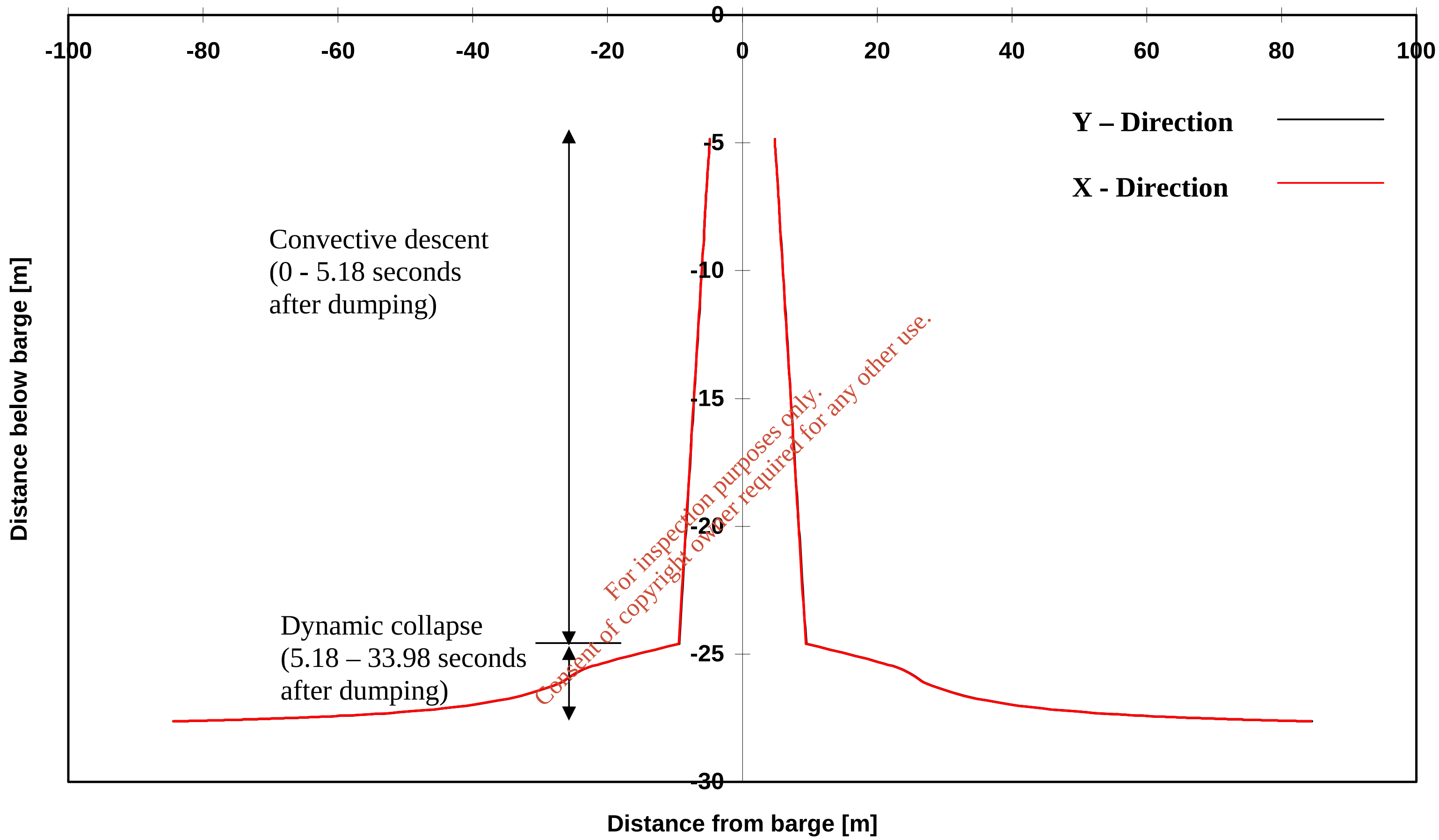

Figure 4.2: *Development of plume extent during convective descent and cloud collapse phases – Analysis* 2.

Long-term Transport-Diffusion Results:

Analysis 1 – Maximum Velocity Condition

After 1 hour had elapsed 99.3% of the sand had settled to the estuary bed following discharge of the dredged material. With regard to the settling of the silt particles, at the end of the simulation period approximately 36.8.2 % had settled to the bed leaving 63.2 % still in a suspended state. After the one hour period, almost no change took place in the amount of material which settled to the bottom of the estuary bed indicating that a steady-state like condition had been reached.

Figure 4.3 shows the movement and growth of the discharge plume at the dump site due to the effects of ambient currents and diffusion during the course of the long-term transport-diffusion phase. Upon inspection of the diagram, it can be seen that the ambient current velocity has a very significant effect during this phase, transporting the plume approximately 5 km from the dump site after 1 hour. The diameter of the plume also increases significantly from 76.35 m (after 35.8 seconds) to 746.8m by the end of the simulation. It should be noted that from 1800 seconds after dumping, onwards, the plume is almost entirely composed of silt particles.

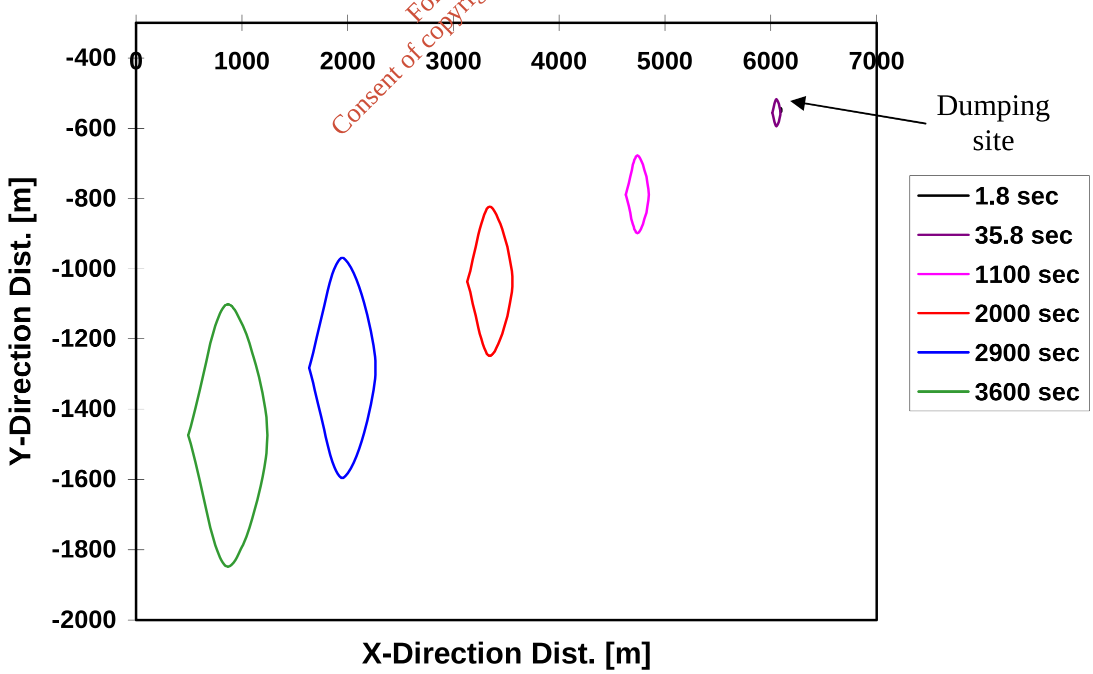

Figure 4.3: *Growth of plume during long-term transport-diffusion phase – Analysis 1.*

At the end of the model simulation in Analyses 1, a peak thickness of 5.78 mm of deposited material was observed to accumulate over a single grid square under the site of the dumping operation. This 5.78 mm layer covers the entire grid square and is composed of both sand and silt. Figure 4.4 shows a three-dimensional deposition plot of the dumped material on the estuary bed within the study area at the end of the simulation period.

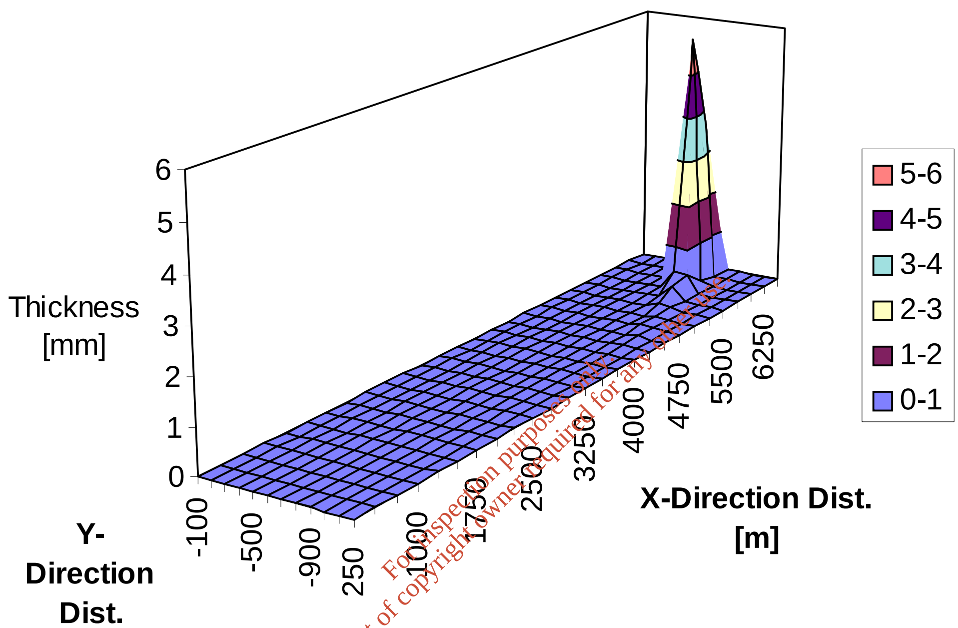

Figure 4.4: *Thickness of deposited material on estuary bed at 1 hour – Analysis 1*

Analysis 2 – Minimum Velocity Condition

Unlike analysis 1, all of the disposed sand had settled to the bed surface by 1100 seconds after dumping. By the end of the simulation, approximately 82.3 % of the silt had also settled to the estuary bed leaving just 17.7 % of the silt still in suspension. Figure 4.5 shows the transport and growth of the plume of suspended material during the course of the transport-diffusion phase. As with analysis 1, almost no change took place in the amount of material which settled to the bottom of the estuary bed after 1 hour. As can be seen from the diagram, the plume did not move very much during this simulation. This was due to the very small current velocity employed in the analysis. However, the extent of the plume did increase by a fairly significant amount during the course of the transport-diffusion phase, growing from an initial diameter of 74.83 (after 34 seconds) to a diameter of 745.2m after 1hour.

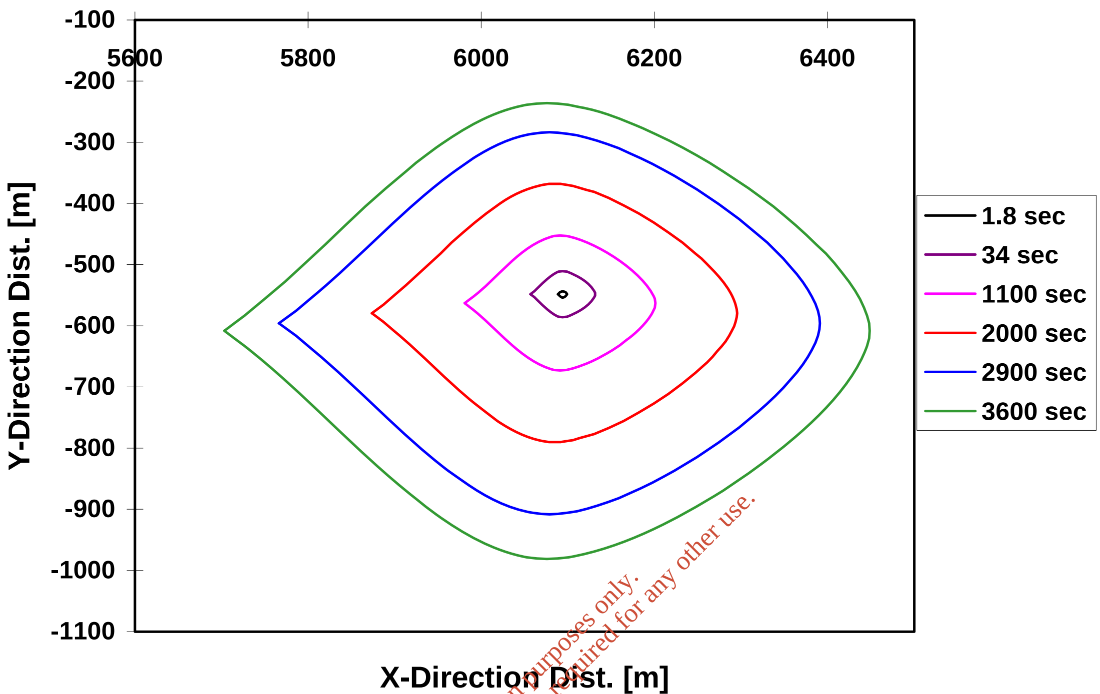

Figure 4.5: *Growth of plume during long-term transport-diffusion phase – Analysis 2.*

With regard to the deposition of the dredged material, a peak thickness of 10.05mm of deposited material was observed to accumulate over a single grid square under the site of the dumping operation. As was the case with the previous simulations this 10.05mm layer covers the entire grid square.

Figure 4.6 gives a three-dimensional graphical representation of the deposited layer of dredged material at the end of the simulation (1 hour). When compared to Analysis 1 it can be seen that the peak thickness of the deposited layer is approximately 4.5 mm greater when the material is dumped under minimum current conditions than when it is dumped under maximum current conditions.

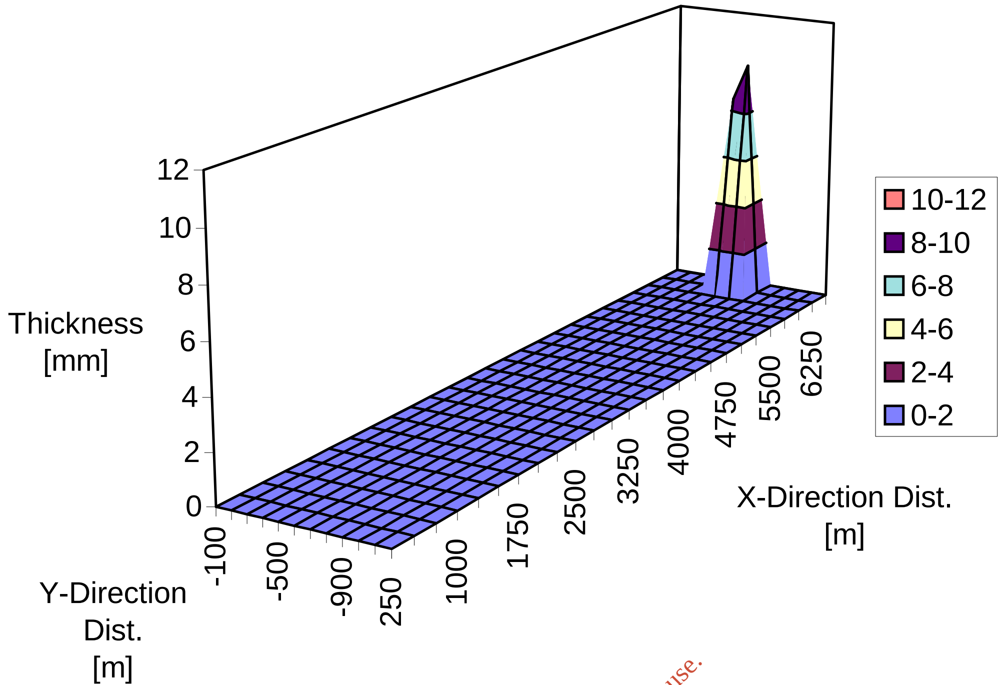

Figure 4.6: *Thickness of deposited material on estuary bed at 1 hour – Analysis 2.*

CHAPTER 5
DISCUSSION OF RESULTS

The results of the model simulations carried out for the proposed dump site are discussed in this chapter. The results were analysed in such a way as to ascertain the possible impacts of the disposal of dredge material on water quality and the estuary bed in the area surrounding the disposal site. The following sections deal with the effect of current velocities on the transport and deposition of dredge material following its disposal and the ecological impacts of the disposal of dredge material within the Shannon Estuary.

5.1 Effects of Current Velocities

From the model results, it can be observed that the peak thickness observed in the simulation carried out under maximum current velocity conditions was lower than that observed under minimum velocity conditions. This is due to the fact that a greater proportion of material is transported away from the dump site prior to reaching the bed surface as a result of the stronger currents. The stronger the current therefore, the more even the distribution of settled dredged material on the bed surface. For the maximum velocity condition, it was observed that 63.2% of the silt was still in suspension. This implies that a significant quantity of the material will be settle far away from the original dump site. However, the rate of silt settlement near the end of the 1 hour period of simulation was extremely low and the maximum thickness which was deposited at this time was 0.03mm per grid square. This suggests that the remaining suspended material will settle out very gradually over a considerable area and some of it may even be transported out to sea. In either case, the sediment will have a negligible impact on the water depth when it does eventually settle. This suggests that the optimum time for disposal is at the time of maximum current speed at the dump site.

5.2 Operational Considerations

The maximum thickness of material accumulated on the bed over a single grid square after a single disposal operation was predicted by the model to be 10.05 mm, or 0.010 m, for the lowest current velocity condition. The average water depth in this area is approximately 28.08 metres. The size of the dump site is approximately 224,000 m^2 and is, therefore, composed of about 9 grid squares (each grid square measures 250m x 100m). Therefore, depending on the number of dumping operations to be performed, they must be spread over the whole dump site area in such a way as to avoid large localised accumulations of dredged material.

In order to ascertain the effects of the full dredge disposal operation on the dump site and its immediate surroundings, an attempt was made to estimate the likely maximum thickness of deposited material on the estuary bed following the disposal of the total volume of material expected to be dredged in a single year.

To calculate the likely maximum deposition at the site the approximate number of equivalent grid cells was calculated for each site based on the area of the site and the area of the grid cells used in the model simulations. The number of dumping operations required at the disposal site was then calculated based on the volume of material dumped during a single operation and the total volume to be dumped. It is assumed that the dumping operations will be spread evenly within the dump site in order to minimise the accumulation of dredge material. Therefore, using the equivalent number of grid cells for each site and the number of disposal operations required, an estimation of the likely maximum thickness of the deposited layer of dredge material was calculated for the disposal site based on the maximum thickness calculated by the model simulations for a single dumping operation. The results of these calculations are summarised in Table 5.1. The calculations were carried out for disposal of the dredge material under maximum and minimum current velocity conditions.

Analysis	Area of Site [m^2]	Area of Cell [m^2]	Equiv. No. of Cells	Total Volume [m^3]	Single Volume [m^3]	No. of Dumps	Thickness after 1 Dump [m]	Maximum Thickness [m]
1	224,200	25,000	9	150,000	234	641	0.00578	0.411
2	224,200	25,000	9	150,000	234	641	0.01005	0.715

Table 5.1: *Summary of calculations to estimate the likely maximum thickness of deposited dredge material following disposal of total volume.*

From the Table 5.1, it is evident that the likely maximum thickness of the deposited layers are reasonably small, estimated at 411mm and 715mm, respectively. It is also apparent that disposal of the dredged material under maximum velocity conditions will result in a significantly smaller annual accumulation of sediment than that at minimum velocity conditions. It is not expected that these variations in bathymetry would have a significant impact on the hydrodynamic patterns within the associated regions. However, the deposited layers of dredge material are of sufficient thickness to adversely affect the flora and fauna of the associated areas, the extent of which is discussed in the following section.

5.3 Ecological Impacts of Dredge Material Disposal

Regarding the biological implications of the disposal of the dredge spoil material, the deposition of 0.4 m of sediment on top of the seabed will smother any benthic epi/infauna that is present. It is evident, therefore, that one of the results of the maintenance dredging activities at the Foynes site will be to destroy any epi/infauna there. Due, however, to the fact that samples collected at the site returned very low numbers of benthic invertebrates, the ecological impact of the disposal of dredge material will be low. The reasons for the low numbers of species maybe due to a number of factors and these include the fact that the site has been previously used as a disposal site and the possibility that salinity fluctuates. As there are extensive areas of seabed close by the dump site that presumably are colonised by the same suite of species as was recorded on the site, it is expected that re-colonisation of the freshly deposited sediments will occur quickly.

With regard to the water column, it is clear that the dumping exercise will increase turbidity levels in the River Shannon. However, the zone of measurable impact will be limited to circa 500m downstream of the dumpsite. Monitoring of suspended solids at other dredge disposal/extraction sites in Ireland has shown that levels fall to below background outside such a distance. Turbidity levels in the River Shannon can be high (McMahon & Quirke, 1992) especially in the vicinity of the upper estuary ca. from Limerick City to 40km westwards. They record levels of ca 80 mg/l in the vicinity of the area closest to Limerick City. In the lower part of the estuary, i.e. 40km west of Limerick City, the authors record $\leq$ 80 mg/l for suspended solids. Given the overall naturally high levels of suspended solids throughout the estuary, it is unlikely that the additional load contributed to the River Shannon during dredge disposal operations will have a significant negative impact on the biological communities in the water column.

The Shannon is proposed as a Special Area of Conservation (pSAC) by Dúchas and this is primarily due to the fact that in the outer area i.e. west of Money Point, there is a pod of dolphins which is resident all year round. The proposed dredging and disposal activities at Foynes will not significantly negatively impact the status of the pSAC.

CHAPTER 6
SUMMARY AND CONCLUSIONS

6.1 Summary

In order to investigate the environmental effects caused by the proposed dredging of the Shannon Estuary and subsequent disposal of the dredged material within the estuary, a mathematical model was developed which simulated the transport and deposition of the disposed material at the proposed dump site near Foynes Island.

The mathematical model used for the study was the U.S. Army Corps of Engineers' Open Water Disposal Model (STFATE) which accounts for the physical processes determining the short-term fate of the dredged material disposed at open water sites.

The bathymetry, the current velocity conditions and the characteristics of the dredged material were input to the model. The STFATE model was executed using two different hydrodynamic conditions, namely, maximum current velocity and minimum current velocity. The current velocity data at the dump site were obtained from the Shannon Estuary Hydrodynamic Model which is already in existence and is owned by Shannon Foynes Port Company.

Finally, the model simulations were executed and the following conclusions were drawn based on the analysis of the results.

6.2 Conclusions

- At the dump site, under maximum velocity conditions, the disposal cloud struck the bottom in 5.27 seconds and grew from an initial radius of 5m to a final radius at the bottom encounter of 9.56m. Collapse on the bottom then occurred with the collapse phase terminating at 35.77 seconds after disposal and the final cloud having a diameter of 86.11m. Virtually all of the sand had settled to the bed after 1 hour while only 36.8 % of the silt had settled by the same time. The cloud of suspended solids had travelled approximately 5 km and had a diameter of 746.8m. The maximum thickness of the settled material after a single dump was recorded at 5.78mm directly beneath the point of dumping.

- At the dump site, under minimum velocity conditions, the disposal cloud struck the bottom in 5.18 seconds and grew from an initial radius of 5 m to a final radius at the bottom encounter of 13.96m. Collapse on the bottom then occurred with the collapse phase terminating 33.98 seconds and the final cloud having a diameter of 84.44 m. By the end the hour, 82.3 % of the silt had settled to the bed while all of the sand had settled. The total distance travelled by the cloud of suspended solids was negligible while its diameter grew to 745.2m. The maximum thickness of the settled material after a single dump was 10.05 mm and was recorded directly beneath the point of dumping.

- Although a large percentage of the dumped material was transported outside of the study area prior to settling under maximum velocity conditions, the rate of settlement was very low resulting in maximum deposition of silt 0.03mm thick (which corresponds to an annual figure of 2mm, which is insignificant). It is very likely that the majority of sediment will be dispersed over an extremely large area and that some of it will remain in suspension until it is washed out to sea. The quantities of silt which do settle are deemed to be small enough not to have a negative impact on water depths or flora and fauna.

- For minimum velocity conditions, 17.7% of the silt remained in suspension at the end of the simulation. Again, a maximum thickness of 0.03mm of sediment was observed to be deposited at this stage of the simulation, indicating that the deposition rate was very low. As the velocity increases (with variation in the tides) it is expected that the silt in suspension will be well dispersed and settle out gradually without negative effects for water depths or flora and fauna.

- The maximum thickness of settled material was found to be significantly smaller when the dredged material was dumped under maximum velocity conditions as opposed to minimum velocity conditions.

- The estimated annual deposition of material at the proposed dump site under maximum and minimum velocity conditions is 0.411m and 0.715m, respectively.

- The deposition of 0.4m of material on top of a biologically active seabed will smother and destroy any benthic epi/infauna at the dump site. However, due to the fact that samples collected at the site returned very low numbers of benthic invertebrates, the ecological impact of the disposal of dredge material will be low. Re-colonisation of the freshly deposited sediments will occur quite quickly as there are extensive areas of seabed in the vicinity of the site which are colonised by the same types of species.

- The dumping exercise will increase turbidity levels in the River Shannon. However, given the overall naturally high levels of suspended solids throughout the estuary and the limited zone of measurable impact (circa 500m downstream of the dump site), it is unlikely that the additional turbidity resulting from the dredge disposal operations will have a significant negative impact on the biological communities in the water column.

- The proposed dredging and disposal activities at Foynes will not significantly negatively impact the status of the proposed Special Area of Conservation (pSAC), west of Money Point.

6.3 Recommendations

- Since the proposed dredging operations will require the re-use of the disposal site, it is necessary to vary the dump location within the dump site area in order to ensure localised accumulations on the estuary bed are kept to a minimum. If this is adhered to then the likely maximum thickness of deposited material at proposed the site following the disposal of a year's worth of dredging operations is 411mm.

- It may be concluded, that careful management of the proposed dredge disposal operations within the Shannon Estuary will be extremely important in minimising the adverse effects of the dumping on both the hydrodynamic regimes and the flora and fauna within the proposed dump sites and their surrounding vicinities.

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Attachment F.1

Sub-Section 3

Impact Assessment Studies

Environmental Survey and Sediment Transport Model for a Proposed Dump Site in Shannon Estuary (Aqua-Fact International Services Ltd)

ENVIRONMENTAL SURVEY
AND SEDIMENT TRANSPORT MODEL
FOR A PROPOSED DUMP SITE IN SHANNON ESTUARY

SEPTEMBER 2005

REPORT TO

SHANNON FOYNES PORT COMPANY

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TABLE OF CONTENTS

1. General Introduction

Aqua-Fact International services Ltd. were commissioned by Shannon Foynes Port Company to:

a) carry out an environmental assessment of a proposed dumpsite in the upper reaches of the Shannon Estuary prior to material being deposited there, and
b) develop a computer based model to simulate the fate of the disposal material on the dump ground.

The approaches to Limerick Dock and the Dock itself require maintenance dredging to maintain the necessary depth for ship traffic. It is proposed to deposit the material from this dredging exercise at a potential dump site in Shannon Estuary, close to Mellon Point (see Figure 1.1). The purpose of this study is firstly describe the environmental condition of the proposed dump site prior to any dumping exercise and secondly, model the transport and deposition of the disposed material in order to assess its impact on water quality and the sea bed in the area surrounding the disposal site.

The results from these studies are presented in two parts in the following report. Part one deals with the environmental assessment of the site in terms of its floral and fauna composition and the importance of the site in terms of defining the ecological habitat of this area. The second part describes the process in constructing the model and presents the results of the model output, which predicts the fate of the disposed material.

The Shannon and Fergus Estuaries form the largest estuarine complex in Ireland. They form a unit stretching from the upper tidal limits of the Shannon and Fergus Rivers to the mouth of the Shannon estuary (considered to be a line across the narrow strait between Kilcredaun Point and Kilconly Point). Within this main unit there are several tributaries with their own sub-estuaries e.g. the Deel River, Mulkear River, and Maigue River. To the west of Foynes, a number of small estuaries form indentations in the predominantly hard coastline, namely Poulnasherry Bay, Ballylongford Bay, Clonderalaw Bay and the Feale or Cashen River Estuary.

The estuarine complex is a candidate SAC selected for lagoons and alluvial wet woodlands, both habitats listed on Annex I of the E.U. Habitats Directive. The site is also selected for floating river vegetation, *Molinia* meadows, estuaries, tidal mudflats, Atlantic salt meadows, Mediterranean salt meadows, *Salicornia* mudflats, sand banks, perennial vegetation of stony banks, sea cliffs, reefs and large shallow inlets and bays all habitats listed on Annex I of the E.U. Habitats Directive. The site is also selected for the following species listed on Annex II of the same directive; Bottle-nosed Dolphin, Sea Lamprey, River Lamprey, Brook Lamprey, Freshwater Pearl Mussel, Atlantic Salmon and Otter.

A site synopsis of this SAC is included as Appendix I.

Part 1 Environmental Assessment of the Proposed Dumpsite

1 Introduction and Methodology

The proposed dumpsite is located south of Sod Island in the upper reaches of Shannon Estuary (Figure 1.1). The site co-ordinates are as follows:

A 52º 40.67' N 08º 51.14' W
B 52º 40.72' N 08º 50.69' W
C 52º 40.57' N 08º 51.11' W
D 52º 40.62' N 08º 50.66' W

An environmental survey was carried out at the site on 12th September 2005. This survey consisted of direct observations, with photographic records, by experienced scientific divers of bottom conditions within the proposed area of the site. The purpose of this survey was to document both the nature of the seabed and bottom conditions at the proposed dumpsite.

In addition, 3 replicate grab samples were taken at 3 locations within the site and retrieved for macrofaunal analysis (see Figure 1.2. for station locations). These benthic samples were taken by means of a small (0.025m^2) stainless steel Van Veen grab and fixed in formalin. On return to the laboratory, the samples were washed trough a 1mm diameter sieve and then backwashed into a sorting tray. The samples were individually sorted under a binocular microscope and fauna encountered were separated according to phyla (i.e. Annelida, Crustacea, Mollusca and other phyla). The fauna returned were later identified to species level using available taxonomic identification keys.

A fourth grab was taken at each of the stations and returned for graunlometric analysis.

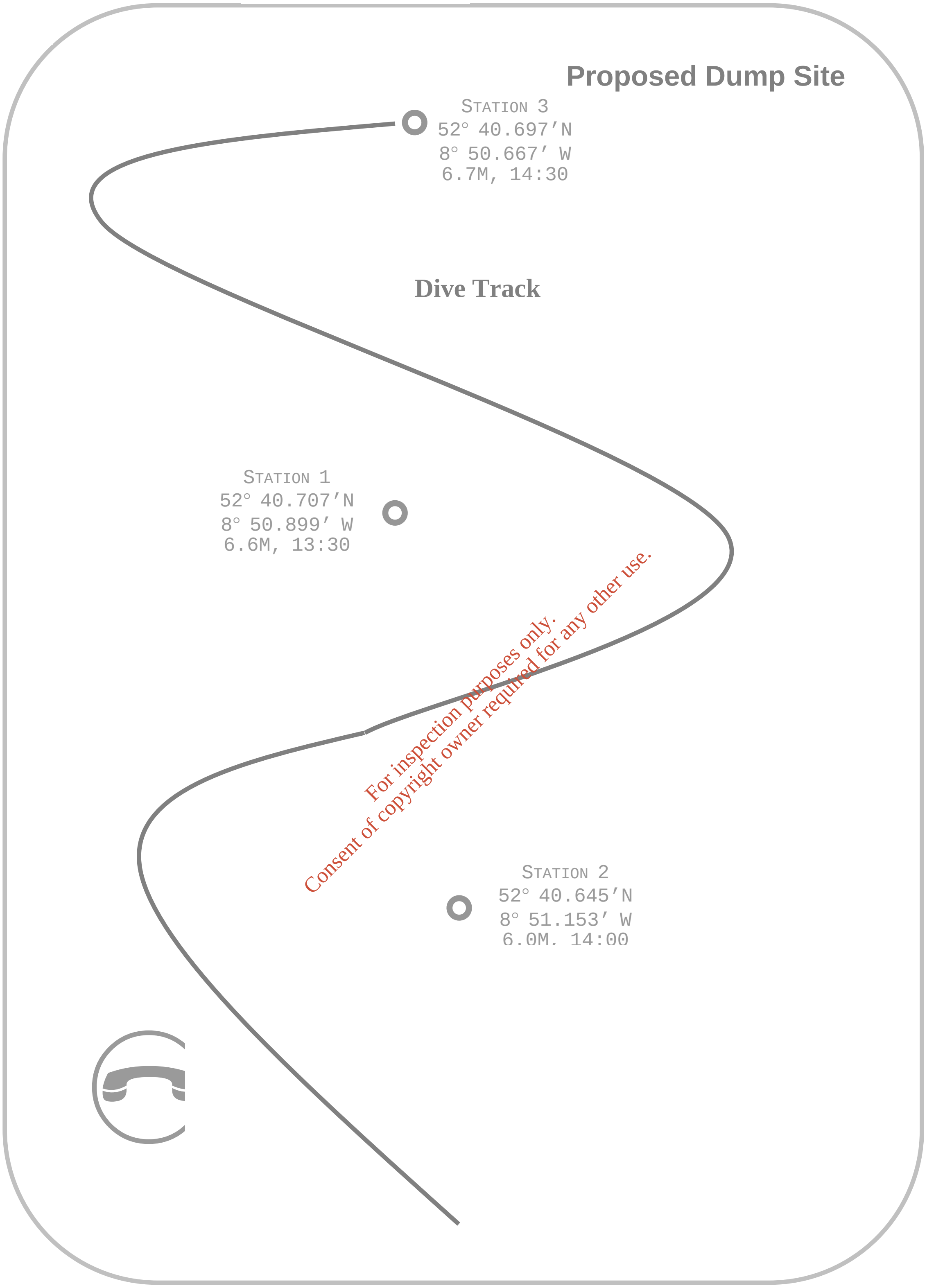

Figure 1.2: Dive survey track at the proposed dump site, Shannon Estuary, 12th September 2005.

2. Results

2.1. Dive Survey

The dive survey began at the eastern side of the proposed dump site and continued in a zigzag fashion along the length of the site (see Figure 1.2). The dive was timed to coincide with high water when current velocity was at a minimum. Turbidity levels were high in the water column, which negated photograph records.

The dive survey was conducted at a depth of between 6-7 m on a relatively flat seabed composed predominantly of fine sand sediment. No reefs or rocky outcrops were encountered during the dive with the seabed surface formed into small sand waves by the action of the current. No macrofauna or algae were encountered during the survey.

2.2. Grab Survey

2.2.1 Faunal Samples

Observations were made once the samples were taken aboard the boat. The sediment type at all the stations was described as reduced muddy sand with a surface layer of ca.1cm of oxidised medium sand. No smell of hydrogen sulphide was noted from the samples.

Biological analyses of the samples returned 12 taxa represented by 1 nematode, 5 polychaetes, 3 crustaceans and 3 bivalves as detailed in Table 2.1. No decapods or echinoderms were recorded. No rare or unusual species were recorded and the area sampled can be described as species-poor.

Species	Station								
	1A	1B	1C	2A	2B	2C	3A	3B	3C
NEMATODA									
Nematoda sp.									1
ANNELIDA									
POLYCHAETA									
PHYLLODOCIDA									
Nephtyidae									
Nephtys sp.									1
SPIONIDA									
Spionidae									
Streblospio shrubsolii	1	2	1	7	12		9	3	
Cirratulidae									
Caulleriella zetlandica								1	
CAPITELLIDA									
Capitellidae									
Capitella capitata		4					1		
Arenicolidae									
Arenicola marina							2	1	
CRUSTACEA									
MYSIDACEA									
Mysidae									
Mesopodopsis slabberi						2			
AMPHIPODA									
Pontoporeiidae									
Bathyporeia pilosa	1	1	2			1			
Corophiidae									
Corophium arenarium	1		1						
MOLLUSCA									
BIVALVIA									
CARDIACEA									
Cardiidae									
Cerastoderma glaucum				1			2		1
MACTRACEA									
Mactridae									
Spisula solida					2				
MYACEA									
Myidae									
Mya arenaria								1	

Table 2.1. The macrofauna recorded from the grab samples, Shannon Estuary.

2.2.2 Sediment Samples

The results of the particle size analysis on the sediment samples collected at each of the stations (see Figure 1.2) within the proposed dump site are presented in Table 2.2. These results reveal that the granulometric composition of the seafloor is varied ranging from a clean medium-fine sand in the centre of the box to muddier sediment on either end with sediments on the eastern side of the box having predominantly a muddy fine sand composition.

St	Gravel	Sand					Silt/Clay
		V.Coarse	Coarse	Medium	Fine	V. Fine	
	>2mm	0.85-2mm	0.5-0.85mm	0.25-0.5mm	0125-0.25mm	0.063-0.125mm	<0.63mm
1	-	-	0.06	36.14	59.50	1.78	2.28
2	-	-	0.30	20.50	54.22	5.69	19.53
3	-	-	-	0.99	33.03	28.29	37.69

Table 2.2. Results of the particle size analysis on the sediment samples collected at the proposed dump site, Shannon Estuary, 12th September 2005.

3. Discussion

The proposed dumpsite is located in an area of the Shannon Estuary whose bottom features are neither unique nor critical to the overall habitat classification of this part of the estuary. Invertebrate species recorded such *as Streblospio shrubsolii*, *Bathyporeia pilosa* and *Cerastoderma glaucum* are common inhabitants of brackish waters in sheltered bays and estuaries such as the Shannon Estuary. The presence of polychaetes from the family Capitellidae such as *Capitella capitata* is a good indicator of organic enrichment and is tolerant of oxygen-stressed conditions.

According to Connor et al. (1997) the most suitable classification for this habitat type is estuarine sublittoral muds (IMU.EstMu). These are shallow sublittoral muds, extending from the extreme lower shore to about 15m depth in estuarine conditions. Characterising species for this type of habitat such as *Streblospio shrubsolii* and *Capitella capitata* were recorded.

PART 2 SEDIMENT TRANSPORT MODEL FOR THE PROPOSED DREDGE DISPOSAL SITE IN THE SHANNON ESTUARY

1. Introduction

The purpose of this section of the study was to model the transport and deposition of the disposed material in order to assess its impact on water quality and the estuary bed in the area surrounding the disposal site. This was achieved with the use of the U.S. Army Corps of Engineers' Open Water Disposal Model (STFATE) (1995) which accounts for the physical processes determining the short-term fate of the dredged material disposed at water sites. The model provides estimates of water column concentrations of suspended sediment and the initial deposition of material on the estuary bed.

All the relevant environmental and hydrodynamic data required as input to the model are described in Chapter 2. The theory, development and application of the model to analyse the short-term fate of the disposed material at the dump site is detailed in Chapter 3. Chapters 4 and 5 present and discuss the results and conclusions obtained from the model simulations.

2. Model Data Input

2.1 Disposal Site

In order to maintain the channel approaching Limerick Dock free of sediment build up, it is necessary to periodically carry out dredging operations. Table 2.1 details the estimated maximum amount of material which is required to be removed to maintain Chart Datum at the approach to and within Limerick Dock (Shannon Estuary Ports).

Location	Material	Quantity
Approach Channel	**Silt/Sand**	120,000 m^3
Limerick Dock	**Silt/Sand/Gravel**	6,000 m^3

Table 2.1: Details of proposed dredging operation.

The bathymetric profile at the proposed dump site was taken from the Admiralty Chart shown in Figure 2.1. The boundary of the dump site is highlighted in yellow. The coordinates of the site are A (52° 40.67' N and 8° 51.14' W), B (52° 40.72' N and 8° 50.69' W), C (52° 40.57' N and 8° 51.11' W), D (52° 40.62' N and 8° 50.66' W). The study area modelled using STFATE and measuring 2100m x 750m is also indicated in the diagram. A three dimensional plot of the bathymetry of the study area is shown in figure 2.2.

The STFATE model can only be run using a flat bed surface or one with a constant slope. Therefore, an average water depth was calculated for the extent of the study area. This figure was then used in model simulations.

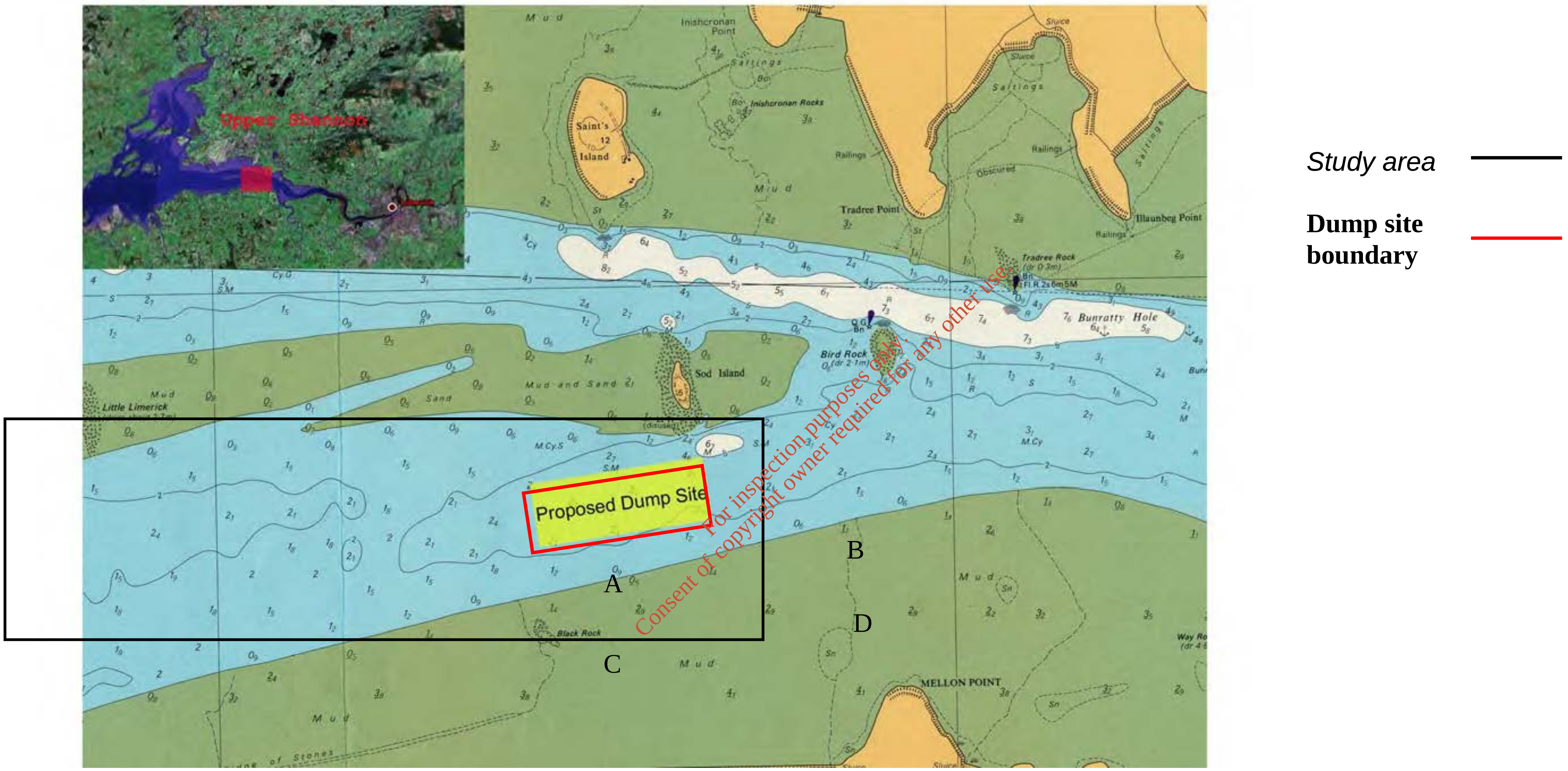

Figure 2.1 Admiralty Chart of section of Shannon estuary illustrating proposed dump site and study area modelled using STFATE

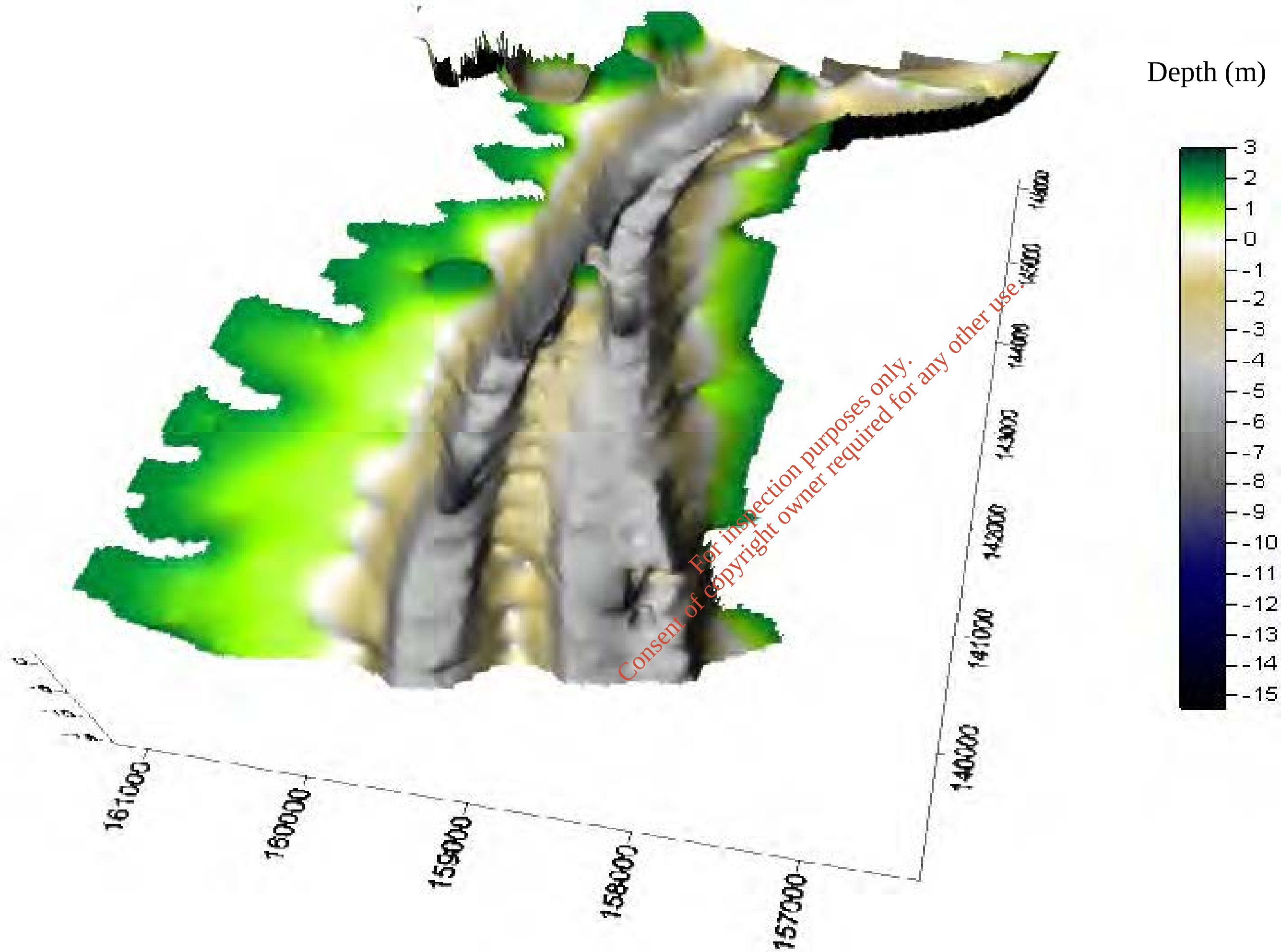

Figure 2.2- 3D bathymetric plot of section of Shannon estuary containing the dump site and study area modelled using STFATE

2.2 Hydrodynamic Data

In studies investigating the impact of the disposal of dredged material there are two important considerations to take into account:

a) Whether the dredged material will be transported outside the boundary of the disposal site by the prevailing currents, which is most likely to occur when the currents are at a maximum.
b) Whether the build-up of dredged material on the sea bottom will significantly reduce the depth of water at the disposal site, which is most likely to occur when the currents are at a minimum.

With these considerations in mind, it was decided to analyse the disposal of the dredged material using two different hydrodynamic regimes, namely the maximum current velocity and minimum current velocity at each of the sites.

The current velocity data at the dump site were obtained from the Shannon Estuary Hydrodynamic Model which is already in existence and is owned by Shannon Estuary Ports. The model was executed and the current velocities and directions were computed and output at the proposed dump site for both spring and neap tidal conditions. From these plots of current velocity, the maximum and minimum velocities were then calculated. The current data for spring tidal conditions were used in the model as current velocities reach their maximum during a spring tide. The current data input to the STFATE model are presented in Table 2.2.

Analysis	Description	Current Speed (m/s)	Current Direction (degrees from N)
1	Maximum Velocity	0.35	265.000
2	Minimum Velocity	0.01	0.000

Table 2.2: Current data used in STFATE model simulations.

2.3 Dredged Material Data

Information on the properties of the dredged material to be disposed of was obtained from site investigations carried out at the Wet Dock in Limerick and at the approach channel to Limerick dock. Shannon Foynes Port Company requested Enterprise Ireland's Shannon Laboratory to collect sediment samples from these locations and have them analysed for a range of specific parameters. In total, three samples were taken from both locations. Analyses showed that the dredged material is composed of a mixture of sand and silt and gravel. The properties of this material are shown in table 2.3.

INSIDE DOCK	Site 1	Site 2	Site 3	Average	CHANNEL	Site 1	Site 2	Site 3	Average
% solids w/w	28.7	29.9	29.4	29.33	% solids w/w	42.2	36.8	46	41.67
% moisture w/w	71.3	70.1	70.6	70.67	% moisture w/w	57.8	63.2	54	58.33
>2mm	0	21.87	28.8	16.89	>2mm	0	0	0	0.00
2mm - 63um	9.43	6.25	1.24	5.64	2mm - 63um	4.88	10.18	15.48	10.18
<63um	90.57	71.88	69.96	77.47	<63um	95.12	89.82	84.52	89.82

Table 2.3: Physical parameters of sediment samples.

Considering that a far greater quantity of dredged material comes from the approach channel than from inside the dock, the properties of the material, as specified to the model, are presented in Table 2.4.

Location	*Type*	Spec. Gravity [mg/m^3]	Volumetric Conc.	Fall Vel. [m/s]	Deposited Void Ratio	Character
Sod Island	Sand	2.70	0.0412	3.05x10^{-2}	0.6	Noncohesive
	Silt	2.65	0.3672	3.05x10^{-3}	4.5	Cohesive
	Gravel	2.70	0.0024	3.05x10^{-1}	99	Noncohesive

Table 2.4: Properties of dredged material input to model.

2.4 Disposal Operation Data

The disposal of dredged material will take place from a grab dredger with bottom opening doors for disposal. Although the dumping operation is considered to be instantaneous, it is assumed that the time to completely empty the dredging vessel will be approximately 3 ½ minutes. The input data specified to the model regarding the disposal operation are presented in Table 2.5 (Shannon Estuary Ports, 2000).

Disposal Operation Detail	Value Input to Model
Mass of dredged material held in vessel ⇒ Volume of material	450 tonnes 234.3 m^3
Vessel length and width	43.6 x 9.9 m
Pre-disposal draft of vessel	3.2 m
Post-disposal draft of vessel	2.9 m
Angle of discharge	Vertical
Time to empty vessel	210 s
Vessel velocity	Stopped

Table 2.5: Details of dredging operation data input to the model.

CHAPTER 3

MODEL THEORY AND DEVELOPMENT

3.1 Introduction

The objective of this study is to determine the impacts on the water column and the seabed of the disposal of dredged material at the proposed dump site. The initial phase of deposition of dredged material follows immediately upon release from the disposal vessel. Accurate representation of the initial mixing process of the dredged material is required to determine estimates of water column concentrations of suspended sediment and the initial deposition of the material on the bottom. In order to accurately represent the physics of the disposal, the mathematical model STFATE was employed to determine the characteristics of the initial mixing phase.

3.2 Theory

In the STFATE model, the behaviour of the material is assumed to be separated into three phases:

1) ***convective descent***, during which the dump cloud or discharge jet falls under the influence of gravity and the initial momentum of the discharge;
2) ***dynamic collapse***, occurring when the descending cloud or jet impacts the bottom or arrives at a level of neutral buoyancy where descent is retarded and horizontal spreading dominates;
3) ***passive transport-diffusion***, commencing when the material transport and spreading are determined more by ambient currents and turbulence than by the dynamics of the disposal operation (U.S. EPA & U.S. Army Corps of Engineers, 1995). Figure 3.1 illustrates these three phases of material behaviour. The passive transport and diffusion phase in the model is handled by allowing the material

settling from the descent and collapse phases to be stored in small Gaussian clouds. These clouds are then diffused and transported at the end of each time step.

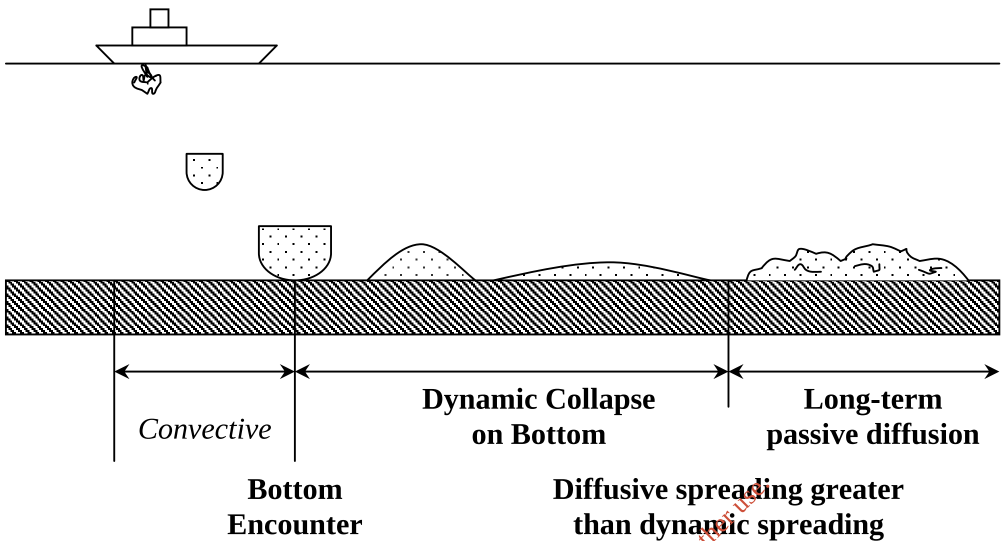

Figure 3.1: The three stages of material behaviour as assumed in STFATE model (U.S. EPA & US Army Corps of Engineers, 1995).

3.3 STFATE Model Development

The study area was declared to the model in the form of a rectangular grid, details of which are given in Table 3.1. Each grid cell was then assigned the average depth that had been calculated for the entire study area. It should be noted that the average depth used in the models was calculated using a water depth at mean water level.

Dump Site	Grid Area [km^2]	Grid Spacing [m]	No. of Rows	No. of Columns	Depth [m]
Sod Island	2.10 x 0.75	60 x 30	25	35	4.2

Table 3.1: Grid size, spacing and depth used in model simulations.

3.4 STFATE Model Analyses

Two different simulations were performed using the velocity conditions listed in Table 2.2. Each simulation predicted the initial deposition of dredged material resulting from a single disposal operation. The simulation time was equal to 1 hour for each model run. A period of 1 hour was chosen for simulations because it was observed that there was very little change in the amount of material settling on the seabed with time after this period had elapsed. The execution time step used during the model runs for the long-term transport-dispersion calculations was 100 seconds, which is the minimum timestep allowable in the model.

In each case the current velocities were assumed to be uniform over the entire water depth and were input to the model as depth averaged velocities. The velocities and directions were also assumed to be constant over the whole of the study area and for the full duration of the simulations.

3.5 STFATE Model Results

Results from the STFATE model are presented using the following formats:

1) Graphs showing the development of the plume and its extent during the cloud collapse phase.
2) Graphs showing the extent and movement of the plume of suspended material during the long-term transport-dispersion phase.
3) Three dimensional deposition plots of material on the seabed at the end of the simulation period.

With reference to the graphs presented in the following section, the x-direction corresponds to East-West, the y-direction corresponds to North-South and the z-direction represents water depth. The usual Cartesian convention applies with North and East corresponding to the positive y and x directions, respectively.

CHAPTER 4
MODEL RESULTS AND DISCUSSION

In this chapter, the results of the STFATE model simulations for the two different hydrodynamic regimes are presented and discussed. Results are presented for two of the three physical processes represented in the model and described in Chapter 3 (i.e. cloud collapse and long-term transport-diffusion). The depth was too shallow for the model to calculate convective descent results so this stage of the process was bypassed. A discussion of the results is presented in Chapter 5.

4.1 Results

Cloud Collapse Results:

Analysis 1 – Maximum Velocity Condition: The cloud collapse phase terminated 8.22 seconds after dumping. At the end of this phase the plume centroid was 0.036m from the barge in the negative x-direction and 0.0m in the negative y-direction. The plume had a vertical thickness of 0.57 m and a diameter of 40.31 m. Figure 4.1 shows the radial extent and position relative to the barge of the plume as it sinks to the estuary bed.

Analysis 2 – Minimum Velocity Condition: The cloud collapse phase terminated 8.22 seconds after dumping. At the end of this phase, the plume centroid had not moved from the barge in the negative x or y-direction while the cloud had a thickness of 0.57m and a diameter of 40.30m. Figure 4.2 shows the radial extent and position relative to the barge of the plume as it sinks to the estuary bed.

From these results it can be seen that the speed of the ambient current has very little effect on both the downward velocity of the plume and its radius. Similarly, it has a negligible effect on the distance over which the plume will be transported during convective descent and collapse. The reason for this is the shallow water depth.

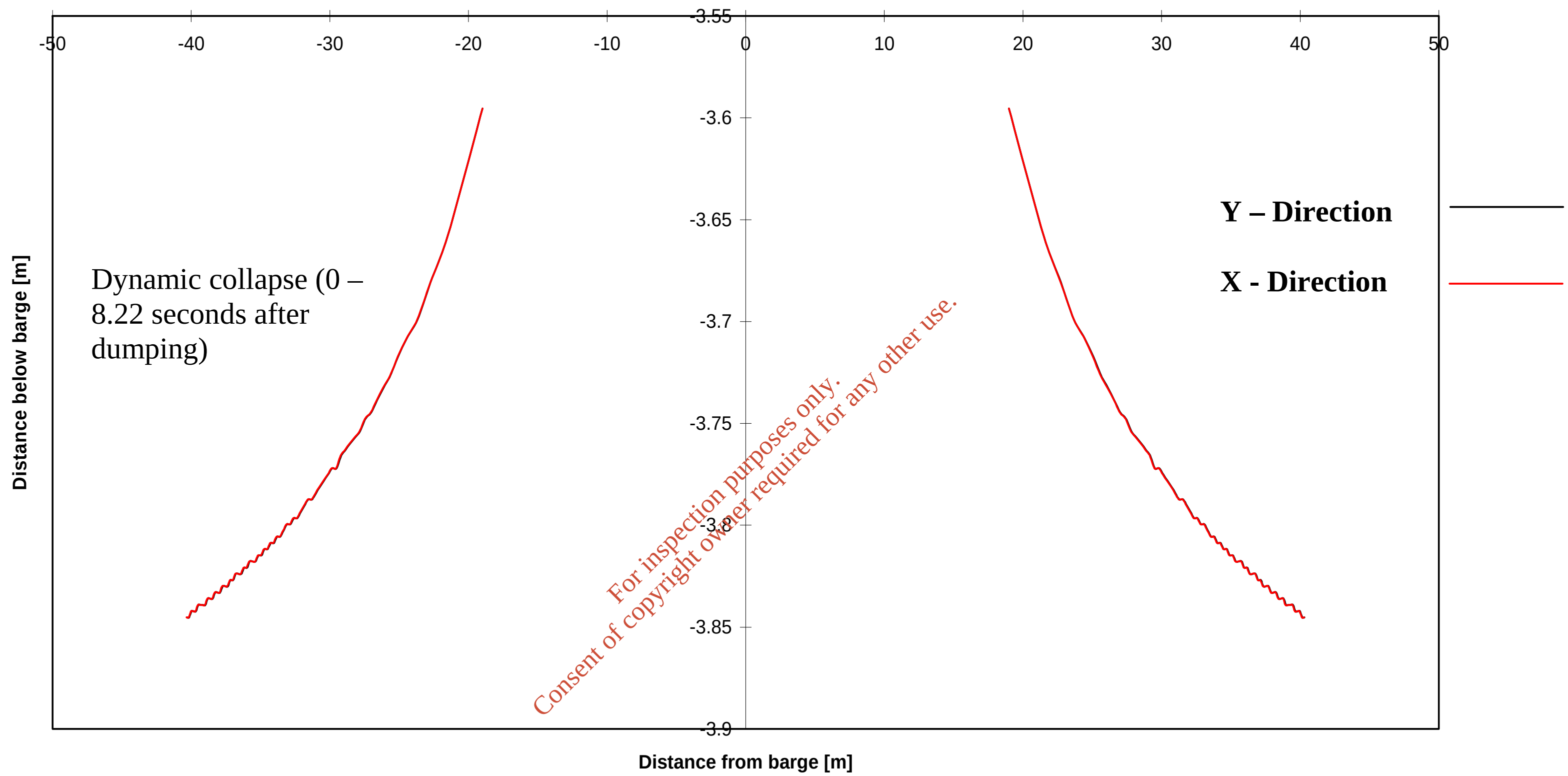

Figure 4.1: Development of plume extent during cloud collapse phase – Analysis 1.

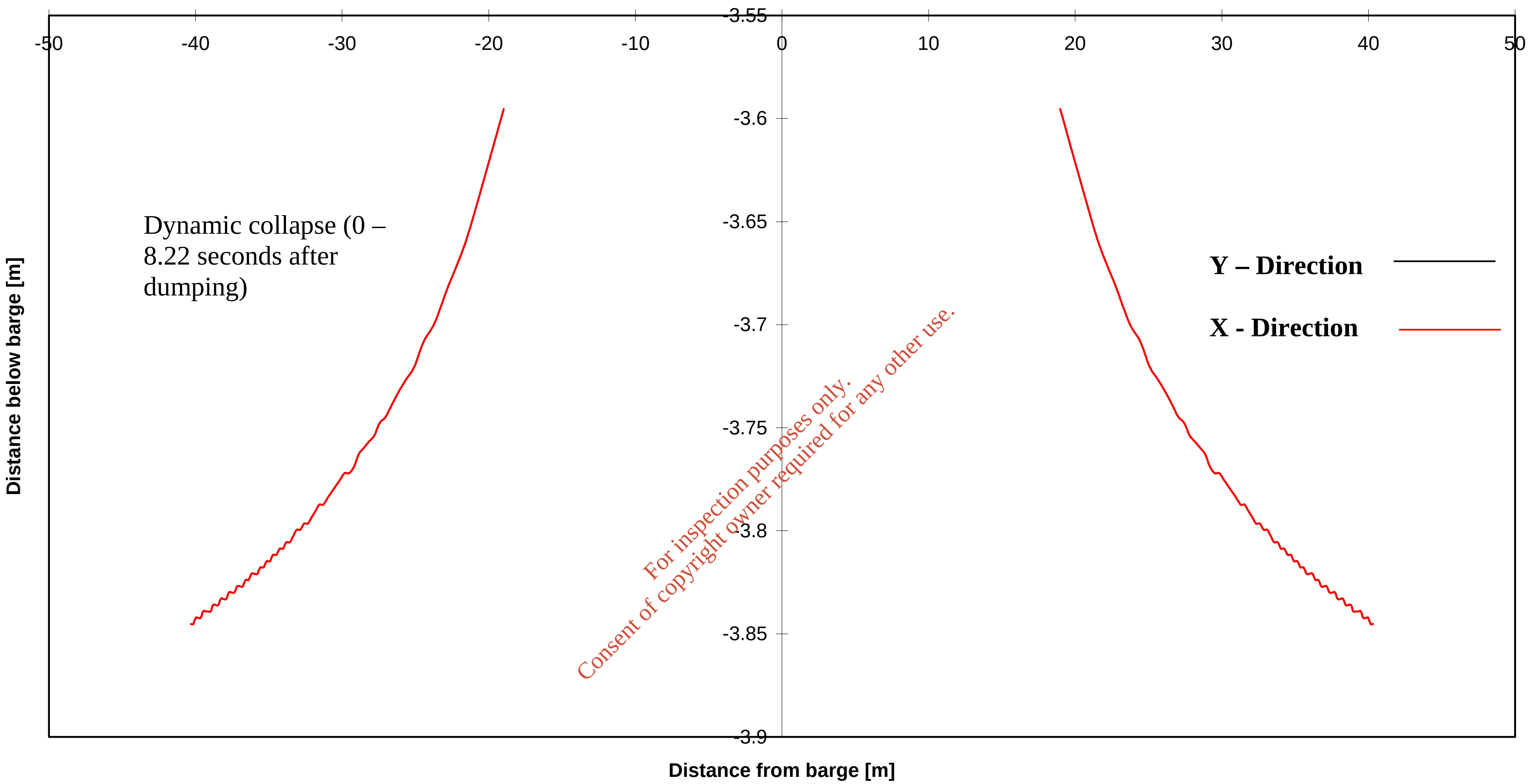

***Figure 4.2: Development of plume extent during cloud collapse phase – Analysis* 2.**

Long-term Transport-Diffusion Results:

Analysis 1 – Maximum Velocity Condition

After 1 hour had elapsed all of the sand had settled to the estuary bed following discharge of the dredged material. With regard to the settling of the silt particles, at the end of the simulation period approximately 64.1 % had settled to the bed leaving 35.9 % still in a suspended state. After the one hour period, almost no change took place in the amount of material which settled to the bottom of the estuary bed indicating that a steady-state like condition had been reached.

Figure 4.3 shows the movement and growth of the discharge plume at the dump site due to the effects of ambient currents and diffusion during the course of the long-term transport-diffusion phase. Upon inspection of the diagram, it can be seen that the ambient current velocity has a significant effect during this phase, transporting the plume approximately 1.3 km from the dump site after 1 hour. The diameter of the plume also increases significantly from 35.77 m (after 8.3 seconds) to 696.8m by the end of the simulation. It should be noted that from 1000 seconds after dumping, onwards, the plume is almost entirely composed of silt particles.

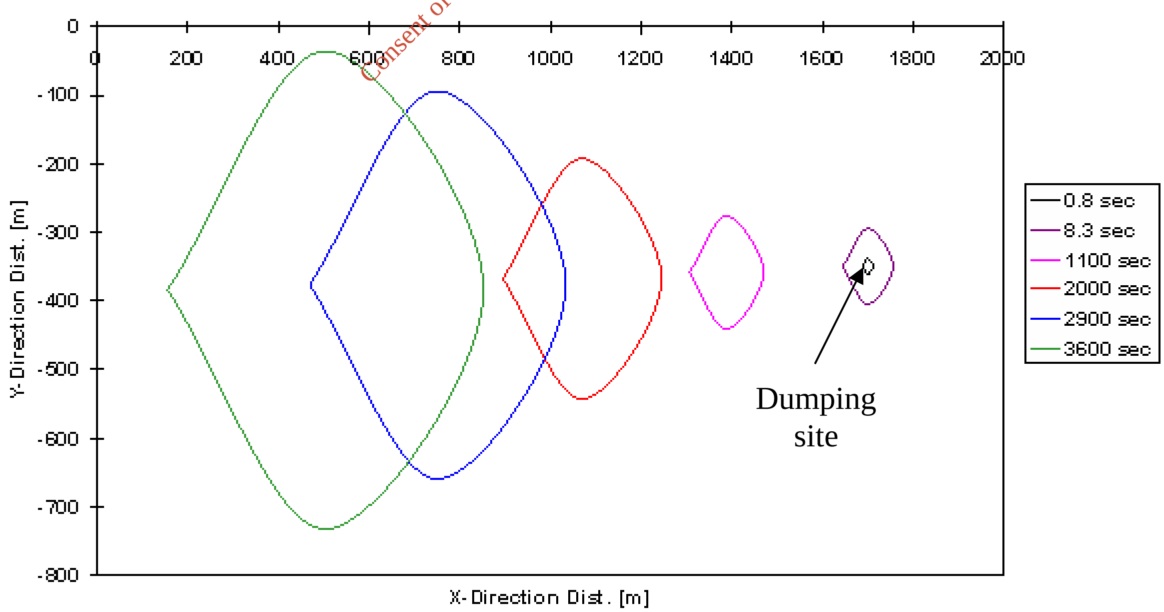

Figure 4.3: Growth of plume during long-term transport-diffusion phase – Analysis 1.

At the end of the model simulation in Analyses 1, a peak thickness of 70.1 mm of deposited material was observed to accumulate over a single grid square under the site of the dumping operation. This 70.1 mm layer covers the entire grid square and is composed of both sand and silt. Figure 4.4 shows a three-dimensional deposition plot of the dumped material on the estuary bed within the study area at the end of the simulation period.

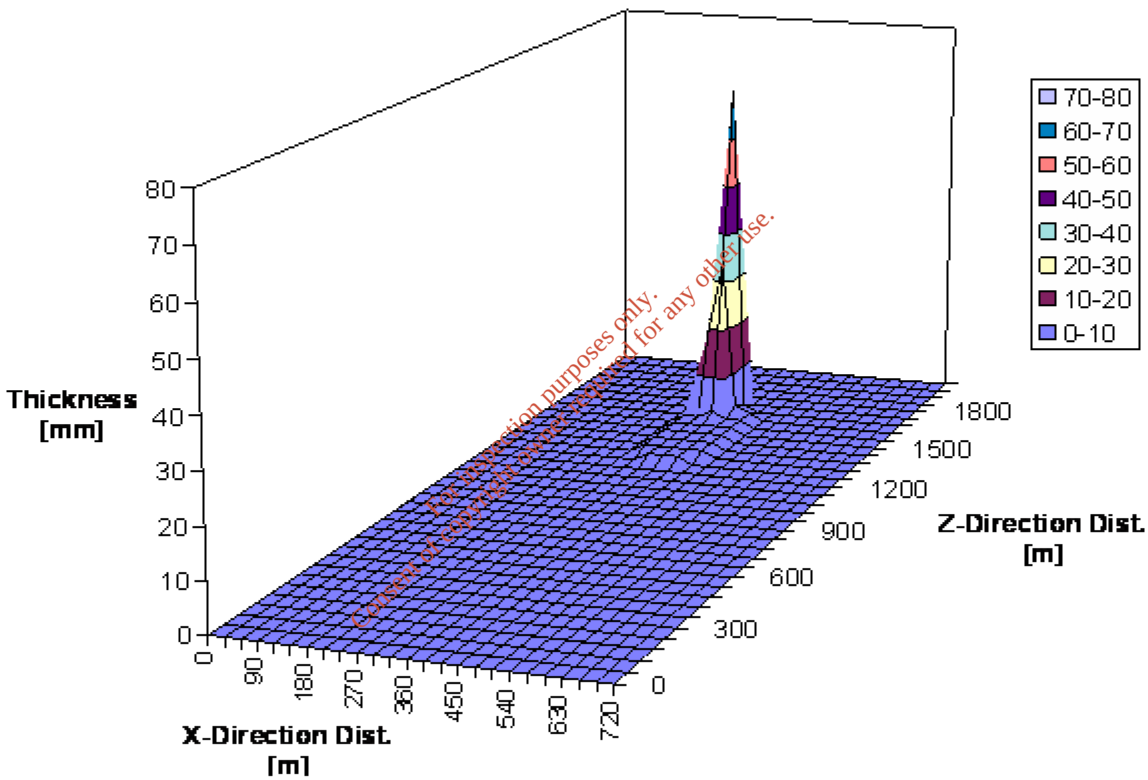

Figure 4.4: Thickness of deposited material on estuary bed at 1 hour – Analysis 1

Analysis 2 – Minimum Velocity Condition

Unlike analysis 1, all of the disposed sand had settled to the bed surface by 500 seconds after dumping. By the end of the simulation, approximately 95.9 % of the silt had also settled to the estuary bed leaving just 4.1 % of the silt still in suspension. Figure 4.5

shows the transport and growth of the plume of suspended material during the course of the transport-diffusion phase. As with analysis 1, almost no change took place in the amount of material which settled to the bottom of the estuary bed after 1 hour. As can be seen from the diagram, the plume did not move very much during this simulation. This was due to the very small current velocity employed in the analysis. However, the extent of the plume did increase by a fairly significant amount during the course of the transport-diffusion phase, growing from an initial diameter of 35.77 (after 8.3 seconds) to a diameter of 696.8m after 1hour.

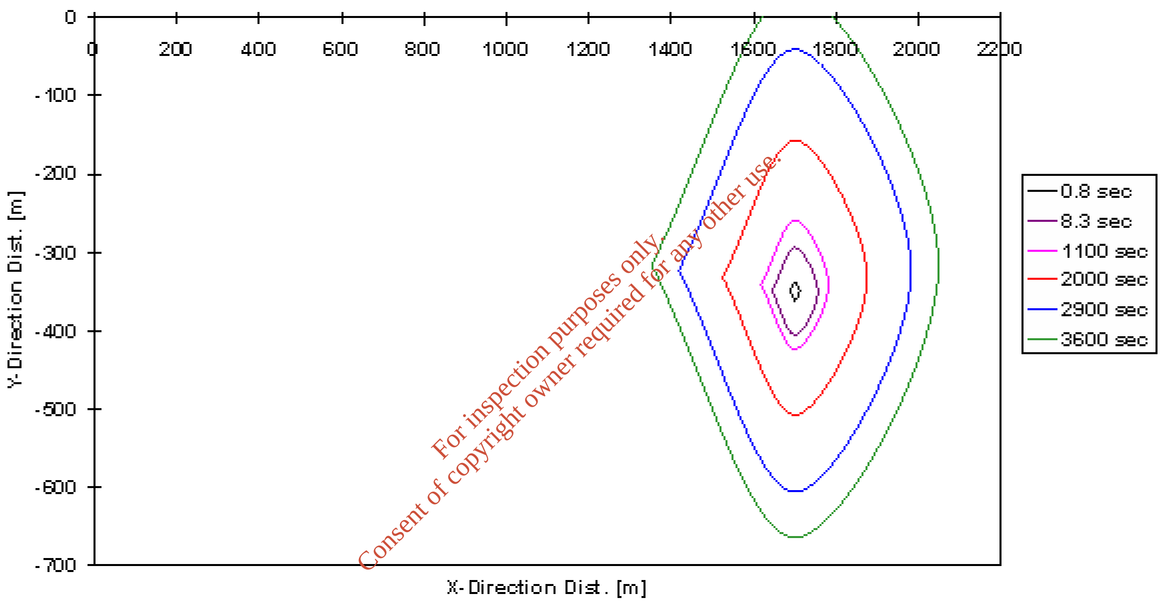

Figure 4.5: Growth of plume during long-term transport-diffusion phase – Analysis 2.

With regard to the deposition of the dredged material, a peak thickness of 158mm of deposited material was observed to accumulate over a single grid square under the site of the dumping operation. As was the case with the previous simulations this 158mm layer covers the entire grid square.

Figure 4.6 gives a three-dimensional graphical representation of the deposited layer of dredged material at the end of the simulation (1 hour). When compared to Analysis 1 it can be seen that the peak thickness of the deposited layer is more than twice as much when the material is dumped under minimum current conditions than when it is dumped under maximum current conditions.

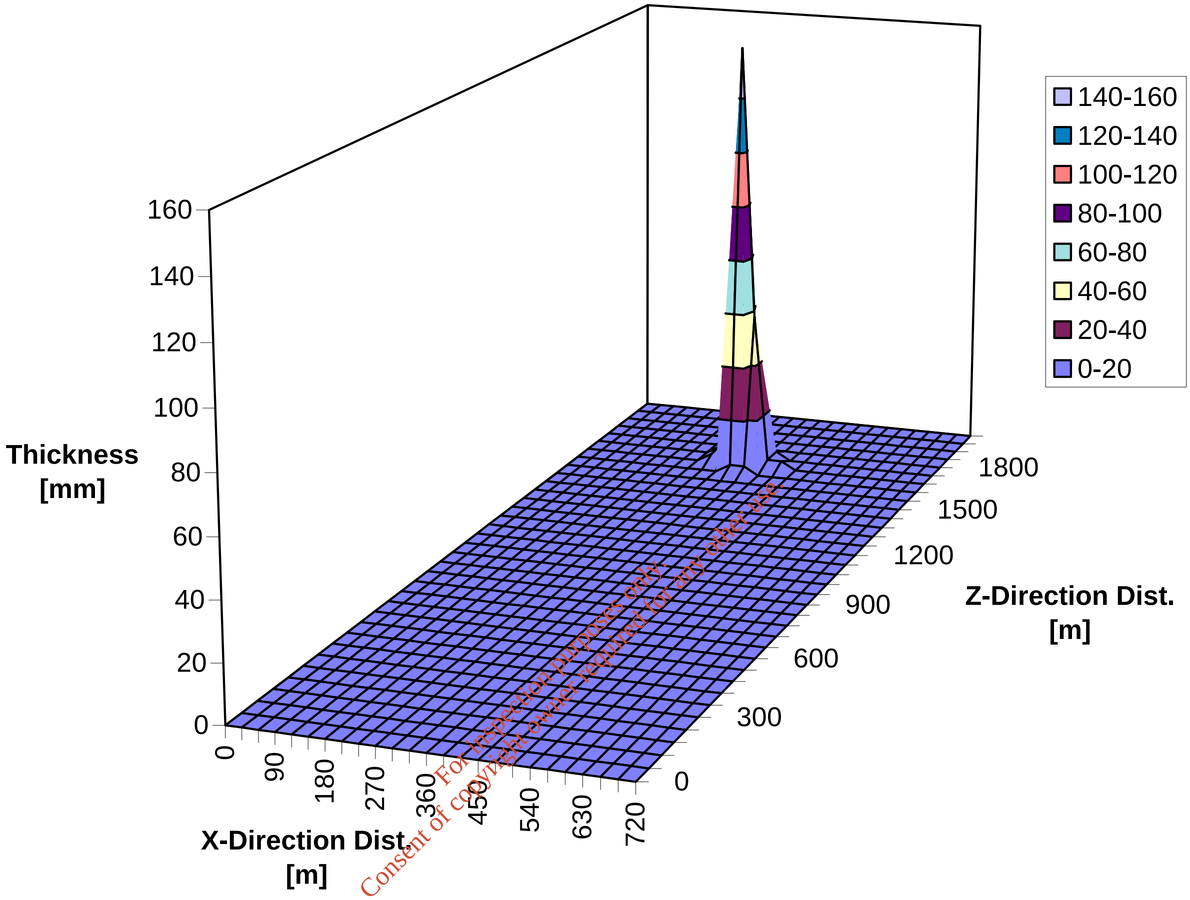

Figure 4.6: Thickness of deposited material on estuary bed at 1 hour – Analysis 2.

CHAPTER 5
DISCUSSION OF RESULTS

The results of the model simulations carried out for the proposed dump site are discussed in this chapter. The results were analysed in such a way as to ascertain the possible impacts of the disposal of dredge material on water quality and the estuary bed in the area surrounding the disposal site. The following sections deal with the effect of current velocities on the transport and deposition of dredge material following its disposal.

5.1 Effects of Current Velocities

From the model results, it can be observed that the peak thickness observed in the simulation carried out under maximum current velocity conditions was lower than that observed under minimum velocity conditions. This is due to the fact that a greater proportion of material is transported away from the dump site prior to reaching the bed surface as a result of the stronger currents. The stronger the current, therefore, the more even the distribution of settled dredged material on the bed surface. For the maximum velocity condition, it was observed that 35.9% of the silt was still in suspension. This implies that a significant quantity of the material will settle far away from the original dump site. However, the rate of silt settlement near the end of the 1 hour period of simulation was extremely low and the maximum thickness which was deposited at this time was 0.05mm per grid square. This suggests that the remaining suspended material will settle out very gradually over a considerable area and some of it may even be transported out to sea. In either case, the sediment will have a negligible impact on the water depth when it does eventually settle. This suggests that the optimum time for disposal is at the time of maximum current speed at the dump site.

5.2 Operational Considerations

The maximum thickness of material accumulated on the bed over a single grid square after a single disposal operation was predicted by the model to be 158 mm, or 0.158 m, for the lowest current velocity condition. The average water depth in this area is approximately 4.2 metres Chart Datum. The size of the dump site is approximately 100,000 m^2 and is, therefore, composed of about 55 grid squares (each grid square measures 60m x 30m). Therefore, depending on the number of dumping operations to be performed, they must be spread over the whole dump site area in such a way as to avoid large localised accumulations of dredged material.

In order to ascertain the effects of the full dredge disposal operation on the dump site and its immediate surroundings, an attempt was made to estimate the likely maximum thickness of deposited material on the estuary bed following the disposal of the total volume of material expected to be dredged.

To calculate the likely maximum deposition at the site the approximate number of equivalent grid cells was calculated for each site based on the area of the site and the area of the grid cells used in the model simulations. The number of dumping operations required at the disposal site was then calculated based on the volume of material dumped during a single operation and the total volume to be dumped. It is assumed that the dumping operations will be spread evenly within the dump site in order to minimise the accumulation of dredge material. Therefore, using the equivalent number of grid cells for each site and the number of disposal operations required, an estimation of the likely maximum thickness of the deposited layer of dredge material was calculated for the disposal site based on the maximum thickness calculated by the model simulations for a single dumping operation. The results of these calculations are summarised in Table 5.1. The calculations were carried out for disposal of the dredge material under maximum and minimum current velocity conditions.

Analysis	Area of Site [m²]	Area of Cell [m²]	Equiv. No. of Cells	Total Volume [m³]	Single Volume [m³]	No. of Dumps	Thickness after 1 Dump [m]	Maximum Thickness [m]
1	100,000	1,800	55	126,000	234	539	0.070	0.688
2	100,000	1,800	55	126,000	234	539	0.158	1.549

Table 5.1: Summary of calculations to estimate the likely maximum thickness of deposited dredge material following disposal of total volume.

From the Table 5.1, it is evident that the likely maximum thickness of the deposited layers are significant, estimated at 688mm and 1.549mm, respectively. It is also apparent that disposal of the dredged material under maximum velocity conditions will result in a significantly smaller accumulation of sediment than that at minimum velocity conditions. Given the relatively shallow water depth in the area these variations in bathymetry would have an impact on the hydrodynamic patterns within the associated regions.

5.3 Recommendations

- Since the proposed dredging operations will require the re-use of the disposal site, it is necessary to vary the dump location within the dump site area in order to ensure localised accumulations on the estuary bed are kept to a minimum. If this is adhered to then the likely maximum thickness of deposited material at proposed the site following the disposal of the maximum worth of dredging operations is approximately 700mm.

Conclusions

Maintenance dredging has been a necessary activity in the Shannon Estuary for many years with the requirement for ships navigated the channels in the estuary to unload their cargos at Limerick. The Shannon River carries large loads of suspended material to the estuary where it is deposited or remains in suspension resulting in high turbidity levels in the water column. McMahon (1988) reports on a turbidity maximum occurring between 14 km and 18 km from Limerick City when investigating suspended matter levels in the Shannon Estuary. From the data collected on suspended matter in the estuary McMahon and Quirke (1989) were able to come to a number of conclusions

a) a turbidity maximum is a regular and recurrent feature of the estuary
b) the geographic location of the maximum is variable but generally coincides with the location of the freshwater/seawater interface which can move up and down the estuary depending on the freshwater discharge and tidal state
c) the intensity of the maximum appears to depend on the tidal state, being greatest at spring tides and lowest at neap tides.

The main physical and biological effects of disposal of the dredge spoil material on the dumpsite, which is contained within a SAC, are

1) smother the biological active seabed with the loss of resident infaunal community
2) increase turbidity levels at both the dredge site and disposal site
3) reduce the natural depth contours in the immediate vicinity of the dump site.

It is probable that each of these impacts will be short lived. As the environmental survey revealed, the proposed dumpsite is species poor and typical of estuarine sublittoral muds. Initially, all fauna buried by the disposed material will be smothered and lost. However, these species are common to the surrounding seabed and once disposal of the material has been completed, the deposited sediments will be re-colonised. Although, the dredging and disposal exercises will increase turbidity levels, similar studies have shown that the measurable impact will be less than 100 m downstream of the operation. These elevated levels will only be present during the physical acts of dumping and dredging and in the context of the overall natural high levels of suspended solids through the estuary, it is unlikely that the additional load will have significant negative impact.

As stated above, the bathymetry at the proposed dump site will change with shallower depths following dumping and an associated alternation in the hydrodynamic patterns within the immediate vicinity of the dumpsite. This is limited to the immediate area of the dumpsite and it is probable that, in time, a natural reduction will occur as currents will erode the material that stands proud of the natural seabed level immediately post dumping.

It may be concluded that careful management of the proposed dredge disposal operations within the Shannon Estuary will be extremely important in minimising the adverse effects of the proposed dredging and dumping and that these exercises will have minimum long term impacts on the SAC.

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Appendix I

Lower River Shannon (002165)

SITE NAME: Lower River Shannon

SITE CODE: 002165

This very large site stretches along the Shannon valley from Killaloe to Loop Head/ Kerry Head, a distance of some 120 km. The site thus encompasses the Shannon, Feale, Mulkear and Fergus Estuaries, the freshwater lower reaches of the River Shannon (between Killaloe and Limerick), the freshwater stretches of much of the Feale and Mulkear catchments and the marine area between Loop Head and Kerry Head. The Shannon and Fergus flow through Carboniferous limestone as far as Foynes, but west of Foynes Namurian shales and flagstones predominate (except at Kerry Head, which is formed from Old Red Sandstone). The eastern sections of the Feale catchment flow through Namurian Rocks and the western stretches through Carboniferous Limestone. The Mulkear flows through Lower Palaeozoic Rocks in the upper reaches before passing through Namurian Rocks, followed by Lower Carboniferous Shales and Carboniferous Limestone. The Mulkear River itself, immediately north of Pallas Green, passes through an area of Rhyolites, Tuffs and Agglomerates. Rivers within the sub-catchment of the Feale include the Galey, Smearlagh, Oolagh, Allaughaun, Owveg, Clydagh, Caher, Breanagh and Glenacarney. Rivers within the sub-catchment of the Mulkear include the Killeenagarriff, Annagh, Newport, the Dead River, the Bilboa, Glashacloonaraveela, Gortnageragh and Cahernahallia.

The site is a candidate SAC selected for lagoons and alluvial wet woodlands, both habitats listed on Annex I of the E.U. Habitats Directive. The site is also selected for floating river vegetation, *Molinia* meadows, estuaries, tidal mudflats, Atlantic salt meadows, Mediterranean salt meadows, *Salicornia* mudflats, sand banks, perennial vegetation of stony banks, sea cliffs, reefs and large shallow inlets and bays all habitats listed on Annex I of the E.U. Habitats Directive. The site is also selected for the following species listed on Annex II of the same directive ? Bottle-nosed Dolphin, Sea Lamprey, River Lamprey, Brook Lamprey, Freshwater Pearl Mussel, Atlantic Salmon and Otter.

The Shannon and Fergus Estuaries form the largest estuarine complex in Ireland. They form a unit stretching from the upper tidal limits of the Shannon and Fergus Rivers to the mouth of the Shannon estuary (considered to be a line across the narrow strait between Kilcredaun Point and Kilconly Point). Within this main unit there are several tributaries with their own ?sub-estuaries? e.g. the Deel River, Mulkear River, and Maigue River. To the west of Foynes, a number of small estuaries form indentations in the predominantly hard coastline, namely Poulnasherry Bay, Ballylongford Bay, Clonderalaw Bay and the Feale or Cashen River Estuary.

Both the Fergus and inner Shannon estuaries feature vast expanses of intertidal mudflats, often fringed with saltmarsh vegetation. The smaller estuaries also feature mudflats, but have their own unique characteristics, e.g. Poulnasherry Bay is stony and unusually rich in species and biotopes. Plant species are typically scarce on the mudflats, although there are some Eel-grass beds (*Zostera* spp.) and patches of green algae (e.g. *Ulva* sp. and *Enteromorpha* sp.). The main macro-invertebrate community, which has been noted from the inner Shannon and Fergus estuaries, is a *Macoma-Scrobicularia-Nereis* community.

In the transition zone between mudflats and saltmarsh, specialised colonisers of mud predominate: swards of Common Cord-grass (*Spartina anglica*) frequently occur in the upper parts of the estuaries. Less common are swards of Glasswort (*Salicornia europaea* agg.). In the innermost parts of the estuaries, the tidal channels or creeks are fringed with species such as Common Reed (*Phragmites australis*) and Club-rushes (*Scirpus maritimus, S. tabernaemontani* and *S. triquetrus*). In addition to the nationally rare Triangular Club-rush (*Scirpus triquetrus*), two scarce species are found in some of these creeks (e.g. Ballinacurra Creek): Lesser Bulrush (*Typha angustifolia*) and Summer Snowflake (*Leucojum aestivum*).

Saltmarsh vegetation frequently fringes the mudflats. Over twenty areas of estuarine saltmarsh have been identified within the site, the most important of which are around the Fergus Estuary and at Ringmoylan Quay. The dominant type of saltmarsh present is Atlantic salt meadow occurring over mud. Characteristic species occurring include Common Saltmarsh Grass (*Puccinellia maritima*), Sea Aster (*Aster tripolium*), Thrift (*Armeria maritima*), Sea-milkwort (*Glaux maritima*), Sea Plantain (*Plantago maritima*), Red Fescue (*Festuca rubra*), Creeping Bent (*Agrostis stolonifera*), Saltmarsh Rush (*Juncus gerardi*), Long-bracted Sedge (*Carex extensa*), Lesser Sea-spurrey (*Spergularia marina*) and Sea Arrowgrass (*Triglochin maritima*). Areas of Mediterranean salt meadows, characterised by clumps of Sea Rush (*Juncus*

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maritimus) occur occasionally. Two scarce species are found on saltmarshes in the vicinity of the Fergus Estuary: a type of robust Saltmarsh-grass (*Puccinellia foucaudii*), sometimes placed within the compass of Common Saltmarsh-grass (*Puccinellia maritima*) and Hard-grass (*Parapholis strigosa*).

Saltmarsh vegetation also occurs around a number of lagoons within the site. The two which have been surveyed as part of a National Inventory of Lagoons are Shannon Airport Lagoon and Clonconeen Pool. Clonconeen Pool (4-5 ha) is a natural sedimentary lagoon impounded by a low cobble barrier. Seawater enters by percolation through the barrier and by overwash. This lagoon represents a type which may be unique to Ireland since the substrate is composed almost entirely of peat. The adjacent shore features one of the best examples of a drowned forest in Ireland. Aquatic vegetation in the lagoon includes typical species such as Beaked Tasselweed (*Ruppia maritima*) and green algae (*Cladophora* sp.). The fauna is not diverse, but is typical of a high salinity lagoon and includes six lagoon specialists (*Hydrobia ventrosa, Cerastoderma glaucum, Lekanesphaera hookeri, Palaemonetes varians, Sigara stagnalis* and *Enochrus bicolor*). In contrast, Shannon Airport Lagoon (2 ha) is an artificial saline lake with an artificial barrier and sluiced outlet. However, it supports two Red Data Book species of Stonewort (*Chara canescens* and *Chara cf. connivens*).

Most of the site west of Kilcredaun Point/Kilconly Point is bounded by high rocky sea cliffs. The cliffs in the outer part of the site are sparsely vegetated with lichens, Red Fescue, Sea Beet (*Beta vulgaris*), Sea Campion (*Silene maritima*), Thrift and Plantains (*Plantago* spp.). A rare endemic Sea Lavender (*Limonium recurvum* subsp. *pseudotranswallinum*) occurs on cliffs near Loop Head. Cliff-top vegetation usually consists of either grassland or maritime heath. The boulder clay cliffs further up the estuary tend to be more densely vegetated, with swards of Red Fescue and species such as Kidney Vetch (*Anthyllis vulneraria*) and Bird?s-foot Trefoil (*Lotus corniculatus*).

The site supports an excellent example of a large shallow inlet and bay. Littoral sediment communities in the mouth of the Shannon Estuary occur in areas that are exposed to wave action and also in areas extremely sheltered from wave action. Characteristically, exposed sediment communities are composed of coarse sand and have a sparse fauna. Species richness increases as conditions become more sheltered. All shores in the site have a zone of sand hoppers at the top and below this each of the shores has different characteristic species giving a range of different shore types in the pcSAC.

The intertidal reefs in the Shannon Estuary are exposed or moderately exposed to wave action and subject to moderate tidal streams. Known sites are steeply sloping and show a good zonation down the shore. Well developed lichen zones and littoral reef communities offering a high species richness in the sublittoral fringe and strong populations of *Paracentrotus lividus* are found. The communities found are tolerant to sand scour and tidal streams. The infralittoral reefs range from sloping platforms with some vertical steps to ridged bedrock with gullies of sand between the ridges to ridged bedrock with boulders or a mixture of cobbles, gravel and sand. Kelp is very common to about 18m. Below this it becomes rare and the community is characterised by coralline crusts and red foliose algae.

Other coastal habitats that occur within the site include the following:

- stony beaches and bedrock shores - these shores support a typical zonation of seaweeds (*Fucus* spp., *Ascophyllum nodosum* and kelps).
- shingle beaches - the more stable areas of shingle support characteristic species such as Sea Beet, Sea Mayweed (*Matricaria maritima*), Sea Campion and Curled Dock (*Rumex crispus*).
- Sandbanks which are slightly covered by sea water at all times ? there is a known occurrence of sand/gravel beds in the area from Kerry Head to Beal Head.
- sand dunes - a small area of sand dunes occurs at Beal Point. The dominant species is Marram Grass (*Ammophila arenaria*).

Flowing into the estuaries are a number of tidal rivers.

Freshwater rivers have been included in the site, most notably the Feale and Mulkear catchments, the Shannon from Killaloe to Limerick (along with some of its tributaries, including a short stretch of the Kilmastulla River), the Fergus up as far as Ennis, and the Cloon River. These systems are very different in character: the Shannon being broad, generally slow-flowing and naturally eutrophic; the Fergus being smaller and alkaline; while the narrow, fast-flowing Cloon is acid in nature. The Feale and Mulkear catchments exhibit all the aspects of a river from source to mouth. Semi-natural habitats, such as wet grassland, wet woodland and marsh occur by the rivers, however, improved grassland is most common.

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One grassland type of particular conservation significance, *Molinia* meadows, occurs in several parts of the site and the examples at Worldsend on the River Shannon are especially noteworthy. Here are found areas of wet meadow dominated by rushes and sedges and supporting a diverse and species-rich vegetation, including such uncommon species as Blue-eyed Grass (*Sisyrinchium bermudiana*) and Pale Sedge (*Carex pallescens*).

Floating river vegetation characterised by species of Water-crowfoot (*Ranunculus* spp.), Pondweeds (*Potamogeton* spp.) and the moss *Fontinalius antipyretica* are present throughout the major river systems within the site. The rivers contain an interesting bryoflora with *Schistidium alpicola* var. *alpicola* recorded from in-stream boulders on the Bilboa, new to county Limerick.

Alluvial woodland occurs on the banks of the Shannon and on islands in the vicinity of the University of Limerick. The woodland is up to 50m wide on the banks and somewhat wider on the largest island. The most prominent woodland type is gallery woodland where White Willow (*Salix alba*) dominates the tree layer with occasional Alder (*Alnus glutinosa*). The shrub layer consists of various willow species with sally (*Salix cinerea* ssp. *oleifolia*) and what appear to be hybrids of *S. alba* x *S. viminalis.* The herbaceous layer consists of tall perennial herbs*.* A fringe of Bulrush (*Typha* sp.) occurs on the riverside of the woodland. On slightly higher ground above the wet woodland and on the raised embankment remnants of mixed oak-ash-alder woodland occur. These are poorly developed and contain numerous exotic species but locally there are signs that it is invading open grassland. Alder is the principal tree species with occasional Oak (*Quercus robur*), Elm (*Ulmus glabra, U. procera*), Hazel (*Corylus avellana*), Hawthorn (*Crataegus monogyna*) and the shrubs Guelder-rose (*Viburnum opulus*) and willows. The ground flora is species-rich.

Woodland is infrequent within the site, however Cahiracon Wood contains a strip of old Oak woodland. Sessile Oak (*Quercus petraea*) forms the canopy, with an understorey of Hazel and Holly (*Ilex aquifolium*). Great Wood-rush (*Luzula sylvatica*) dominates the ground flora. Less common species present include Great Horsetail (*Equisetum telmeteia*) and Pendulous Sedge (*Carex pendula*).

In the low hills to the south of the Slievefelim mountains, the Cahernahallia River cuts a valley through the Upper Silurian rocks. For approximately 2km south of Cappagh Bridge at Knockanavar, the valley sides are wooded. The woodland consists of Birch (*Betula* spp.), Hazel, Oak, Rowan (*Sorbus aucuparia*), some Ash (*Fraxinus excelsior*) and Willow (*Salix* spp.). Most of the valley is not grazed by stock, and as a result the trees are regenerating well. The ground flora feature prominent Greater wood-rush and Bilberry (*Vaccinium myrtillus*) with a typical range of woodland herbs. Where there is more light available, Bracken (*Pteridium aquilinum*) features.

The valley sides of the Bilboa and Gortnageragh Rivers, on higher ground north east of Cappamore, support patches of semi-natural broadleaf woodland dominated by Ash, Hazel, Oak and Birch. There is a good scrub layer with Hawthorn, Willow, Holly and Blackthorn (*Prunus spinosa*) common. The herb layer in these woodlands is often open with a typically rich mixture of woodland herbs and ferns. Moss species diversity is high. The woodlands are ungrazed. The hazel is actively coppiced in places.

There is a small area of actively regenerating cut away raised bog at Ballyrorheen. It is situated approx. 5km north west of Cappamore Co. Limerick. The bog contains some wet areas with good moss (*Sphagnum*) cover. Species of particular interest include the Cranberry (*Vaccinium oxycoccos*) and the White Sedge (*Carex curta*) along with two other regionally rare mosses including *S. fimbriatum*. The site is being invaded by Birch (*Betula pubescens*) scrub woodland. Both commercial forestry and the spread of rhododendron has greatly reduced the overall value of the site.

A number of plant species that are Irish Red Data Book species occur within the site - several are protected under the Flora (Protection) Order, 1999:

- Triangular Club-rush (*Scirpus triquetrus*) - in Ireland this protected species is only found in the Shannon Estuary, where it borders creeks in the inner estuary.
- Opposite-leaved Pondweed (*Groenlandia densa*) - this protected pondweed is found in the Shannon where it passes through Limerick City.
- Meadow Barley (*Hordeum secalinum*) - this protected species is abundant in saltmarshes at Ringmoylan and Mantlehill.
- Hairy Violet (*Viola hirta*) - this protected violet occurs in the Askeaton/Foynes area.
- Golden Dock (*Rumex maritimus*) - noted as occurring in the River Fergus Estuary.

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- Bearded Stonewort (*Chara canescens*) - a brackish water specialist found in Shannon Airport lagoon.
- Convergent Stonewort (*Chara connivens*) - presence in Shannon Airport Lagoon to be confirmed.

Overall, the Shannon and Fergus Estuaries support the largest numbers of wintering waterfowl in Ireland. The highest count in 1995-96 was 51,423 while in 1994-95 it was 62,701. Species listed on Annex I of the E.U. Birds Directive which contributed to these totals include: Great Northern Diver (3; 1994/95), Whooper Swan (201; 1995/96), Pale-bellied Brent Goose (246; 1995/96), Golden Plover (11,067; 1994/95) and Bar-tailed Godwit (476; 1995/96). In the past, three separate flocks of Greenland White-fronted Goose were regularly found but none were seen in 1993/94.

Other wintering waders and wildfowl present include Greylag Goose (216; 1995/96), Shelduck (1,060; 1995/96), Wigeon (5,976; 1995/96); Teal (2,319; 1995-96); Mallard (528; 1995/96), Pintail (45; 1995/96), Shoveler (84; 1995/96), Tufted Duck (272; 1995/96), Scaup (121; 1995/96), Ringed Plover (240; 1995/96), Grey Plover (750; 1995/96), Lapwing (24,581; 1995/96), Knot (800; 1995/96), Dunlin (20,100; 1995/96), Snipe (719, 1995/96), Black-tailed Godwit (1062; 1995/96), Curlew (1504; 1995/96), Redshank (3228; 1995/96), Greenshank (36; 1995/96) and Turnstone (107; 1995/96). A number of wintering gulls are also present, including Black-headed Gull (2,216; 1995/96), Common Gull (366; 1995/96) and Lesser Black-backed Gull (100; 1994/95). This is the most important coastal site in Ireland for a number of the waders including Lapwing, Dunlin, Snipe and Redshank. It also provides an important staging ground for species such as Black-tailed Godwit and Greenshank.

A number of species listed on Annex I of the E.U. Birds Directive breed within the site. These include Peregine Falcon (2-3 pairs), Sandwich Tern (34 pairs on Rat Island, 1995), Common Tern (15 pairs: 2 on Sturamus Island and 13 on Rat Island, 1995), Chough (14-41 pairs, 1992) and Kingfisher. Other breeding birds of note include Kittiwake (690 pairs at Loop Head, 1987) and Guillemot (4010 individuals at Loop Head, 1987)

There is a resident population of Bottle-nosed Dolphin in the Shannon Estuary consisting of at least 56-68 animals (1996). This is the only known resident population of this E.U. Habitats Directive Annex II species in Ireland. Otter, a species also listed on Annex II of this directive, is commonly found on the site.

Five species of fish listed on Annex II of the E.U. Habitats Directive are found within the site. These are Sea Lamprey (*Petromyzon marinus*), Brook Lamprey (*Lampetra planeri*), River Lamprey (*Lampetra fluviatilis*), Twaite Shad (*Allosa fallax fallax*) and Salmon (*Salmo salar*). The three lampreys and Salmon have all been observed spawning in the lower Shannon or its tributaries. The Fergus is important in its lower reaches for spring salmon while the Mulkear catchment excels as a grilse fishery though spring fish are caught on the actual Mulkear River. The Feale is important for both types. Twaite Shad is not thought to spawn within the site. There are few other river systems in Ireland which contain all three species of Lamprey.

Two additional fish of note, listed in the Irish Red Data Book, also occur, namely Smelt (*Osmerus eperlanus*) and Pollan (*Coregonus autumnalis pollan*). Only the former has been observed spawning in the Shannon.

Freshwater Pearl-mussel (*Margaritifera margaritifera*), a species listed on Annex II of the E.U. Habitats Directive, occurs abundantly in parts of the Cloon River.

There is a wide range of landuses within the site. The most common use of the terrestrial parts is grazing by cattle and some areas have been damaged through over-grazing and poaching. Much of the land adjacent to the rivers and estuaries has been improved or reclaimed and is protected by embankments (especially along the Fergus Estuary). Further, reclamation continues to pose a threat as do flood relief works (e.g. dredging of rivers). Gravel extraction poses a major threat on the Feale.

In the past, Cord-grass (*Spartina* sp.) was planted to assist in land reclamation. This has spread widely, and may oust less vigorous colonisers of mud and may also reduce the area of mudflat available to feeding birds.

Domestic and industrial wastes are discharged into the Shannon, but water quality is generally satisfactory - except in the upper estuary, reflecting the sewage load from Limerick City. Analyses for

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trace metals suggest a relatively clean estuary with no influences by industrial discharges apparent. Further industrial development along the Shannon and water polluting operations are potential threats.

Fishing is a main tourist attraction on the Shannon and there are a large number of Angler Associations, some with a number of beats. Fishing stands and styles have been erected in places. The River Feale is a designated Salmonid Water under the E.U. Freshwater Fish Directive. Other uses of the site include commercial angling, oyster farming, boating (including dolphin-watching trips) and shooting. Some of these may pose threats to the birds and dolphins through disturbance. Specific threats to the dolphins include underwater acoustic disturbance, entanglement in fishing gear and collisions with fast moving craft.

This site is of great ecological interest as it contains a high number of habitats and species listed on Annexes I and II of the E.U. Habitats Directive, including the priority habitat lagoon, the only known resident population of Bottle-nosed Dolphin in Ireland and all three Irish lamprey species. A good number of Red Data Book species are also present, perhaps most notably the thriving populations of Triangular Club-rush. A number of species listed on Annex I of the E.U. Birds Directive are also present, either wintering or breeding. Indeed, the Shannon and Fergus Estuaries form the largest estuarine complex in Ireland and support more wintering wildfowl and waders than any other site in the country. Most of the estuarine part of the site has been designated a Special Protection Area (SPA), under the E.U. Birds Directive, primarily to protect the large numbers of migratory birds present in winter.

17.05.2005

Attachment F.1

Sub-Section 4

Impact Assessment Studies

Archaeological Inspection 2016, Wooden Fishtrap Structures, O'Brien's Point, River Shannon, Co. Clare (Donal Boland- Maritime Archaeologist)

Archaeological Inspection 2016, Wooden Fishtrap Structures, O'Brien's Point, River Shannon, Co. Clare.

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Report No: DB 01-07-16

Licence Number: 16D0055

Cover: Wooden Fishtraps, O'Brien's Point,
River Shannon, County Clare.

CONTENTS

1.0 INTRODUCTION

1.1 INTRODUCTION

Shannon Foynes Port Company commissioned *Mr Donal Boland* to conduct an inspection of a Wooden Fishtrap Complex at O'Brien's Point, River Shannon, County Clare. (Figure 1.1).

The Fishtrap complex was first located in 1998
Report: Underwater Inspection of Three Proposed Dump Sites in the Shannon Estuary,
Management for Archaeology Underwater Ltd, 1998

The Fishtrap complex was surveyed in 1999
Report: Archaeological Inspection of Wooden Structures at O'Brien's Point
In the Shannon Estuary, Management for Archaeology Underwater Ltd, 1999.

The Fishtrap complex was re-assessed in 2002
Report: Archaeological Re-Assessment, Wooden Fishtrap Structures, O'Brien's Point,
River Shannon, Co. Clare. BAS 01-09-02

The Fishtrap complex was re-assessed in 2008
Report: Archaeological Inspection, Wooden Fishtrap Structures, O'Brien's Point,
River Shannon,Co. Clare. DB 01-09-08

The Fishtrap complex was re-assessed in 2012
Report: Archaeological Inspection, Wooden Fishtrap Structures, O'Brien's Point,
River Shannon,Co. Clare. DB 01-09-12

Fig 1.1 The location of the fishtrap complex, indicated by the red dot

1.2 THE SITE

The O'Brien's Point fishtrap complex (Fig 1.2) of at least six wooden fences is situated on the north bank of the Shannon estuary, on a gently sloping foreshore of very firm grey, sandy, estuarine silts (52, 40.6829   8, 44.6154). The structures located midway between O'Brien's Point to the east and the mouth of an unnamed creek to the west are well preserved and deeply set. A Late Medieval towerhouse site at Castle Donnel is situated on the drylands to the north-east and a Post Medieval landlord house is found on the drylands to the north.

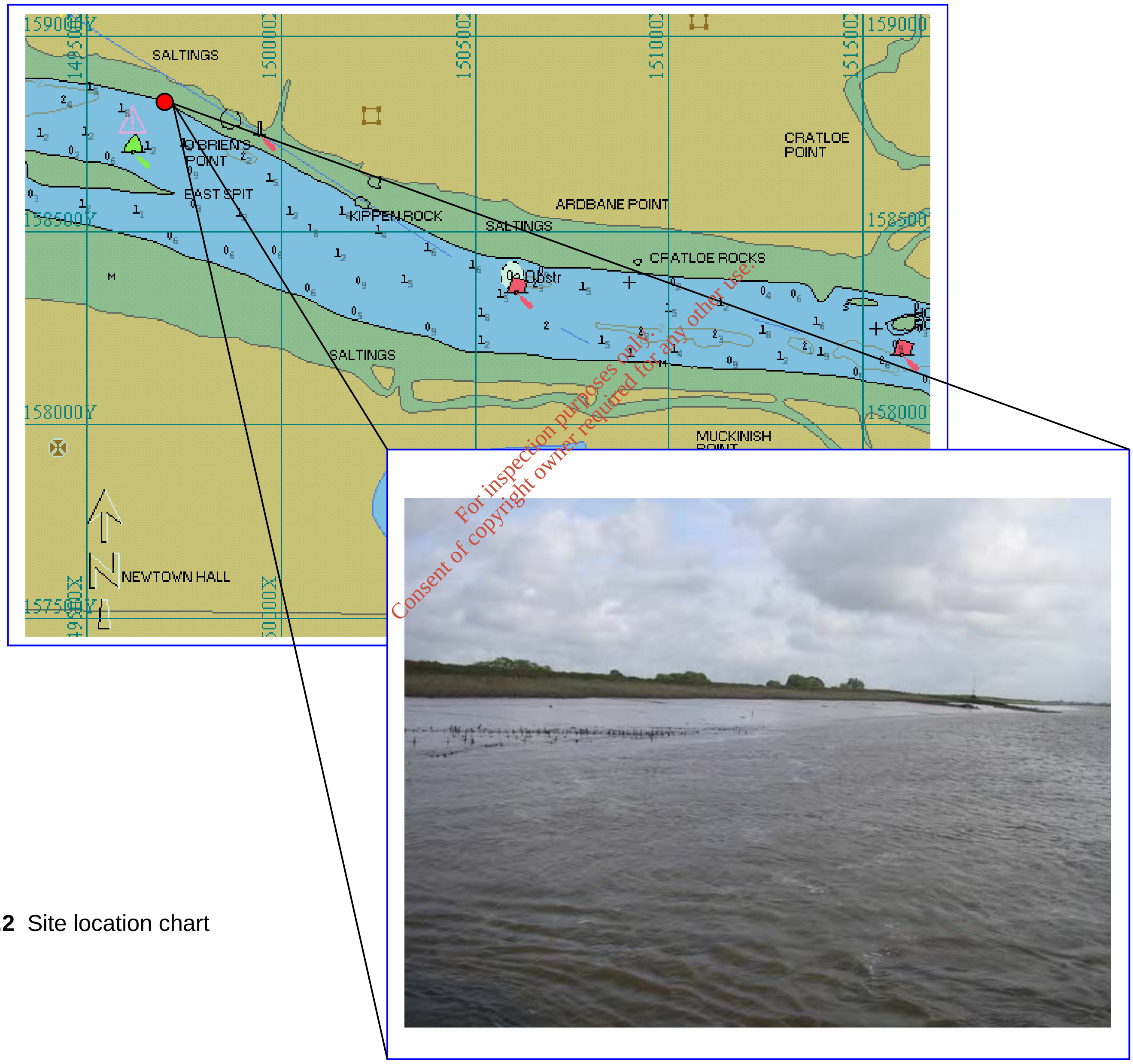

Fig 1.2 Site location chart

1.3 THE DEVELOPMENT

The narrow and shallow nature of the Shannon at and above Limerick coupled with the flushing effect created by the discharge of an upstream power plant creates high sediment transportation rates within the river, which abate causing siltation downstream where the river widens adjacent to Limerick docks.

Maintenance dredging of Limerick docks and its approaches has been conducted on an annual basis since 1955 to control the level of deposited silt and maintain the required depth within the navigation channel.

The Shannon Foynes Port Company has dumped approximately 35,000 tons of transient estuarine silts dredged from Limerick docks and its approaches at the dumpsite located close to the O'Briens Point fishtrap complex during the period 1999 to 2016.

The Shannon Foynes Port Company propose to dredge the berths at Limerick docks and the approaches to the docks during the coming years. It is proposed to dump the material dredged from Limerick at the dumpsite located on the opposite side of the river from the O'Brien's Fishtrap Complex.

The dredging operations will be conducted by the port companies grab/rake dredge and attending dump barges. The dredge is utilised to extract the transient silt material from the bed of the river and deposit it in a bottom opening dump barge. When full the dump barge travels to the dumpsite where the material is deposited in a linear stream along the riverbed.

1.4 HISTORICAL AND ARCHAEOLOGICAL BACKGROUND

In medieval and late medieval times, headweirs were the most common type of fishweir used in Irish coastal and riverine waters. They were constructed of two post and wattle fences or 'wings' which converge to a point in a V -shape. The widest opening of these fences most commonly faced upstream or towards the shore, to funnel fish coming down on the ebbing tide into the 'eye' of the weir. At the 'eye' of the weir, fish were trapped in a 'coghill' net, which was suspended from a raised platform. These nets were conical in shape being long composite mesh bags kept open by means of attachments to the uprights of the wooden platform. More primitive forms of tidal weir (and possibly of early origin) were the 'fish pounds' or I salmon walls' in Doonbeg Bay, Co. Clare and Lough Swilly, Co. Donegal. These were formed of long, low stone walls on the sand flats. They trapped fish moving out to sea on the ebbing tide, whereupon they were taken from the remaining pools by nets.

Headweirs were typically in use in Irish tidal waters until the late nineteenth-century, with the best-known examples at Castlebellingham, Co. Louth, Bunratty, Co. Clare and Buttermilk Castle, Co. Wexford surviving up until the twentieth-century. The Buttermilk castle weir was known to produce large amounts of cod, ling, herring and salmon. However, all tidal head weirs, other than the three mentioned above were abolished by English government legislation after 1863. It was asserted that these weirs were both a hazard to navigation and ruinous to fish stocks.

The second type of Post Medieval fishtrap recorded at O'Brien's Point is the stake-net weir. In the early nineteenth century, this different form of 'fixed engine' began to be used in competition with the earlier headweirs. They were known as stake weirs or Scotch nets because they entailed the use of walls of netting anchored by long stakes to the shore, thus diverting fish into a trap net. They were much more ruthless and efficient than head weirs and quickly replaced them in Irish estuaries and reputedly menaced fish stocks to such an extent, that successive attempts were made to restrict their use by further legislation. The stake-net weirs on the Shannon estuary consist of very lengthy post alignments, which run straight down the foreshore.

Fish weirs were also extremely common in recent times on most Irish rivers, notably the Bann, Erne, Corrib, Boyne, Blackwater, Suir and Shannon rivers. Riverine fishweirs were in contrast placed wholly or partially across the span of a river and worked on the basis of a constant flow of water in one direction. Legislation generally prevented them from being constructed entirely across the river to protect fish stocks. Thus a 'free gap' was left to let some fish move unimpeded past the weir. Depending on the type of weir, salmon and other fish were caught on their way upstream and eels were trapped while migrating downstream in autumn. Like the other weirs, riverine weirs were typically formed of complex post-and-wattle barriers or stone walls with several box-shaped enclosures or 'cribs' situated along its length.

Fish could either be taken from the calm pools within the enclosures or 'coghill' nets were used as traps. Particularly famous were the fisheries at Galway, Athlone and Limerick. The latter was known as the Lax Weir, a name which derives from the Norse word for salmon and suggests its early origin. It is first recorded in twelfth century charters, is thereafter marked on the Down Survey maps and is recorded in the Civil Survey of 1654-6 as a 'greate salmon weare called Lax weare'. Two hundred years later in 1864, it was reported as having fifty-one stone piers, twelve boxes or cribs and a small 'free gap'. Other famous fisheries were the eelweirs at Toome, Co. Antrim, strategically placed to catch mature silver eels moving down the River Bann from Lough Neagh. These weirs consisted of a series of V -shaped wattle lanes or 'skeaghs' which guided the eels into heavy 'coghill' nets, enabling catches of up to one hundred and fifty tons a year.

2. THE SITE SURVEY

2.1 THE SURVEY DESIGN

The site was inspected in July 2016 by way of a non impact visual and photographic survey conducted from the multicat vessel *Shannon 1 and its tender,* provided by the Shannon Foynes Port Company. The results of the inspection were compared to the results of the re-assessment inspection, conducted in 2012 and conclusions drawn (Fig 2.1).

2.2 THE SITE INSPECTION

The foreshore at and surrounding the fishtrap complex located at O'Brien's point was inspected over a period of six hours during a period of low water on a spring tide. The overall topography of the foreshore does not appear to have changed since the date of the initial assessment undertaken in 1999 and or the re-assessment surveys conducted in 2002, 2008 and 2012. The wooden fishtrap structures are intact as originally surveyed and appear to have changed little in the intervening years (Fig 2.2 - 2.24).

A layer of soft estuarine mud continues to overlay firm grey, sandy, estuarine silts on the foreshore. The mud appears to be transient in nature being removed and redeposited by the forces of tide and storm. At the time of this inspection (July 2016) it was noted that the deposit of this soft mud had remained stable.

The inspections conducted in 2008 /12 noted a build up of soft estuarine mud which completely covered a number of the posts along the upper to mid foreshore (fig 2.6) with erosion pits extending only to the depth of the transient mud layer (Fig 2.5).

This inspection revealed no change to the above observation (Fig 2.23/24).

Comparing the results of the photographic record with those of the previous inspection (2012) shows no change in the foreshore area and no discernable change to the fishtrap structures. As we are dealing with archaeology contained within an active intertidal maritime environment some change in sediment cover is normal and will increase or decrease depending on tidal and / or storm forces.

Based on the results of this and the previous inspections the writer concludes that the dredging and / or dumping operations being conducted by the Shannon Foynes Port Company is not having any adverse affect on the fishtrap complex situated at O'Brien's Point.

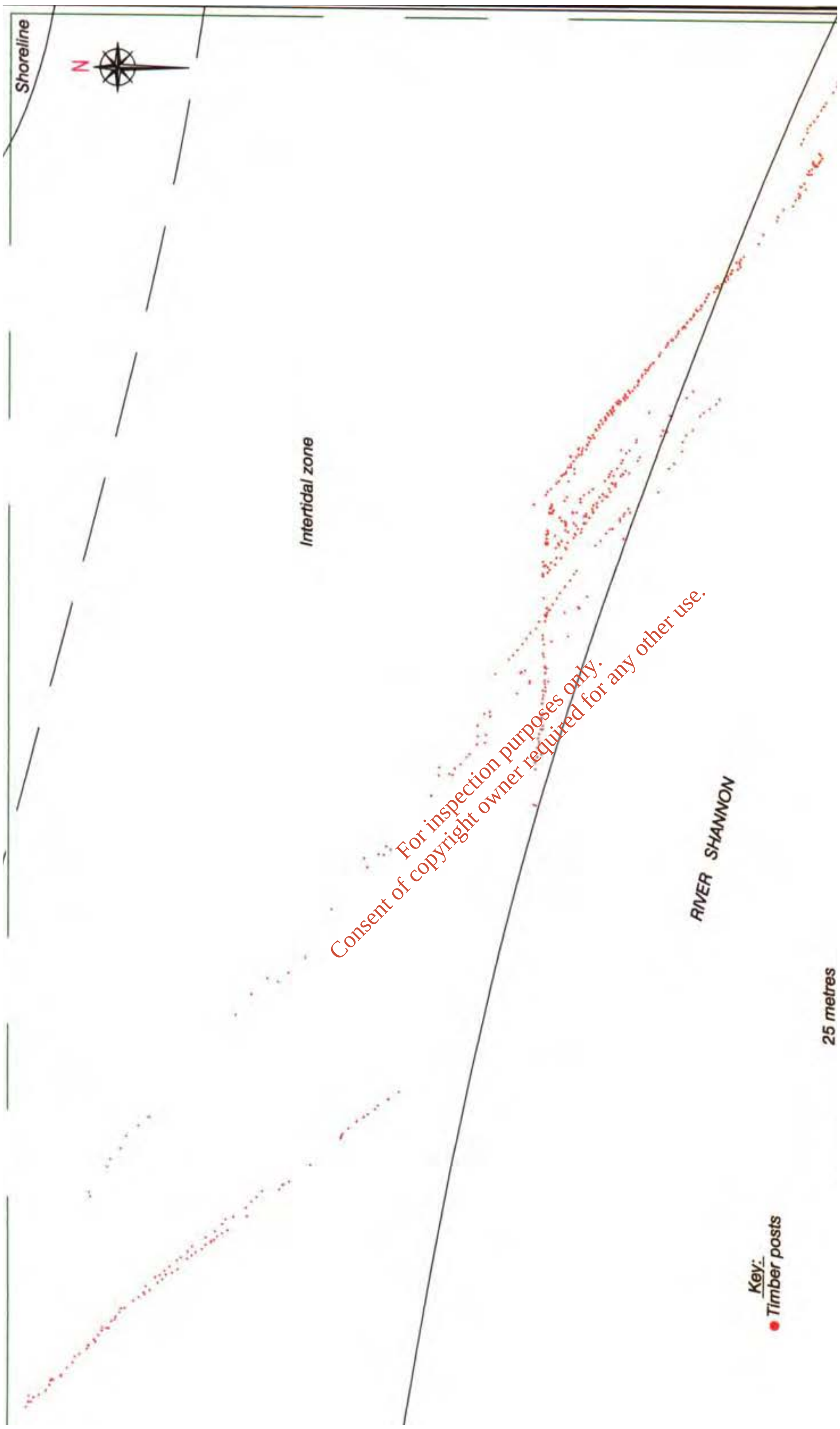

Fig 2.1 Site as surveyed in 1999

Fig 2.2 The site in 2002, looking downstream

Fig 2.3 The site in 2002, looking upstream

Fig 2.4 Small erosion pits within mud layer surrounding upright post on lower foreshore 2002

Fig 2.5 Soft estuarine mud overlaying posts on mid / upper foreshore 2002

Fig 2.6 Fishtrap Structures intact on mid / lower foreshore looking downstream 2002

Fig 2.7 Fishtrap Structures on mid / lower foreshore in 1999 looking downstream

Fig 2.8 Fishtrap Structures on mid / lower foreshore in 1999 looking upstream

Fig 2.9 Fishtrap Structures intact on mid / lower foreshore looking upstream 2002

Fig 2.10 Fishtrap Structures intact on the upper foreshore 2008, looking north

Fig 2.11 Fishtrap Structures intact on the mid foreshore 2008, looking north east

Fig 2.12 Fishtrap Structures intact on the mid and lower foreshore 2008, looking north.

Fig 2.13 Fishtrap Structures intact on the lower foreshore 2008, looking north east

Fig 2.14 Fishtrap Structures intact on the lower foreshore 2008, looking north east

Fig 2.15 Fishtrap Structures intact on the lower foreshore 2008, looking north east

Fig 2.16 Fishtrap Structures intact on the lower foreshore 2008, looking north

Fig 2.17 Fishtrap Structures intact on the lower foreshore 2008, looking north

Fig 2.18 Fishtrap Structures intact on the foreshore, 2012, looking north east

Fig 2.19 Fishtrap Structures intact on the upper foreshore, 2016

Fig 2.20 Fishtrap Structures intact on the upper and mid foreshore, 2016

Fig 2.21 Fishtrap Structures intact on the lower foreshore, 2016

Fig 2.22 Fishtrap Structures intact on the lower foreshore, 2016

Fig 2.23 Fishtrap Structures intact on the lower foreshore, 2016

Fig 2.24 Small erosion pit within mud layer surrounding upright post on lower foreshore, 2016

Fig 2.25 The dumping site at O'Brien's Point as inspected in July 2016

Fig 2.26 The survey vessel at anchor, midstream at the location of the fishtrap structures 2016

3. IMPACTS, CONCLUSIONS, MITIGATION

3.1 IMPACTS

Estuarine silts dredged from the approaches and berths at Limerick docks will be deposited at a dump site on the opposite side of the River Shannon from a fish weir complex located at O'Brien's Point in County Clare.

A record of the dredged material quantities dumped at the O'Brien's Point dump site are listed below with the year's in which surveys/inspections were conducted highlighted. It should be noted that no dumping of dredged material has taken place at the dump site since 2015 when a quantity of 5,750 tons were deposited.

Year	Quantity
1999	**10,950**
2000	09,000
2001	14,850
2002	11,700
2003	19,350
2004	**24,050**
2005	07,900
2006	06,150
2007	0
2008	**0**
2009	0
2010	0
2011	0
2012	**0**
2013	0
2014	0
2015	05,750
2016	**0**

3.2 CONCLUSIONS BASED ON THE ABOVE ASSESSMENTS.

- The fishtrap complex at O'Briens Point is intact as surveyed in 1999, 2002, 2008 and 2012
- A layer of transient silty estuarine mud continues to overlay the firm estuarine mud comprising the foreshore at O'Briens Point.
- The transient mud is forming a protective layer around and above the fishtrap structures on the foreshore.
- The site exhibited no features, which could be attributed to the dumping operations other than possibly, the accumulation of a protective layer of estuarine silts.
- 5,750 tons of dredged material has been dumped at the O'Briens point dump site in the period since the last inspection in 2012

3.3 MITIGATION

1. The fishweir complex at O'Brien's Point to be re-assessed in 2020 **if dumping operations continue at the present location until that time.**

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Attachment F.1

Sub-Section 5

Impact Assessment Studies

Archaeological Assessment, Proposed Marine Dump Site, Sod Island, Shannon Estuary, Co. Limerick (Donal Boland & Ciara Herron- Maritime Archaeologists)

Archaeological Assessment, Proposed Marine Dump Site, Sod Island, Shannon Estuary, Co. Limerick

Donal Boland and Ciara Herron, Maritime Archaeologists
Cushcallows
Banagher
Co. Offaly
Ireland

DJBMA Report 03-10-05
Licence No. 05D107 / 05R120

Client:	Shannon Foynes Port Company
Date:	October 2005
Licence No:	05D107 / 05R120
Report No:	D.J.B.M.A.
Author:	Donal Boland, Maritime Archaeologist Dr. Ciara Herron, Maritime Archaeologist Claire Callaghan Breen, Maritime Archaeologist
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Contents

1 EXECUTIVE SUMMARY

Sod Island (1591500N, 142850E) lies in the centre of the upper Shannon Estuary. It is approximately 1km north west of Mellon Point on the Shannon's southern shore in Co. Limerick and approximately 1.3km south of Inishcullin Hill on the Estuary's northern bank in Co. Clare. The site investigated, to the south of Sod Island, is the proposed location of a dumpsite for dredged material from adjacent areas of the Shannon Estuary.

The pre-development assessment and geophysical surveys were conducted by Mr Donal Boland under guidelines and acquisition parameters as recommended by the Maritime Unit of The Department of the Environment, Heritage and Local Government Licence Number: 05R120 / 05D107.

The Shannon estuary has long been occupied and exploited by humans. Prehistoric foragers and farmers, medieval and postmedieval fishermen, mariners, farmers, landlords and labourers have worked on the land, foreshore and the waters themselves. While some of the archaeological remains from these people have been known about for a long time, others such as the numerous fishtraps were only discovered in recent years. As parts of the estuarine muds continue to be eroded more archaeological features may be revealed; likewise with the shipwreck record. There must be many more vessels lying in the estuarine muds, the place and time of loss forgotten. The potential for uncovering archaeological material in the vicinity of Sod Island is high, given the proven level of activity in the estuary in the past and the quality and frequency of archaeological remains already recorded.

The substrate at the proposed development is characterised by low backscatter returns without texture, indicative of fine muddy seabed (Fig. 16). Little of no bedform development at the site provides further indication of this fine silty mud. Bathymetry ranges from <1m on the north-western margin of the survey area, to a maximum depth of over 6m in an isolated depression of approximately 0.4km x 0.2km to the north east. The survey zone's shallow area (<2m) extends for approximately 1km in the direction of the Estuary's South Channel.

No anomalies of archaeological potential were interpreted from the side-scan sonar survey at the site. The results of the magnetometer survey are dominated by magnetic deviation in the range of -35 to -45nT, interspersed with areas of approximately –50nT. There are nine anomalous magnetic signatures (M1-M9) in the survey data. In terms of the data range, M8 is the most significant large anomaly, with a deviation of up to –5nT and an area of approximately 1km^2. Sites M2 and M8 are the only anomalies on the fringes of the development, while the majority is clustered around the proposed site.

It is concluded that:

- No sites of archaeological potential are interpreted from 500 kHz side-scan sonar data acquired in the survey of the proposed dump site.
- Nine magnetic anomalies are identified from the site, however only anomalies M2 and M8 are in direct association with the proposed development. With strong indications of extensive anthropogenic activity in the area, and the field of minor deviations, it is likely that the magnetic results reflect cultural debris, which has been buried by sediment accretion processes at the site.
- The proposed development is unlikely to have an adverse effect on any potential buried cultural material, as it will lie on the seabed and involves no invasive activity on the riverbed.

It is recommended that:

- The proposed marine dump site should proceed at Sod Island, River Shannon, Co. Limerick; and
- Procedures for archaeological monitoring during engineering works are not required as the development involves no dredging or invasive activity on the riverbed.

2 INTRODUCTION

2.1 The Site

In south-west Ireland, the River Shannon and its tributaries form an extensive freshwater system that drains an areas of c. 15, 700km2 of the Irish midlands. The greater Shannon estuary comprised the tidal reaches of the lower River Shannon between Limerick City and the Atlantic and incorporates the Fergus estuary south of Clarecastle (Hickey and Healy, 2005) (Fig. 1). Its environs encompass parts of north Co. Kerry, north Co. Limerick and south Co. Clare. The geology dominates local topography, consisting of a conformable succession of Silurian rocks, upper Old Red Sandstone, Lower Carbiniferous Limestone series and Upper and Middle Carboniferous Limestone series (Hickey and Healy, 2005). These are overlain in turn by Yoredale Beds (shale series), Flagstone series (Millstone Grit) and, in some locations, Ouarternary glacial deposits and alluvium (Wheeler and Healy, 2001). Land adjacent to the estuary is generally low-lying, mostly extending from tidal High Water Mark (HWM) to 30m OD (OSI, 1974).

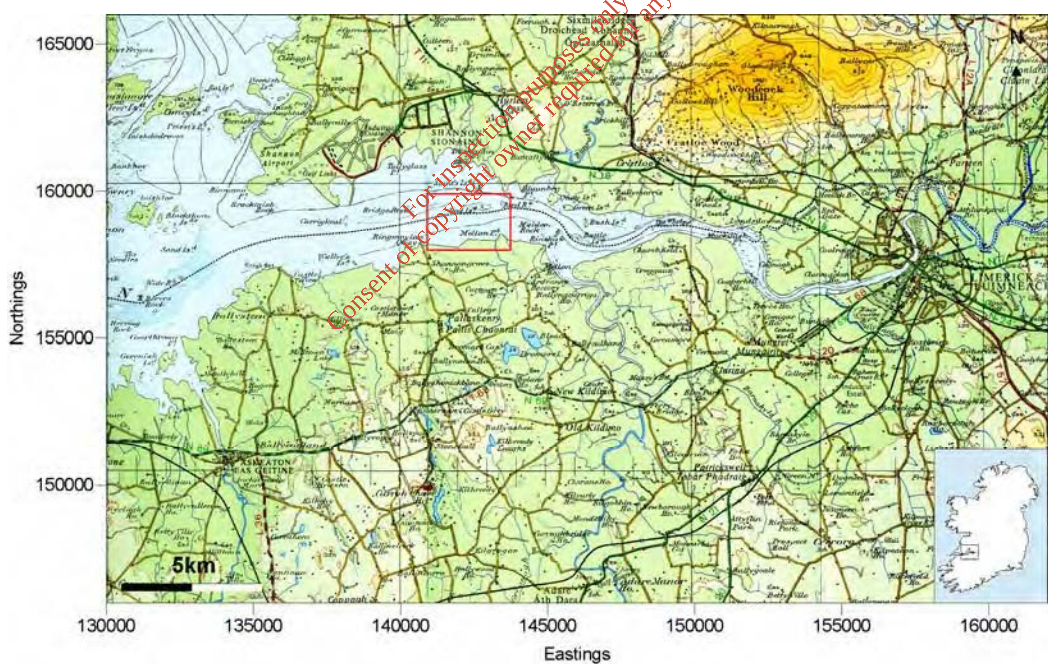

Figure 1: Locational map of Sod Island (red box), Shannon Estuary, within its national context (1/2 inch to 1 mile Map 17 – Shannon Estuary (OSI, 1986). Co-ordinates are in Irish National Grid.

The Shannon Estuary (Fig. 1) is subject to permanent marine inundation and tidal flows through a generally west-east aligned main channel measuring almost 100km from its mouth to Limerick City. The estuary is macrotidal, having the largest tidal range (5.44m at Limerick

Docks) on the Irish Coast. Water depths vary from approximately 37m at the estuary mouth to less than 5m near Limerick City. The estuary system has extensive associated inter-tidal mudflats, fringing reed-beds, swamps, salt marshes, wet-marsh habitats and reclaimed wetlands (Hickey and Healy, 2005). The mudflats are generally unvegetated, though patches of cord grass (spartina sp.) occur in places. Healy (2002) describes the reed beds and associated habitats that typify the margins of the river and stream channels and sheltered creeks within the system. The Estuary is a candidate Special Area of Conservation (EU Habitats Directive 92/43/EEC and Natura 2000) and an existing Special Protection Area for birds (EU Birds Directive 79/409/EEC) (Hickey and Healy, 2005). The site contains several habitats and species of international importance, among which are the priority lagoon habitat, the resident population of Bottle-nosed Dolphin and all three Irish lamprey species (*petromyzon marinus, lampetra planeri, l. fluviatilis*). Several Red Data Book species are present, including triangular club-rush (*scirpus triqueter*), opposite-leafed pondweed (*groenlandida densa*), meadow barley (*hordeum secalimum*), hairy violet (*viola hirta*) and bearded stonewort (*chara canescens*) (Hickey and Healy, 2005). It is also amongst the most important sites in Europe for wintering and migrating waterfowl (Healy, 2002).

The current ecological value of the Estuary as an important habitat is recognised nationally and internationally, but this was not always so. The estuarine environment has experienced considerable anthropogenic alteration over a very long time period stretching as far back as the Neolithic, some of which is linked to land reclamation (Wheeler and Healy, 2001; O'Sullivan, 1993 and 2001; O'Sullivan and Condit, 1995 and O'Sullivan and Daly, 1999).

Currently, the Shannon Estuary accommodates 8m tonnes of port traffic annually, particularly in coal, iron ore, oil and animal feedstuffs, making a significant contribution to international port traffic in Ireland. Shannon Estuary shipping includes large vessels, as much as 200,000 dwt, a dominance of bulk cargo and a low density of vessel numbers, about 1-2 per day (Shannon Development, 2002). In terms of industrial strengths, the Shannon estuary has several characteristics of international significance, specifically deep water adjacent to potential industrial land with low population density. Unlike established seaports, the estuary offers substantial physical capacity to accommodate maritime industrial developments. The Shannon estuary currently sustains an emerging aquaculture industry and has potential for further exploitation (Shannon Development, 2002). Therefore the modern habitat, and the environment generally, has been hybridised from elements that are both natural and anthropogenic (Hickey and Healy, 2005).

Sod Island (1591500N, 142850E) (Fig. 2), is in the centre of the upper Shannon Estuary (Fig. 1). It is approximately 0.6km north of Black Rocks (Fig. 3a), 1km north west of Mellon Point on the Shannon's southern shore in Co. Limerick, approximately 0.6km south of Saint's Island and approximately 1.3km south of Inishcullin Hill on the Shannon's northern bank in Co. Clare.

Figure 2: Sod Island: a) view from the south and b) clastic upper foreshore and algae-vegetated lower intertidal zone.

Figure 3: a) View of Black Rocks from the north east and b) Southern riverbank of the Shannon Estuary in Co. Limerick, viewed from the survey area to the north.

2.2 The Development

The site investigated is the proposed location of a dumping site for dredged material from adjacent areas of the Shannon Estuary and materials from the proposed tunnel crossing, *Limerick Southern Ring Road phase 11.*

The co-ordinates of the dump site, south of Sod Island are provided in Table 1 and its location is indicated in Fig. 4.

Position	Easting	Northing	Latitude	Longitude
1	142399.614	158816.781	52.67783333	-8.852333333
2	142907.974	158903.542	52.67866667	-8.844833333
3	142939.619	158717.677	52.677	-8.844333333
4	142431.24	158630.912	52.67616667	-8.851833333

Table 1: Site Location Points in Irish National Grid. These co-ordinates are located on the area map in Fig. 4.

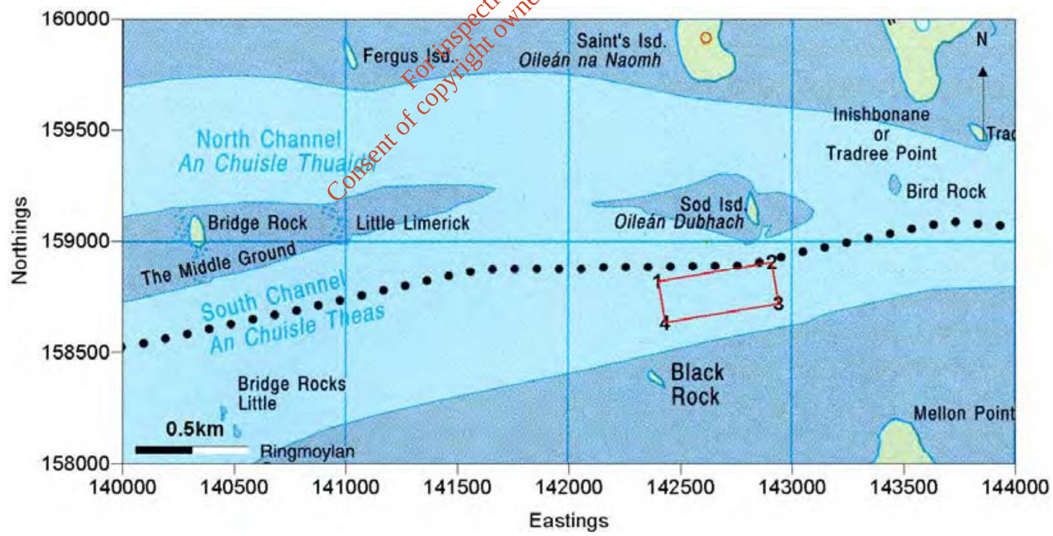

Figure 4: Location of proposed development south of Sod Island, Shannon Estuary; scale in Irish National Grid. Positional information for the site is provided in Table 1.

2.3 The Scope of this Report

This report details and interprets the desktop and geophysical survey data recorded at the site of and adjacent to the dredging dumpsite south of Sod Island, Shannon Estuary, Co. Limerick.

The pre-development assessment and geophysical surveys were conducted by Donal Boland under guidelines and acquisition parameters as recommended by the Maritime Unit of The Department of the Environment, Heritage and Local Government.

Licence Numbers: 05D107 / 05R120

2.4 Data Acquisition Method

2.4.1 Data Acquisition

Geophysical surveys were conducted by Donal Boland from a local survey vessel, *Graig* (Fig. 5), at an average lane spacing of 30m. Details of the survey suite and operational parameters are provided in Sections 2.4.2-2.4.4.

Figure 5: *Graig*, aboard which marine geophysical surveys were conducted at the Shannon Estuary development site.

2.4.2 Global Positioning System

Positional data with a quoted accuracy of 1-3m, were provided by a *DGPS MAX* series differential global positioning system with differential corrections supplied by the General Lighthouse Authority (GLA) reference station at Loop Head. Positional data were downloaded at a 1-second interval via a standard RS-232 serial port interface into *Hypack* software on a laptop platform. The WGS-84 ellipsoid was used as datum. Parameters utilised for conversion of WGS84 data to Irish Grid are detailed in Table 2.

Parameter	Conversion factor
Semi-major Axis	6377340.189
1 / Flattening	299.324964
Latitude of Origin in Degrees	53.500000
Longitude of Origin in Degrees	-8.000000
False Easting	200000.000
False Northing	250000.000
Scale Factor	1.000035
Datum Shift DX	-482.530
Datum Shift DY	130.596
Datum Shift DZ	-564.557
Datum Shift RX	-1.042000
Datum Shift RY	-0.214000
Datum Shift RZ	-0.631000
Datum Shift Scale	8.150000

Table 2: Parameters utilised for conversion of WGS84 data to Irish Grid.

2.4.3 Bathymetric Survey

The bathymetric survey was conducted using a single-beam echo-sounder operating at 200 kHz. Positional and bathymetric data was downloaded at 1-second intervals via an RS-232 serial port interface to a laptop. Layback corrections were not required as the DGPS antenna was mounted directly above the echo-sounder.

2.4.4. Side-Scan Sonar Survey

The side-scan sonar survey was conducted using a dual-frequency *GeoAcoustics* Model 159A side-scan sonar towfish and Model SS941 transceiver system at an operational frequency of 500kHz. Data was acquired without slant-range correction, with swath width set at 74m (37m range per channel). Trackline spacing was fixed at 30m ensuring that in excess of 200% riverbed coverage was achieved throughout the survey. Sonar data was acquired in SEG-Y format, processed in *GeoPro LC* on an Apple Macintosh platform and logged to disk.

2.4.5. Magnetometer Survey

The magnetometer survey was conducted using an *Aquascan* AX2000 proton magnetometer linked to a *Litton Marine* LMX-400 DGPS unit. Magnetic data were acquired in XYZ Raw ascii files. Trackline spacing followed the same 30m pattern as the side-scan sonar survey, thus ensuring adequate coverage for archaeological survey as recommended by the Maritime Unit, The Department of the Environment, Heritage and Local Government

2.5 Data Processing and Interpretation

2.5.1 GPS

The track resulting from survey of the proposed dredge dumpsite, south of Sod Island, Shannon Estuary is shown in Fig. 6.

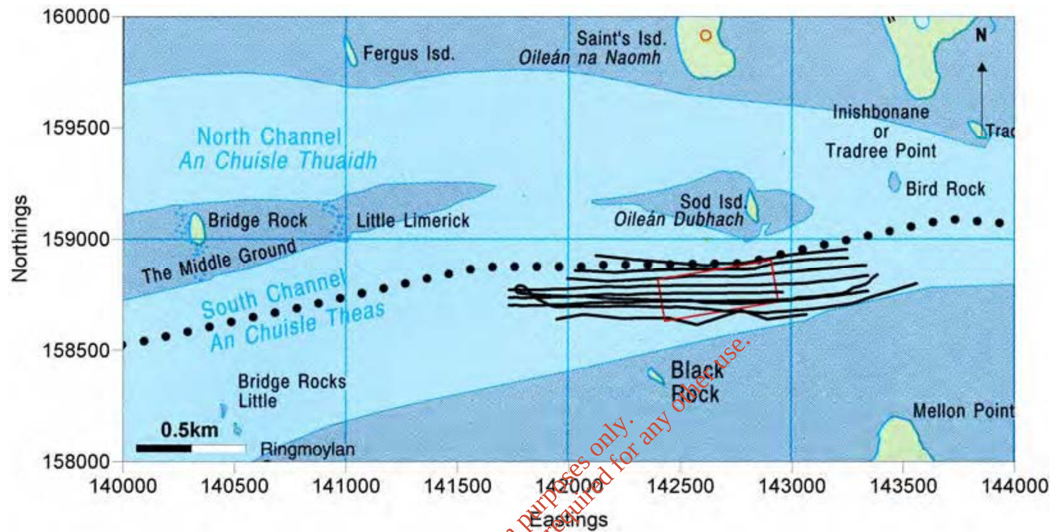

Figure 6: Track chart resulting from the site survey (Scale in Irish National Grid). The position of the proposed development is indicated by the red box.

2.5.2 Bathymetric Survey

Bathymetric XYZ files were processed using *Surfer 8*. Raw ascii files were gridded in 2m bins using the Nearest Neighbour interpolation method. Two- and three-dimensional contour plots were produced for interpretation and data integration.

2.5.3. Side-Scan Sonar Survey

500kHz data in SEG-Y format were examined for each survey line. Sonar data was processed in *GeoPro LC* on an Apple Macintosh platform. Images were extracted as GeoTIFF files for inclusion in this report.

2.5.4. Magnetometer Survey

Magnetometer data were processed using *Surfer 8*, gridded in 10m bins using the Nearest Neighbour interpolation method. Two- and three-dimensional contour plots were filtered and examined for anomalies.

3.1 Desktop Survey

3.1.1 Introduction and Landscape

Sod Island forms part of what is known as the middle ground in the upper Shannon Estuary (Fig. 7). County Clare lies to the north and county Limerick to the south. In the past, before relatively modern reclamation works, the upper Shannon estuary would have flowed through a range of features such as estuarine and freshwater wetlands, with mudflats, saltmarshes, reed-swamps, fens and bogs, giving way further inland to a scrubby, wet cover of carr woodland. The surrounding drumlin hills and upland terraces on both sides of the estuary would have been the main focus for rural settlements, agriculture and woodlands.

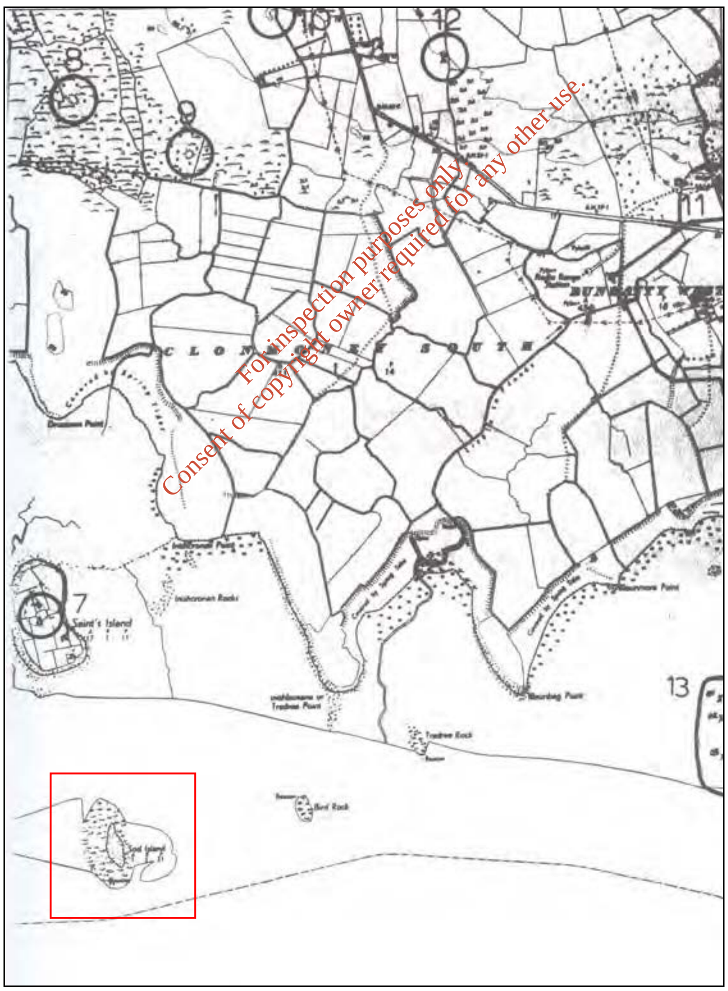

Figure 7: Co. Clare OS 6” Sheet 61 showing the location of Sod Island in the Upper Shannon Estuary.

3.1.2 Archaeological and Historical Background

Sod Island is situated on the main water-way to the city of Limerick and is very close to the historical town of Bunratty. This is an area very rich in archaeological material. Recent surveys carried out by O'Sullivan (2001) on the Shannon estuary region has revealed a number of previously unrecorded archaeological sites, mostly in the form of wooden fishtraps. His survey covered the inter-tidal area from Limerick to the Maigue estuary on the south bank and from Limerick to Saint Island on the north bank. This means that the inter-tidal zone to the south of Sod Island was not intensively examined in this survey. A rapid survey was also carried out from Saint's Island to Rineanna (Shannon Airport). This work has greatly increased our knowledge of this area and how estuarine resources were exploited. It appears that rather than being a marginal and inhospitable area, the estuary was an important trade route to Limerick and provided a good source of fish.

Some of the archaeological sites discussed here may be up to 6km from Sod Island but the range of multiperiod archaeological and paleo-environmental deposits found there are important in demonstrating the level of activity in the past in the estuary and the potential for archaeological remains. Also, seeming as the foreshore to the south of Sod Island was not included in O'Sullivan's Shannon Estuary survey, there is a high potential for the existence of archaeological remains in the area that have not yet been recorded.

Mesolithic Period (7000-4000 BC)

The earliest inhabitants of the Shannon estuary area date to the Mesolithic period. While a number of Mesolithic sites have been found in Limerick, little evidence of Mesolithic activity has been identified along the Shannon estuary yet. Even so, it is thought that due to the plentiful wetland and riverine resources of the estuary, it would have been a very attractive place for the hunter-gatherer lifestyle of the Mesolithic people, which involved hunting, fishing and the collecting of plant foods. A Late Mesolithic wooden plank, measuring 4.3m long, was found Carrigdirty Rock 8, located on the upstream south bank (Fig. 8, Fig. 9). It is uncertain what this plank was. Initially it was thought to be part of a dugout boat but the lack of evidence of wood-working has raised suggestions that it is natural in origin. At Carrigdirty Rock 11 there is a 2m long scatter of brushwood along a clay shelf. Again it is uncertain whether this is a natural feature or formed part of a trackway or platform.

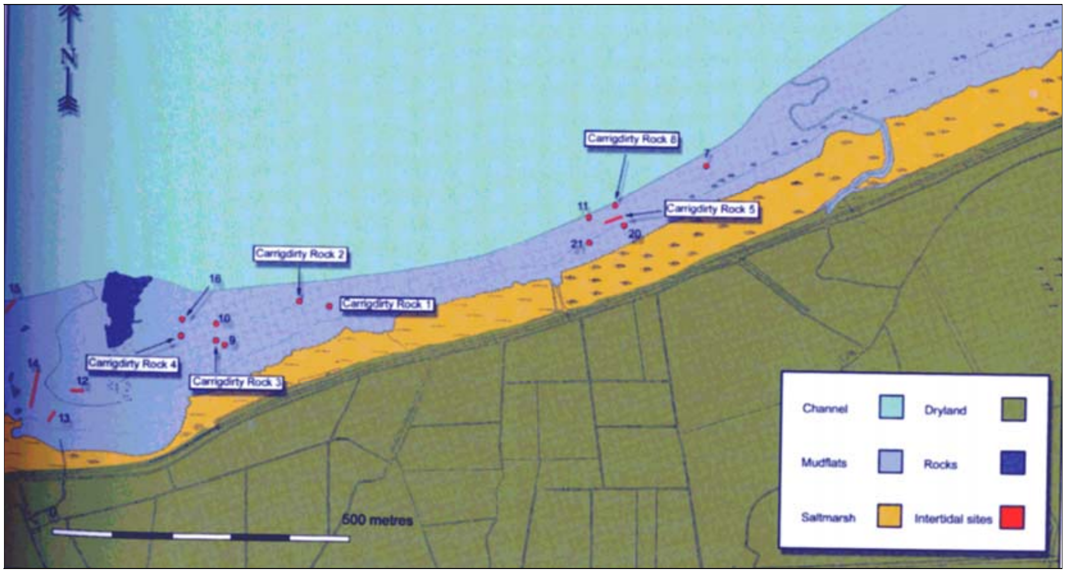

Figure 8:Location of Intertidal Sites at CarrigdirtyRock (O'Sullivan, 2001).

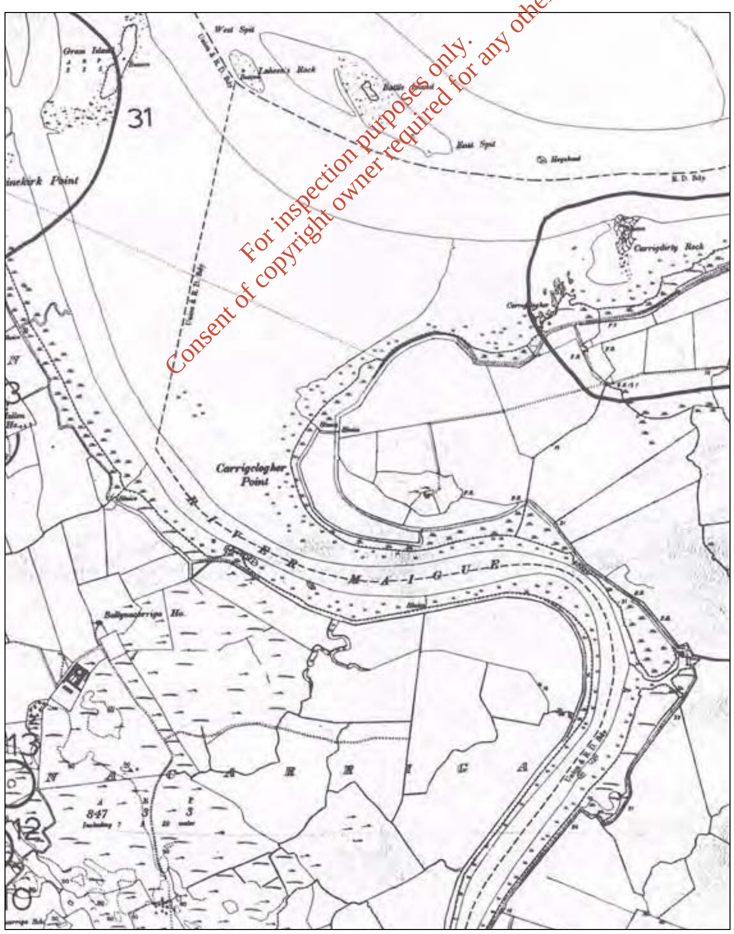

Figure 9: Co. Limerick OS 6" Sheet 4 showing the location of Carrigdirty Rock.

Neolithic Period (4000-2500 BC)

Farming, which was an important feature of the Neolithic, may have been introduced to the area by small groups of people coming into the region or the native hunter-gathers may have developed towards their own Neolithic lifestyle. These early farmers probably combined cattle-herding, crop cultivation and the use of fixed dwellings with some seasonal movement, incorporating hunting and gathering activities.

Mesolithic, Neolithic and Bronze Age submerged forests are common features of intertidal peat deposits around the Irish coast. Submerged forests dating to the Late Neolithic or Bronze Age have been identified at in the vicinity of Sod Island, at Carrigdirty Rock 16, Co. Limerick (Fig. 8 and 9), and possibly at Bunratty 5, Co. Clare. Carrigdirty Rock is a low, natural bedrock outcrop on the intertidal zone on the south bank of the Shannon estuary, 2km east of the River Maigue. A range of multiperiod archaeological and paleo-environmental deposits can be found there.

Carrigdirty Rock 5, located some 6-7m to the south of Carrigdirty Rock 8, contains a scatter of lithic and organic artefacts and animal bone. Finds at the site include worked wood, charcoal, hazelnuts, a stone axe, woven basketry, human bone and swan and young cattle bone. This site is thought to be evidence for a Neolithic short-stay cattle-grazing site, perhaps also associated with hunting, fishing and wild-fowling in the late summer of early autumn. The presence of human bone fragments may also suggest some other symbolic activity at the site. It was probably occupied by a small group of people who only stayed there for a few days at a time.

Bronze Age Period (2500-600BC)

By the Bronze Age, the upper Shannon estuary may have had a range of estuarine landscapes, with saltmarshes, mudflats and tidal creeks in some areas, while elsewhere, such as at Carrigdirty Rock, there were carr woodlands, sedge fens and perhaps raised bogs. A range of possible Bronze Age sites was recorded at Carrigdirty Rock (Fig. 8 and 9). Carrigdirty Rock 1 is a Middle Bronze Age house site consisting of at least 23 vertical roundwood post, spread out over an area measuring 6.2m by 6m. There were also at least seven larger posts. These are thought to represent either the main features in a small ‘bender’ hut or the internal roof supports of a larger oval or circular structure. The limestone slabs found to the north-east of the structure may have been used as hearthstones or as post-pads for larger roof timbers. There were two concentrations of dense fen-wood tree roots in the peat.

There are other sites, possibly from the same period, at Carrigdirty Rock 2, 3 and 4. Carrigdirty Rock 2 consists of a cluster of vertical posts, limestone slabs and a spread of animal bone in the peat. Carrigdirty Rock 3 consists of a shallow, 0.90m long, pit cut into woody peat. It contained a shell-rich clay and disarticulated bone and antler of red deer and pink-footed goose, but these did not show any evidence of butchering or working. This has been interpreted as a pit for storing food or for as a place for refuse. It has also been suggested that this may have been a place for the ritual deposition of animal bones. It may be contemporary with Carrigdirty Rock 1 but its higher location of the foreshore may suggest a slightly later date, such as the Late Bronze Age or Iron Age.

Carrigdirty Rock 4 consists of two roundwood posts and one cleft post set at varying angles in the peats. These may be the remains of a small structure built with sturdy posts, sharpened using both an axe and cleaving techniques. It has been interpreted as a Late Neolithic or Bronze Age wildfowling structure or the remains of a small shelter or windbreak.

Carrigdirty Rock 20 consists of a wooden plank measuring 3.4m long, 5cm thick and an average of 50cm wide. Carrigdirty Rock 21, another plank, is situated 30m further to the west. It was 5.6m long, a maximum of 76cm wide and 2 to 5.5cm thick. The date and function of these planks are not known but their location in the peats, suggest a Middle Bronze Age date.

All of these Carrigdirty Rock sites are firmly embedded in organic-rich peats, with well-preserved remains of reeds, sedges, roots, and trunks and branches of shrubby trees. This suggests a freshwater environment containing possibly fen, carr woodland or a high saltmarsh. It is unclear whether or not the sites are contemporary.

Early Historic (400-1100AD)

In the early historic period the upper Shannon estuary probably appeared somewhat similar to what it does today. The sea levels were the same and the estuary channel flowed through mostly saltmarshes and mudflats, with the islands on the estuary being mostly cut off at low tide. The reclamation banks had not yet been constructed though, so there would have been extensive areas of waterlogged marshes and corcass. This corcass would have been used for grazing cattle, sheep and horses. The estuary would have been used by various types of vessels, from small dug-out boats and coracles to large ships trading in the port of Limerick and the smaller ports of Bunratty, Askeaton and Ennis.

There is much evidence for settlement around Sod Island in the early historic period. These can be seen on the land fringing the estuary such as early historic ringforts, churches and monastic sites, which could be found on the surrounding mainland and islands. There are a considerable amount of archaeological sites classified as enclosures and ringforts in the surrounding land. Ringforts would have been the main occupation sites of the Iron Age, acting as enclosed farmsteads, where a farmer, his family and possibly some of his animals lived. It is known that ringforts continued to be inhabited and constructed throughout the early historic period and even in some cases up until medieval times. An example of such is located north of Sod Island at Clonmoney West (CL061-009; Fig. 7).

Enclosures are less definite monuments. They could be damaged ringforts or they could be all that remains of early monastic enclosures. Examples of these include LI003-024 to the south of Sod Island in the townland of Ballydoole (Fig. 10), LI004-002 to the south-east at Cartown (Fig. 11) and CL061-007, directly north in the centre of Saint's Island (Fig. 7). Given the name of this latter island, this enclosure may hold the remains of an early monastic site. There is also a stone wall running across the inter-tidal area between Saint's Island and Inishcronan Point (Fig. 12). It is some 370m long and forms a large V-shape. It is not marked on the 1st edition OS map but is marked on the 2nd edition and on the Admiralty Chart. The date and function of this feature is unknown but it may represent a causeway to the island, a failed mudflat reclamation feature, a fishtrap or a tidal mill. Historic sources also suggest that there was a Viking settlement at Bunratty in the 10th century. Of course, the Hiberno-Norse City of Limerick, which was very important in the 10th and 11th centuries, was upstream of Sod Island.

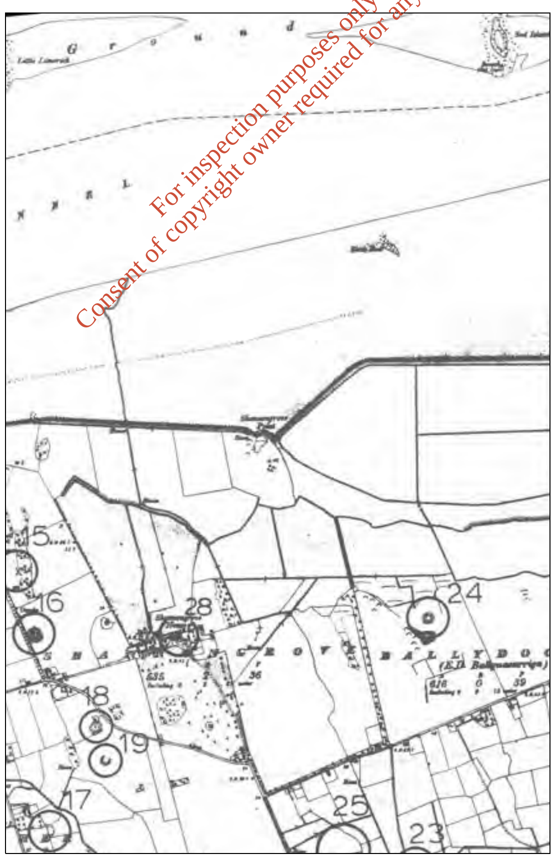

Figure 10: Co. Limerick OS 6" Sheet 3 showing the location of the townland of Ballydoole.

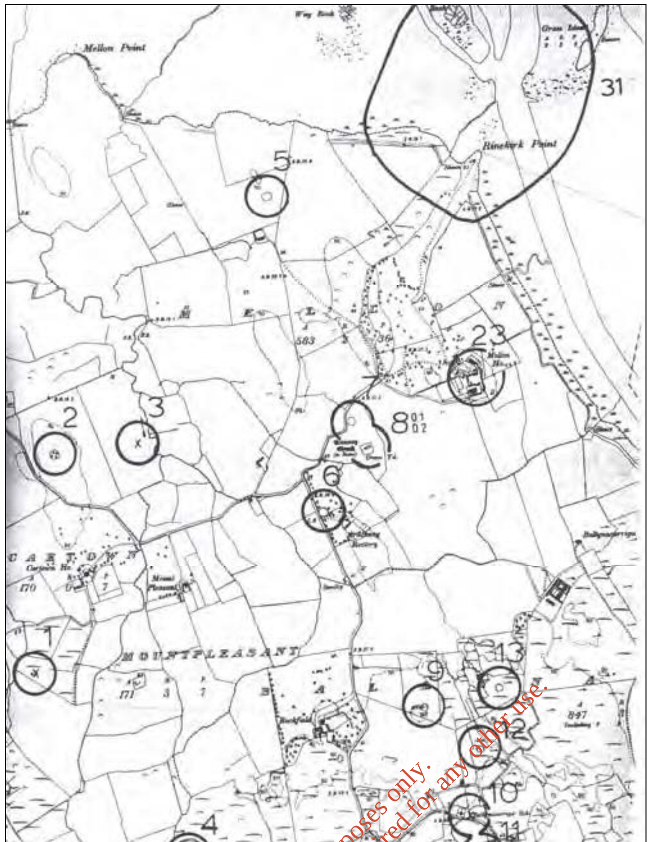

Figure 11: Co. Limerick OS 6” Sheet 4 showing the location of the townland of Ballydoole.

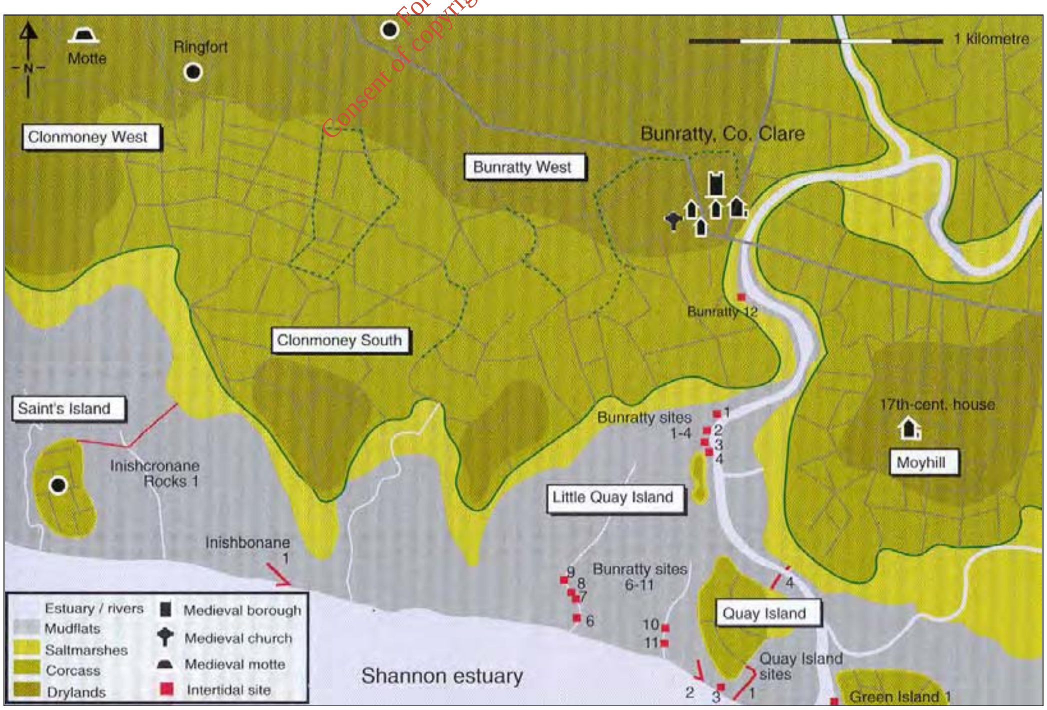

Figure 12: Location of intertidal sites in the vicinity of Bunratty, Co. Clare (O’Sullivan, 2001).

Medieval Period (1100-1350AD)

The earliest evidence for Anglo-Norman settlement at Bunratty is found in the form of a motte-and-bailey at Clonmoney West (CL061-008; Fig. 7), possibly relating to the granting of territories at Traddery to Arnold Keating in 1199. A motte castle was a fortification built on an artificial mound, overlooking the enclosed courtyard or bailey, below. In this case the motte-and-bailey overlooks the Shannon estuary and consists of a circular, flat-topped mound with an adjoining triangular bailey. However the Anglo-Norman manor of Bunratty was first established in earnest in 1248, with the granting of the cantred of Tranderry to Robert de Muscegros. By 1251 a possible castle or motte-and-bailey was under construction to the north of the later O'Brien castle (Fig. 10). The borough may have been surrounded by an earthen bank and ditch, a feature that is described in the *Caithreim Thoirdhealbhaigh* as 'broad-based, high-crested ramparts, running from the stream to the sea'. Westropp described the presence of earthen ramparts around Bunratty, but more recent excavations have cast doubt upon their early date. It is possible that these earthen banks are the remains of 17th century reclamation features.

By 1253 de Muscegros was allowed to have a 'vill', with a weekly market and yearly fair, in his land at Bunratty. In 1277 Bunratty passed to Thomas de Clare, who built a stone castle and populated it with English tenants. During the remainder of the 13th century the castle was unsuccessfully attacked by the Irish many times. Following the defeat of the Anglo-Normans and the death of de Clare in 1318 at the Battle of Dysart O'Dea the castle and town were burnt by his widow. Bunratty was then granted to James Bellafago, but in 1325 and 1331 it was seized by followers of the Earl of Desmond. In 1332 the castle was taken and destroyed by Desmond's ally, King Muirchertach O' Brien of Thomond. The English Justiciar, Sir Thomas de Rokeby, built a new castle there in 1353. Two years later, the castle was captured by Murchadh O'Brien, and from that date until the 17th century the castle remained in Irish hands.

The Anglo-Norman borough of Bunratty was one of the most important medieval settlements and ports in the region at that time. By the 13th and 14th centuries Anglo-Norman and Gaelic Irish hall-houses, castles and fortresses were being built along the banks of the estuary. Medieval churches and abbeys were also established along the estuary. By 1287 Bunratty had a substantial population, a harbour, a castle, a church, markets, watermill, a fish-pond and a rabbit warren. The Anglo-Norman manor also probably consisted of arable fields closer to the town and cattle pasture on the corcass down nearer the estuary, including three islands in the estuary. Local fishermen would have worked along the foreshore, collecting fish from the numerous wooden fishtraps, and carrying out any necessary repairs. Local Gaelic Irish lords and their tenants also appeared to have been exploiting the fisheries prior to the Anglo-Norman colonisation, catering for local and more urban needs. These local fishermen may have continued to work the traps as free tenants on the Anglo-Norman manors and estates in the 13th and 14th centuries, when the fisheries became a highly prized and guarded resource.

By the 15th century, tower-houses owned by the Desmond lords and the O'Briens and MacNamaras of Thomond were located along the upper Shannon estuary, one of which was at Bunratty (CL062-001) and another possible castle (LI004-023; Fig. 11) at Mellon House, directly across the estuary. Bunratty Castle was built in 1425 by the MacNamaras but possession passed to the O'Briens, who were the Earl of Thomand, during the following century. The castles acted as visible statements of power and wealth on what was a significant routeway, and their landing places would have been used by boats and ships, with their fisheries also a valued resource. In 1642 and again in 1645, Brian, the Sixth earl of Thomond, handed the castle over to the Parliamentarians. The castle was soon blockaded by a Confederate force under Lord Muskerry, who forced its surrender after some two months. All that remains are fragments of the curtain and the large, rectangular keep of three storeys with four complex angle turrets. The original entrance, in the north face, leads to a vaulted hall. Beneath the hall is a vaulted cellar, while above it is an upper hall with evidence of 16th century stucco. It remained in the possession of the Earl of Thomond until 1712.

The communities along the estuary were building and using wooden fishtraps to provide fish for local consumption and for trading at market. Archaeological surveys of the Shannon estuary by O'Sullivan discovered a large number wooden fishtraps. Fishtraps are artificial barriers of wood or stone erected in rivers or estuaries to deflect fish into an opening where they can be trapped in nets or baskets. They most often take the form of head weirs, being V-shaped structures of converging vertical post-and-wattle fences or stone walls, forming a small gap, which is usually blocked by a wicker basket (Fig. 13).

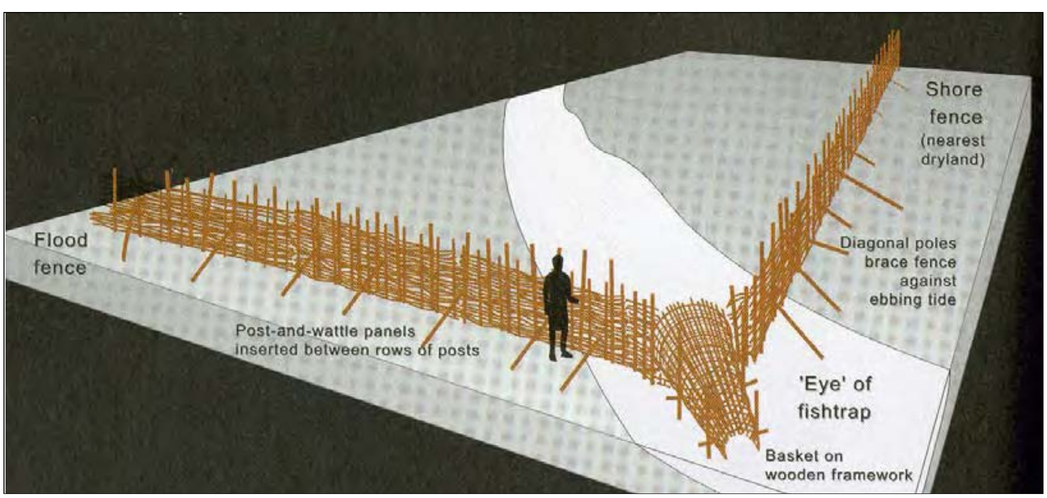

Figure 13: Reconstruction of a Medieval fishtrap (O'Sullivan, 2001).

Depending on their orientation, they caught fish, such as salmon, moving upstream to the headwaters in spring or caught eels moving downstream in the autumn. In coastal and estuarine waters fish tend to move up the shore with the flooding tide and back down again with the ebbing tide. This means that fishtraps in these areas can be built to catch fish moving either up or down with the tide. Many examples of medieval fishtraps were found adjacent to the townland of Bunratty West (Fig. 12). At this point the estuary is quite broad, with extensive mudflats, rock outcrops and islands on both banks. The Owenagarney River flows into the estuary on the north bank. There are several former islands that are now hills in the reclaimed corcass. The medieval fishtraps are located in two clusters, Bunratty 1-4 (CL061-031) and Bunratty 6-11 (CL061-013). Bunratty 1-4 are located on the east bank of the River Owenagarney, just north-east of Little Quay Island. A submerged peat shelf, Bunratty 5, probably of pre-historic date, is also located here.

Bunratty 1 consists of a number of features exposed during low water. These include a vertical post and wattle fence, a horizontal post and wattle panel and several other vertical posts and horizontal pieces of roundwood further to the south-east. These are thought to represent two converging fences of a small V-shaped fish trap. The trapping mechanism would have been some distance further to the south-east. This structure is thought to be early historic or medieval in date. Bunratty 2 consists of a single post-and-wattle fence, orientated east-north-east/west-south-west, at a 90° angle to the modern channel. The exposed section measures 4m in length. There are no interwoven branches on the lower part of the foreshore, where intertidal and channel erosion has exposed several of these posts right down to their sharpened tips. This is thought to indicate that the structure was formerly used on a foreshore that was slightly higher and more level that that of today. The structure has been interpreted as a single post-and-wattle fence, possibly with a basket at its end. It may also have held netting, thereby being a net weir rather than a head weir. It probably dates from the late medieval period, although the density and state of preservation may indicate a late or even post medieval date.

Bunratty 3 consists of a single post alignment and two baskets, located on the west-bank of the River Owenagarney, around 60m north-north-east of Quay Island. There is a rock outcrop or a ballast dump immediately to the south-west. The two baskets are on the extreme lower foreshore and therefore are only visible during extremely low tides. It appears to be a fishtrap, consisting of a single vertical fence, leading down to horizontal baskets. The baskets may have been just anchored in place in the creek bed or may have been pinned down with a few posts, such as those found beside one of the baskets. The baskets would have been portable traps that could be left in creeks, streams or artificial mill-streams. This site is thought to be Medieval in date.

Bunratty 4 appears to consist of at least four phases of activity, representing two styles of fishtrap. The earliest fishtrap was probably a simple V-shaped structure. The second, third and fourth phases of activity involved a more complex V-shaped fishtrap. In its final phase the fishtrap appeared as a small V-shaped structure of two converging post-and-wattle fences, with a rectangular space defined at the apex by two parallel rows of vertical posts. A net or basket may have been placed within this area. The two baskets to the north at Bunratty 3 may have been used in this structure.

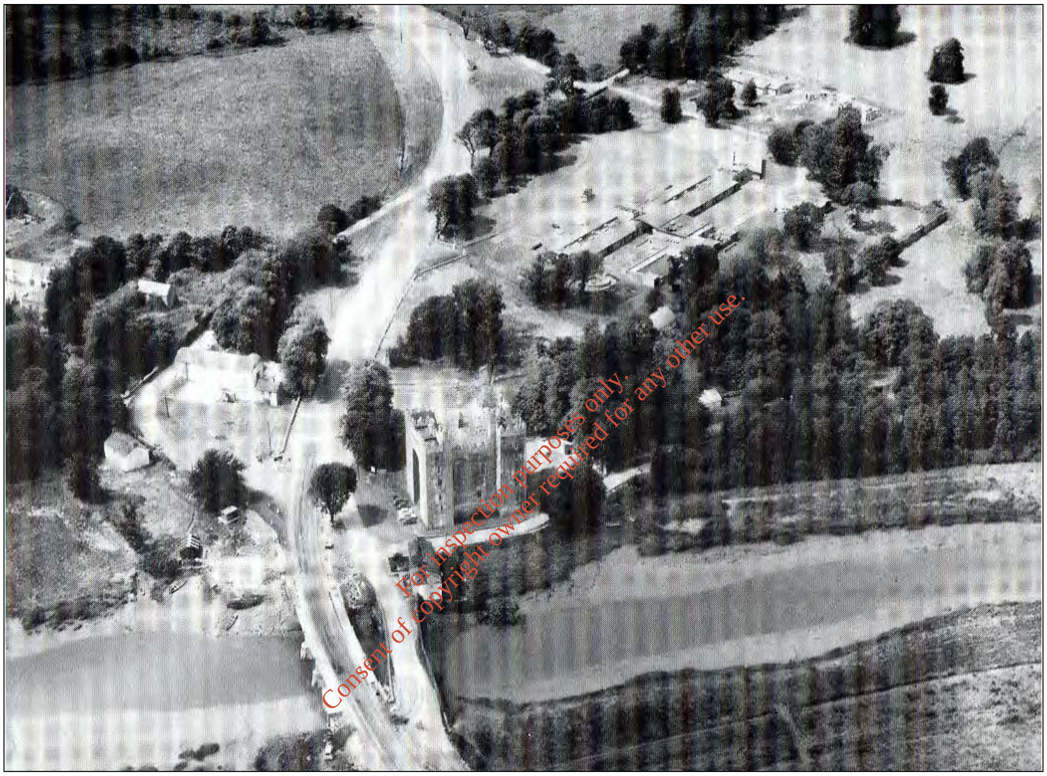

Figure 14: Aerial photograph of Bunratty Castle on the Owenagarney River, Co. Clare (O'Sullivan, 2001).

Bunratty 6-11 (CL061-013; Fig. 14) are located closer to the main channel of the estuary, on the mudflats of a large creek that drains the foreshore between Quay Island and Illaunbeg Point. Bunratty 6 is being exposed due to erosion of the sides of the modern creek that flows in a south-easterly direction across the mudflats. This site consists of a very well preserved medieval fishtrap, with a post-and-wattle fence leading to a large woven horizontal basket. It has been radiocarbon dated to 820±35BP (cal. AD 1164-1279). The fishtrap could not catch fish in its present day location but there is evidence to suggest that it originally functioned in the bed of a now buried paleochannel. The modern creek is cutting across and exposing this ancient silted-up channel, which probably flowed in a north-east/south-west direction. The

Bunratty 6 fishtrap was probably V-shaped, with two converging fences, perhaps up to 20m in length, leading towards a woven basket on a platform. It was an ebb weir, made to catch eels and other fish on an ebbing tide. The single exposed fence was at least 10m long and was constructed of two rows of vertical roundwood posts, against which were placed several post-and-wattle panels. Brushwood and interwoven rods may also have been laid in the gap between the inner and outer rows of posts.

The post-and-wattle fence at this site is thought to have stood to a height of 1.5-2m. Posts driven into the clays immediately upstream of the fence also helped to keep it upright in the tides. There is evidence of a possible repair at the middle, where there is a dense concentration of vertical posts, a post-and-wattle panel placed on its end and some possible bracing posts. The basket was at least 4.1m long and 0.70m in diameter and was supported by a wooden framework. It may have had a second, portable basket placed at its end. O'Sullivan has suggested that the very good state of preservation may be due to it being covered by heavy clays and silts during a sudden flood.

The 11th to 13th century fishtraps of Bunratty 4 and Bunratty 6 are important archaeological evidence for earlier medieval activity in the vicinity of Bunratty. They provide new insights into this medieval landscape, in terms of woodland management, the consumption of fish by the local population and the economic exploitation of the estuary itself. The medieval fisheries on the Shannon estuary mudflats were probably an important source of revenue, providing salmon, eels and trout for the borough's markets and households. The Bunratty 4 site has been radiocarbon dated to 1018-1159, which was well before Anglo-Norman activity in the area. This may indicate that some settlement was present at Bunratty in the 11th or 12th century but it is unknown whether this was a native Irish settlement or an outlying settlement associated with Hiberno-Norse Limerick.

Fishing, in the Middle Ages, was an important source of food, livelihood and income in coastal and riverine area, and the ownership, regulation and use of fisheries was a key aspect of the organisation of local society and economy. Fish and shellfish were important elements in the medieval diet. Fresh and salt-water fish were caught for local consumption and were also preserved and transported elsewhere. In the early Middle Ages fishing would have been carried out on a subsistence basis only but by the later Middle Ages, with the development of urban markets, better methods of preservation and the development of Atlantic sea fisheries, fishing was potentially a great source of wealth and power.

Bunratty was also a significant medieval port or harbour, situated as it was on a low ridge overlooking a crossing-point of the river, near the mouth of the Bun Ráite or Owenagarney River, with extensive views to the south over the Shannon estuary. Bunratty was described in the 14th century as being of 'wide roads, oared galleys and safe harbour'. There may also have been a plank bridge across the river. A bridge is known to have been there during Toirdhealbhach Ó Briain's siege of Bunratty. It spanned the sea-channel to the opposite shore, thereby preventing ships from gaining access to the castle. Bunratty Castle remained a significant fortification throughout the late Middle Ages, being in Irish hands throughout the 15th century.

Post-Medieval Period (1534-1700AD)

During the post-medieval period, the Shannon estuary's fisheries, seaweed, oysters, reed-beds, saltmarshes and other resources were all being increasingly exploited. During the 17th, 18th and 19th centuries fishtraps of increasingly ambitious design and size were being constructed and used in places around Sod Island such as Inishbonane, Quay Island, Maiden Rock and Carrigdirty Rock. Some of these date from the 17th century while others are of 18th or early 19th origin. These fishtraps were mostly controlled by local landlords and were a source of local friction and class division.

By the 17th century the landscape around the Shannon estuary was being transformed by wetland reclamation projects but most schemes were probably carried out in the 18th and 19th centuries. Over the years, a series of earthen and stone sea-banks gradually pushed towards the estuary. Drainage ditches and field systems were then built to drain and retain the corcass, thereby creating large areas of low-lying alluvial levels now found on both the Clare and Limerick coastlines. Many of the earthworks, low banks and substantial walls visible today in the corcass may be former reclamation banks, such as the unusual rectilinear enclosure at Clonmaney West, north of Sod Island. While much time, money and effort was invested in these defences, the rewards were great. These areas of reclaimed land were used to grow wheat, barley, oats, coleseed and hay, as well as for pasture for cattle, with yields described as 'extraordinary'.

In 1646 the English garrison at Bunratty castle surrendered. It had been surrounded by earthwork defences, including a fort. Bunratty was of great strategic importance, controlling the Shannon estuary. Artillery was able to command the navigation channel and the garrison was supported by warships of the English parliament. Bunratty was then the seat of Barnaby O'Brien, the Sixth Earl of Thomand, who was said to be a Royalist and Irish rebel all at once. Those who had retained their estates at the Restoration in 1660 appeared to be able to change allegiance at appropriate time. The remains of a post-medieval stone quay are visible running under the foundation of the old stone bridge, which crosses the Owenagarney River (Fig. 12). It is built of large flat stones laid horizontally, and stands to a height of over 1m in places. This structure may constitute part of the medieval waterfront or may represent a later structure that follows the line of an earlier quay. A post-medieval slipway is also situated on the mudflats to the south, consisting of flat, angular stones, running down to the low water mark. This was probably used to haul small boats above the high-water mark and ashore. In the 18th and 19th centuries, small scale fishing and some transportation operated out of Bunratty, aided by the construction of a 'new quay' in the middle of the 19th century. The Shannon estuary continued to act as a major nautical routeway during the post-medieval period, providing access to the growing port of Limerick

Fishtraps continued to be used during the post-medieval period. An example can be found north-east of Sod Island at Inishbonane, adjacent to the townland of Clonmoney South (Fig. 10). Inishbonane or Tradree Point, as it is also known, is a prominent headland that is only fully exposed during spring low tides. Inishbonane 1 is a large head weir, with its mouth orientated down stream in order to catch fish such as salmon moving up the channel with the flooding tide. A wooden platform or perch may have been used at the eye for hanging a net. The good state of preservation has suggested an 18th or 19th century date but it may be on the site of an earlier weir as there are references dating to 1703 refer to a salmon-weir at 'Clonmunny farm'.

Another post-medieval fishtrap can be found further east, near Quay Island, just west of where the Owenagarney River joins the Shannon estuary (Fig. 12). In fact there are a number of post-medieval intertidal features around this island, such as two wooden jetties or piers and a stone built causeway leading to Moyhill. The intertidal survey carried out by O'Sullivan identified very few quays and landing-places, possibly because boats there would have been drawn up onto the mudflats and marshes. These examples appear to be related to the use of this island as a pilotage for Limerick City in the 19th century. The fish trap, Quay Island 2, is a large U-shaped wooden fishtrap of unusual construction, with a narrow internal enclosed space and a rounded end. It is made up of two converging fences, each consisting of a double row of vertical wooden posts. There is a low mound of limestone slabs inside the flood fence, perhaps to prevent it from being undercut by erosion. This structure is thought to be a head weir, orientated so as to catch fish on the flooding tide and is thought to date from the mid-19th century.

More traps are evident at Bunratty, on the north bank of the estuary (Fig. 12). These fishtraps are situated in the mudflat creek that slows south-eastwards across the mudflats, midway between Illaunbeg Point and Quay Island. The Medieval fishtrap discussed earlier was situated some 100m south-east of these examples. Bunratty 7 is a single post alignment of four roundwood posts, stretching 5m across the creek. Bunratty 8, c. 10m north of Bunratty 7, is also a single post alignment. It is 8m long, consisting of at least 17 roundwood posts, and crosses the creek and runs up along the northern bank. Bunratty 9, c. 60m north-west of Bunratty 8, is a double post alignment measuring c. 9m in length and comprised of at least eleven posts. Immediately downstream are three obliquely set posts, acting as braces for the main vertical structure. These three structures were probably small creek traps designed to catch fish in the water draining out of the mudflats at low tide. Similar creek traps were observed to the east, Bunratty 10 and 11, but there were not recorded in detail by O'Sullivan.

To the east of Quay Island is another island, called Green Island (Fig. 12). A single post alignment (Green Island 1) can be found to the south-west of the island, on the firm clays of the sloping foreshore. It runs diagonally down the foreshore from a low stone mound or ballast dump in a north-east/south-west direction. It is c. 17m long and consists of at least 36 regularly spaced, vertical roundwood posts. The structure is thought to be either the remains of a post-and-wattle flood fence of a small head weir or may be the poles of a small stake-net weir. It is probably post-medieval or modern in date.

Further east on the north bank of the estuary is Bush Island (Fig. 15). There are fishtraps located off both the western and eastern shores of the island. On the west and north-west shore a particularly large creek hooks around the island and enters the estuary between Bush island and Green Island, while on the east shore a wide, shallow creek appears from the north-east during the ebbing tide. At least eighteen fishtraps, of varying size and complexity, have been recorded around the island.

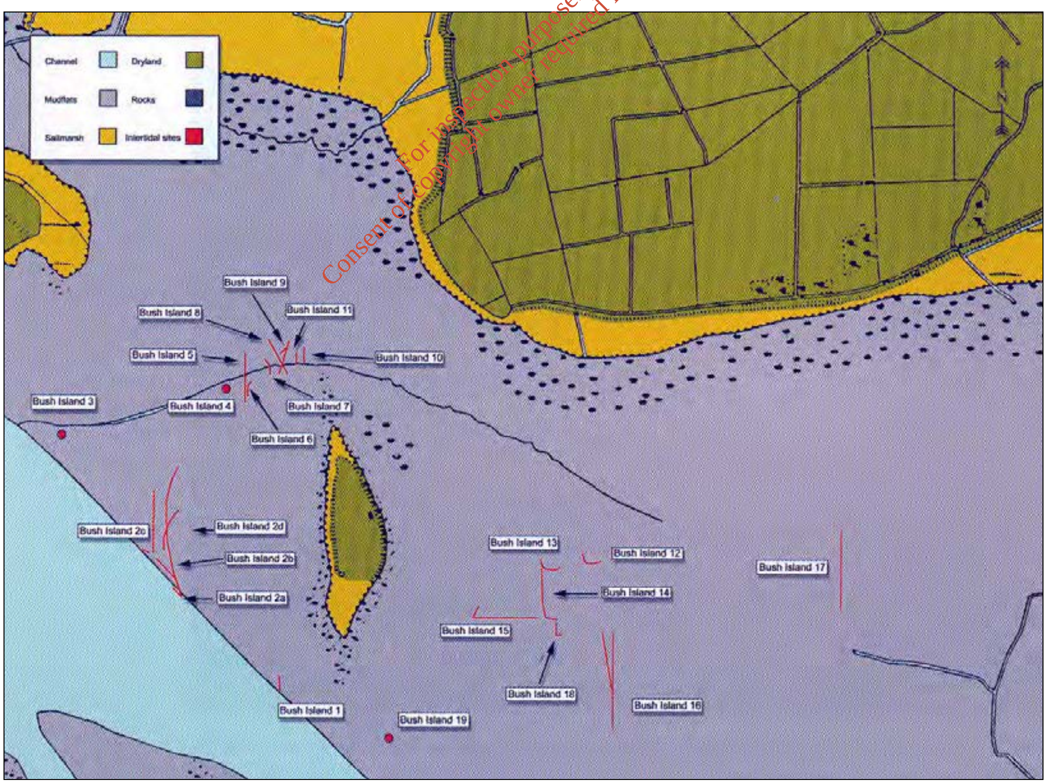

Figure 15: Location of Post-Medieval Fishtraps at Bush Island, Co. Clare (O'Sullivan, 2001).

Bush Island 4-11 are a concentration of at least seven creek traps in a very confined area, indicative of the good fishing that must have been in the area. They are thought to represent several phases of activity. The structures are depicted on the OS 1st edition map but not on subsequent ones, thereby suggesting their use during the mid-19th century, although Bush Island 4 may be of medieval date. The structures Bush Island 12 to 18 represent several different types of fishtrap, such as C-shaped, L-shaped and straight post alignments. Bush Island 14 was depicted on the 1st edition OS map of 1841 but not subsequent editions. These head and stake weirs are probably 18th to 19th century in date and may have been owned and maintained by the landlords, labourers and tenants of Ballymorris House, which is located on the mainland to the north.

There are also a number of post-medieval fishtraps on the south side of the estuary. Just opposite of Bush Island is Carrigdirty Rock, where Neolithic and Bronze Age sites have already been discussed. Two post-medieval fishtraps and two possible post-medieval trackways have also been discovered (Fig. 6). Carrigdirty Rock 12 consists of a post-and-wattle panel measuring 2.2m long and 1m wide, c. 80m south-west of Carrigdirty Rock, on the mudflats just north of the creek. It has been interpreted as a trackway providing access to the mudflats south of the rock. Another post-and-wattle panel can be found at Carrigdirty Rock 13, beside a saltmarsh cliff, to the south of the mudflat creek. It measured 2.5m in length and 60cm wide, with other roundwood poles in the surrounding area. It has been interpreted as a trackway or platform providing access for fishermen accessing the saltmarhes to get to the nearby fishtraps.

Carrigdirty Rock 14 is located on the upper foreshore near Carrigclogher Rocks, c. 160m south-west of Carrigdirty Rock. It consists of a substantial post-and-wattle fence and is c. 60m long. It is thought to represent the remains of a stake weir, designed to catch fish moving upstream or downstream between the island and the marshes. Carrigdirty Rock 15 is located on the main Shannon estuary channel at the low water mark, c.160m west of Carrigdirty Rock. It consists of a vertical post-and-wattle fence running 16m diagonally down the foreshore to below LWM. It appears to be the shore fence of a tidal head weir, orientated to catch fish on the flooding tide. It is of unknown date its small size and poor sate of preservation suggests a late medieval or post-medieval date.

Further west, on the shore opposite to Bunratty, and south east of Sod Island, is Maiden Rock (Fig. 11). The post-medieval fishtraps and post-and-wattle (LI004-031) at Maiden Rock are located adjacent to the townland of Mellon, Co. Limerick. They are situated on the west bank of the River Maigue, directly north of Rinekirk Point. There are at least five wooden structures, of which Maiden Rock 1 and 2 are substantial post alignments running down towards the River Maigue channel, Maiden Rock 3 is a post-and-wattle panel at the LWM and Maiden Rock 4 and 5 are two small post alignments at the rock itself.

Maiden Rock 1 is on the foreshore immediately north of Rinekirk Point, running from the saltmarsh towrds the main river channel. It consists of a single post alignment running some 80m on a north-east/south-west orientation. It is constructed from c. 40 roundwood posts driven vertically into the clay. This structure is thought to be a 19th century stake-net weir, where a net was hung from the fence and weighted down with small stones against the force of the tide. Maiden Rock 2 is located also located on the estuarine clays, around 60m north-west of site 1. It too is a single post alignment, set on the same orientation, but appears to be shorter, at c. 30m long. This is also likely to be a stake-net weir but possibly earlier in date than site 1 and designed to catch fish coming down the River Maigue with the ebbing tide.

Maiden Rock 3 is on the estuarine clays just above the LWM on the channel of the River Maigue, just north-west of site 2. It consists of a horizontal post-and-wattle panel, exposed over an area measuring 5m by 2m. This panel is made from strong posts, around which some roundwood rods were woven. O'Sullivan has suggested that the panel may have been part of a trackway providing easier access to the end of the fishtrap or it may simply be a panel that drifted away from it original vertical structure. This structure is also thought to be post-medieval in date. O'Sullivan has also suggested that the fisheries around Maiden Rock were owned by the occupants of Mellon House in the adjacent townland. Maiden Rock 4 and 5 were two post alignments to the west of sites 1, 2 and 3, measuring 10-15m in length. They are situated to the south of the rocks, orientated north-west/south-east, and appear to be small creek traps of modern date.

Other post-medieval features in the landscape include the church and graveyard at Mellon (LI004-00801, LI004-00802). These are the ruins of a Protestant church built in 1738, on the site of an earlier Catholic Church. This earlier church was known as Ardcanny Church, which was also once the parish name of the area. This was derived from the Irish 'Árd Caithne', meaning 'height of the arbutus tree'. To the east of the church site is a holy well (LI004-003). While often holy wells have no artificial features associated with them or if they do, they are frequently of modern construction, these places are often of ancient tradition. Some wells are found associated with ecclesiastical sites, while others may have their origins in pre-Christian well veneration and ritual activity. On the other hand some wells are of quite recent origin but it is often difficult to determine which is the case.

Early Modern

Large head weirs continued to be constructed and used at various locations along the estuary in the 19th century before they were prohibited in the middle of that century due to their danger to navigation and fish stocks.

In the early 19th century nearby Bunratty contained 1200 inhabitants. Up until a few years before Lewis's, in the early 1800's, the castle there was the residence of T. de Clare Studdert, who also erected a ‘mansion’ in the demense. The old castle was then being used as a police barracks. It was described by Lewis as ‘a lofty and massive quadrangular structure, with a tower at each angle’. Studdert had also built a fine one-arched bridge over the Owenagarney River, along with a commodious quay, which was about to be enlarged, although boats of a large nature could already come alongside. Lewis notes that considerable amounts of ‘sea manure’ were landed here for use in the local area, along with turf, which was commonly brought from Kilrush. At the mouth of the Owenagarney River is Quay Island. The anchorage off this island, which was known as Bunratty Roads, was considered to be the best in the Shannon. It was here that the West India vessel discharged their cargoes for Limerick. Saints Island was considered to contain the richest land, and was inhabited by two families.

3.1.2 Maritime Archaeology and History

In an environment such as the Shannon estuary, boats would always have been one of the primary means of communication and transport. Prehistoric and early medieval people who inhabited the land around the estuary must have made extensive use of dug-out boats and other vessels, examples of which were found in the Fergus estuary. Plank-built boats and vessels constructed with reeds may also have been in use. Skin covered vessels, such as currachs and corracles were also commonly used in Irish waters. The arrival of the Vikings at the end of the 8th century would have introduced new boat building practices to the Irish. The Shannon estuary would have been attractive to the Vikings, given its strategic and economic importance. It is known that a Viking fleet and stronghold were established on these waters by the early part of the 9th century, and became a raiding base for much of the inland waterways of the country. Native Irish fleets were also active on the Shannon at that time.

The arrival of the Anglo-Normans in 1169 led to much economic and social changes in the country. Many urban centres became successful ports and the protection of these ports and the safe passage of shipping was essential. Galleys, which were wooden, clinker-built, double-ended ships powered by oars, were employed to provide this protection. Bunratty, which seems to have acted as an outport for Limerick, was home to a number of galleys. The increase in mercantile activity led to a need for vessels with larger cargo-carrying capacity. This saw the emergence of the cog, which must have been commonly seen in the Shannon estuary. These vessels were clinker built and had flat, flush-laid bottoms.

Further developments in ship construction in the early 15th century. Carvel construction, with planking laid end to end, became more common, but the clinker method was seen found on smaller, more localised vessels. This saw a variety of new vessel types coming to Irish shore. The advantages of the Shannon estuary to these sea going vessels was that vessels of 200 tons could dock over 60 miles from the sea, a fact that allowed Bunratty to be involved in overseas trade.

The 18th and 19th centuries saw an intensification of maritime activity around the Shannon estuary. There was a general increase in shipping and a boom in coastal industries, which required waterfront facilities and vessels to transport their goods. By the mid-18th century ships from Limerick port were involved in large-scale exportation of its hinterland's agricultural surplus to Europe and further afield.

With this amount of shipping activity over the years, there must also have been a considerable number of vessels lost in the estuary. Recording of shipwrecks was only initiated in the 1740's by Lloyd's, an insurance and shipping company in London. It was not until the middle of the 19th century that the systematic recording of shipwrecks was carried out by the British Board of Trade. These sources were usually only concerned with larger vessels so the loss of smaller, more localised vessel would have gone unrecorded, unless it features in local newspapers. Therefore the following list of shipwrecks is not a complete listing of vessels lost in the estuary around Sod Island and is biased towards vessels of a post-1740 date.

There are no records of any vessel being lost on or near Sod Island, but the closest loss appears to be *Treenaglass*, a 1513-ton steamer, ran aground and broke amidship at Bridges Bank, near Palaskenry (possibly Pallaskenry), Shannon estuary on 1 August 1833. There are a considerable number of vessels that have very general information on their place of loss. These have been included below, as there is a possibility that there were lost in the vicinity of Sod Island:

- *Alice*, foundered in a gale in the Shannon on 30 March 1814;
- *Catherine*, was lost in the Shannon on the 4 November 1849;
- *Cicero*, was wrecked on the River Shannon in 1833;
- *Defiance*, lost in the Shannon in 1835;
- *Elizabeth and Mary*, went ashore in the Shannon on the 13 January 1843 but was got off;
- *Flora*, went ashore near Limerick in September 1802;
- *Georgina*, a schooner, collided with the SS Vale of Calder on the Shannon on the 9 May 1884 and sank immediately;
- *Hannah*, was lost near Limerick on the 22 January 1747;
- *Lark*, was lost in the Shannon on 28 January 1803;
- *Mary*, parted from her anchors and went ashore in the Shannon on the 24 December 1811;
- *Myrtle*, a 100ton vessel, was wrecked in the Shannon in 1828;
- *Peggy*, was lost in Limerick River in December 1790;
- *Solidade*, went ashore and was seriously damaged in Limerick River on the 28 December 1781;
- An unnamed French longboat capsized while transferring men to another ship in the River Shannon on the 4 November 1691; and
- An unnamed smack was lost in the Shannon in November 1850.

3.1.3 Conclusion

The Shannon estuary has long been occupied and exploited by humans. Prehistoric foragers and farmers, medieval and postmedieval fishermen, mariners, farmers, landlords and labourers have worked on the land, foreshore and the waters themselves. While some of the archaeological remains from these people have been known about for a long time, others such as the numerous fishtraps were only discovered in recent years. As parts of the estuarine muds continue to be eroded more archaeological features may be revealed; likewise with the shipwreck record. There must be many more vessels lying in the estuarine muds, the place and time of loss forgotten. The potential for uncovering archaeological material in the vicinity of Sod Island is high, given the proven level of activity in the estuary in the past and the quality and frequency of archaeological remains already recorded.

3.1.6 Sites and Monuments Record

The Sites and Monuments Record for the area adjacent to the proposed development site at Sod Island, Shannon Estuary, is detailed in Table 3.

Site No.	Sh/Pl/Tr	NGR	Townland	Class
LI003014	003/12/4	14088/15734	Shannongrove	Windwill
LI003015	003/12/4	14100/15722	Shannongrove	Potential site
LI003016	003/12/4	14106/15699	Shannongrove	Enclosure
LI003018	003/16/1	14128/15665	Shannongrove	Enclosure
LI003019	003/16/1	14131/15653	Shannongrove	Enclosure
LI003024	003/12/6	14250/15701	Ballydoole	Enclosure
LI003028	003/12/5	14157/15697	Shannongrove	House
LI004002	004/13/1	14338/15674	Cartown	Enclosure
LI004003	004/09/4	14366/15679	Cartown	Holy well
LI004005	004/09/2	14415/15764	Mellon	Enclosure
LI004006	004/13/2	14434/15651	Mellon	Enclosure
LI00400801	004/13/2	14451/15672	Mellon	Church
LI00400802	004/13/2	14451/15672	Mellon	Graveyard
LI004023	004/09/6	14491/15696	Mellon	Castle (possible site)
LI004031	004/09/3	14497/15801	River Maigue	Fish trap(s)
CL061007	061/08/1	142559/15989	Saints Island	Enclosure
CL061008	061/04/1	14274/16160	Clonmoney West	Motte and bailey
CL061009	061/04/1	14314/16143	Clonmoney West	Ringfort
CL061010	061/04/2	14344/16185	Clonmoney West	Possible enclosure
CL061012	061/04/2	14397/16174	Clonmoney North	Potential site
CL06101301	061/08/3	14484/15958	River Shannon Bunratty West	Fish weir
CL06101302	061/08/3	14483/15951	River Shannon Bunratty West	Fish weir
CL06101303	061/08/6	14485/15938	River Shannon Bunratty West	Fish weir
CL062001	062/01/4	14498/16092	Bunratty East & Bunratty West	Historic town
CL06203101	062/05/1	14507/16022	River Shannon Bunratty West	Fish weir
CL06203102	062/05/1	14503/16013	River Shannon Bunratty West	Fish weir
CL06203103	062/05/1	14503/16007	River Shannon Bunratty West	Fish weir

Table 3: Sites and Monuments Record for the area adjacent to the proposed development site at Sod Island.

3.2 Site Surveys

3.2.1 Geology and seabed sediments

The substrate at the proposed development is characterised by low backscatter returns without texture, indicative of fine muddy seabed (Fig. 16). Little of no bedform development at the site provides further indication of this fine silty mud. Figs. 16 displays the mosaic sonograph of the survey area.

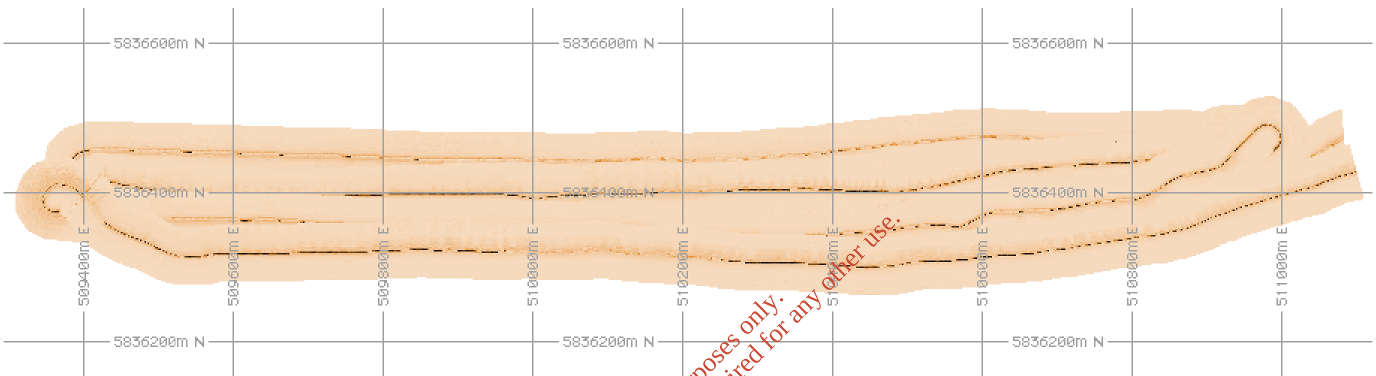

Figure 16: Mosaic sonograph showing the low to medium-high backscatter returns at the location of the proposed dump site. (Co-Ordinates UTM)

3.2.2 Bathymetric Data

The bathymetric data of the site are displayed as a 2-dimensional and 3-dimensional contour plots in Fig. 17. Bathymetry ranges from <1m on the north-western margin of the survey area, to a maximum depth of over 6m in an isolated depression of approximately 0.4km x 0.2km to the north east. The survey zone's shallow area (<2m) extends for approximately 1km in the direction of the Estuary's South Channel. The majority of the survey identified bathymetry in the range of 2-2.7m. From Fig. 17, it is apparent that the proposed development extends across a range of depths from 2m-6m.

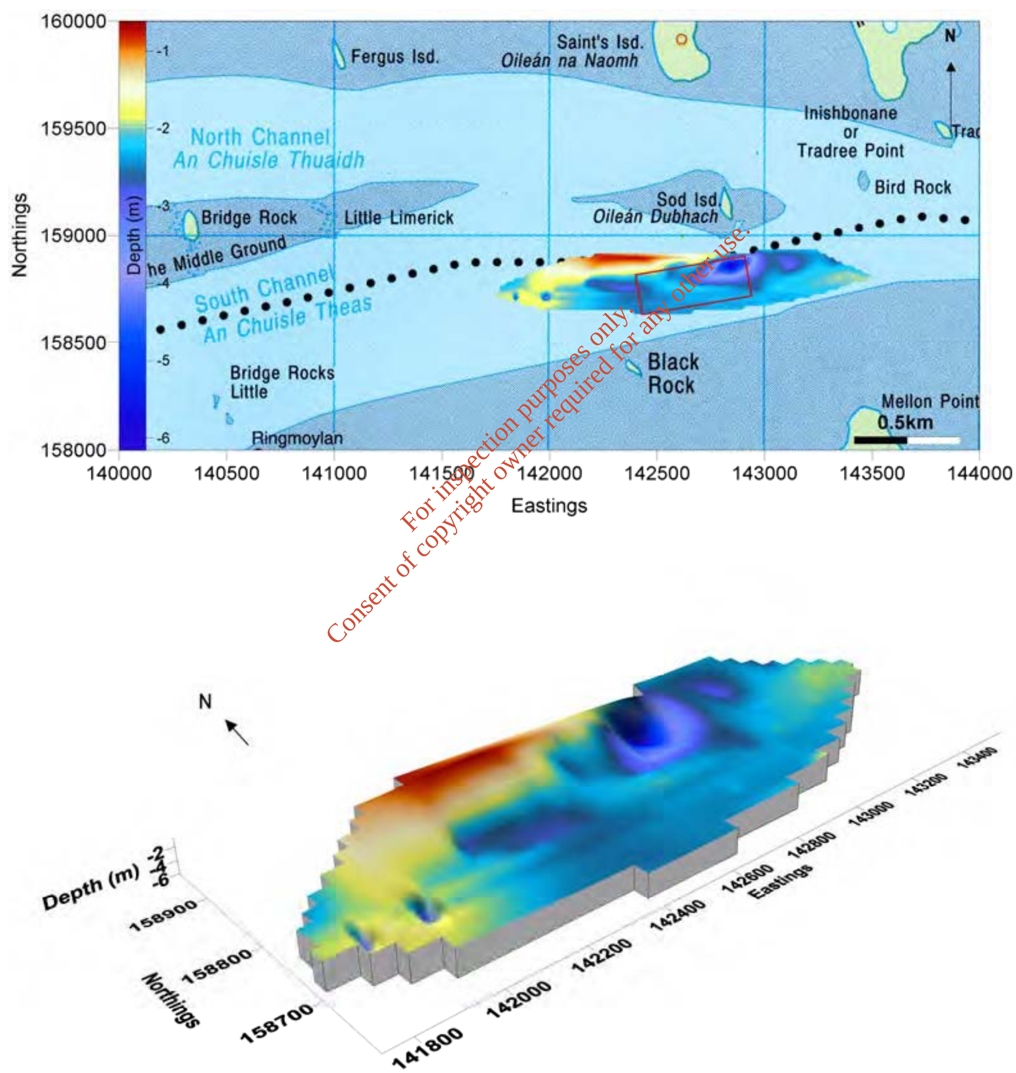

Figure 17: 2- and 3-dimensional contour plot of bathymetric data overlain on Discovery Series Map 65 (OSI, 1999, 2nd Edition).

3.2.3 Magnetic Survey

The results obtained from the magnetometer survey range from +200nT to –1200nT on a background of 0nT. The results are presented in Fig. 18 as 2-dimensional and 3-dimensionsal contour plots of magnetic deviation.

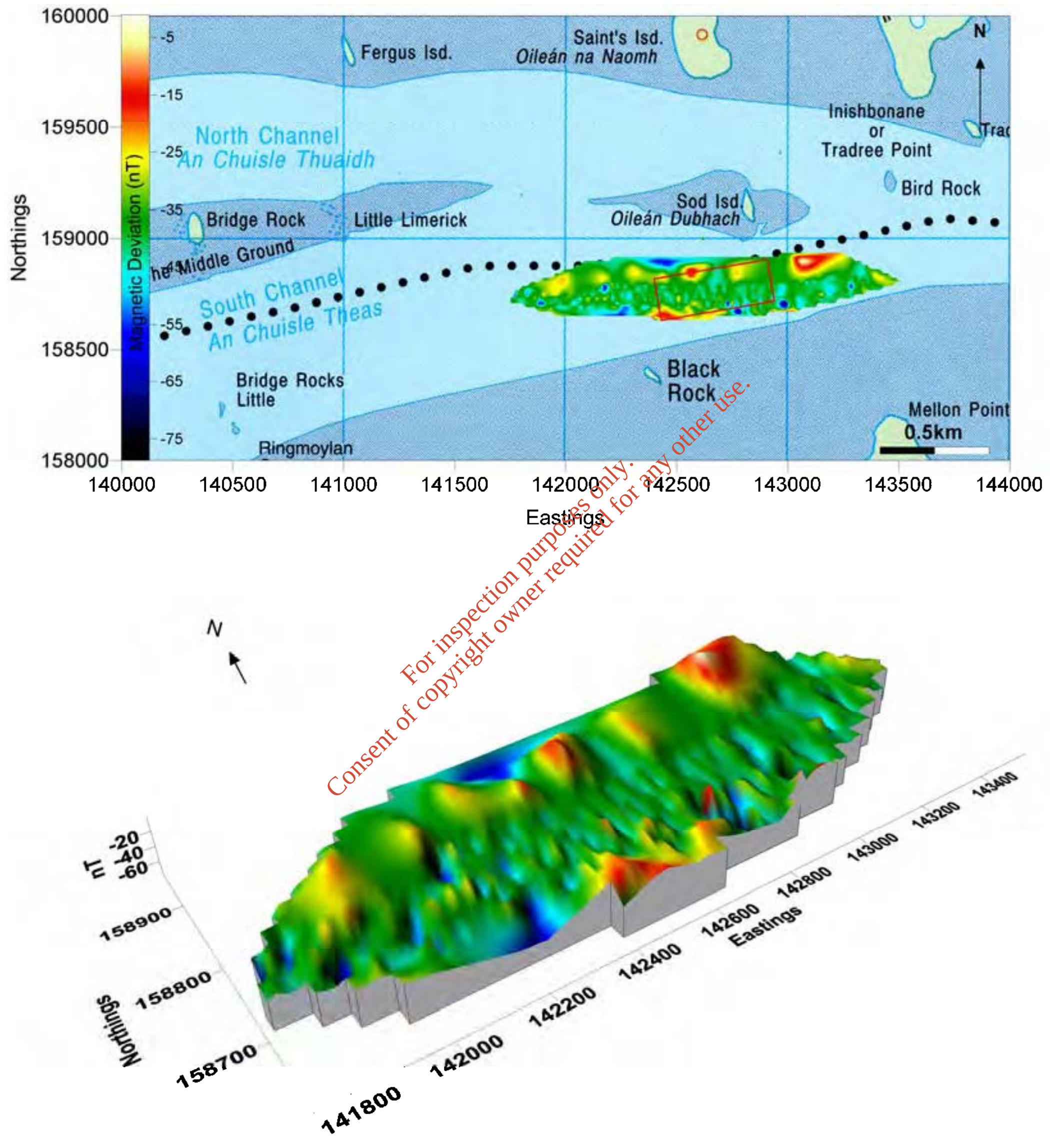

Figure 18: 2- and 3-dimensional contour plot of magnetic data overlain on Discovery Series Map 65 (OSI, 1999, 2nd Edition).

The results are dominated by magnetic deviation in the range of -35 to -45nT, interspersed with areas of approximately –50nT. There are nine anomalous magnetic signatures (M1-M9) in the survey data. The identification tag and position of each is presented in Table 4. Fig. 19 displays the location of the anomalies overlain on a chart of the survey area. The west of the survey area, from 142400E, is interspersed with anomalies of approximately –60 to –65nT, while east of this point, the majority of anomalies are between –10 and –20nT. Both areas are, however, widely-interspersed with minor deviations. In terms of the data range, M8 is the most significant large anomaly, with a deviation of up to –5nT and an area of approximately 1km^2. Sites M2 and M8 are the only anomalies on the fringes of the development, while the majority is clustered around the proposed site.

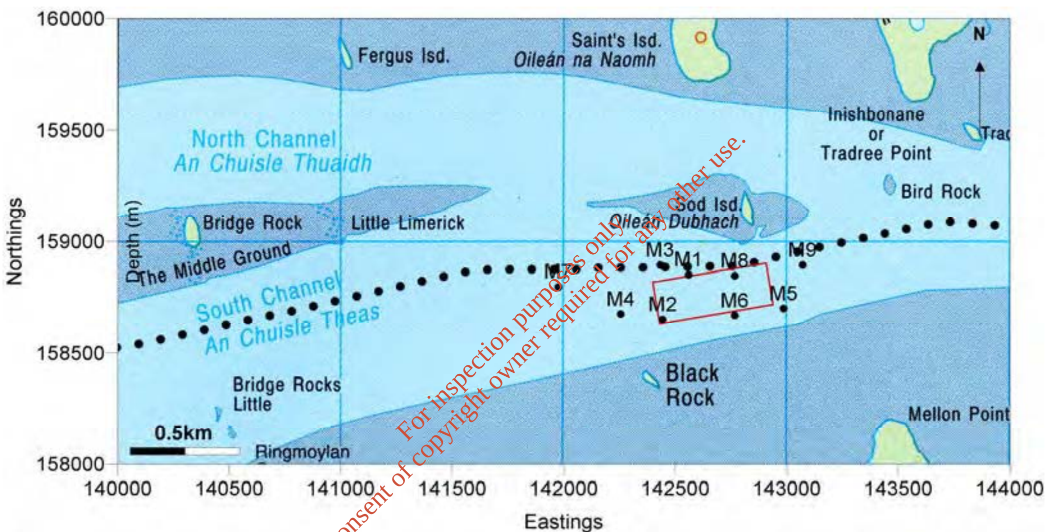

Figure 19: Anomaly positions and ID tags for the 9 magnetic anomalies identified at the site overlain on Discovery Series Map 65 (OSI, 1999, 2nd Edition).

ID/Tag	Easting	Northing
M1	142559.855106	158852.178273
M2	142444.221165	158651.340946
M3	142432.048714	158894.7806
M4	142255.555001	158675.684601
M5	142985.874133	158700.028877
M6	142766.778704	158669.598998
M7	141975.599179	158797.404739
M8	142766.778704	158846.09267
M9	143071.078187	158894.7806

Table 4: Co-ordinates and ID-tags for the anomalies interpreted from magnetic contour plot of the survey area. Their location is shown in Fig. 19.

3.2.4 Side-scan sonar survey results

No anomalies were interpreted from the side-scan sonar survey south of Sod Island, Shannon Estuary, Co. Limerick.

3.2.5 Data integration and interpretation

The spatial relationship between bathymetry, magnetic anomalies M1-M9 and the development site is displayed in Fig. 20. The shallow bathymetric data reflects the submarine morphology of Sod Island. The proposed development is directly associated with magnetic anomalies M2 and M8 and with a range of water depths greater than 2m, including the deepest area of the channel. With strong indications of extensive anthropogenic activity in the area, and the field of minor deviations exposed in the magnetic data in Fig. 18, it is likely that the magnetic results reflect cultural debris at the site. These have not been displayed on the 500kN side-scan sonar record at the site, likely due to accretion of fine muddy riverbed material.

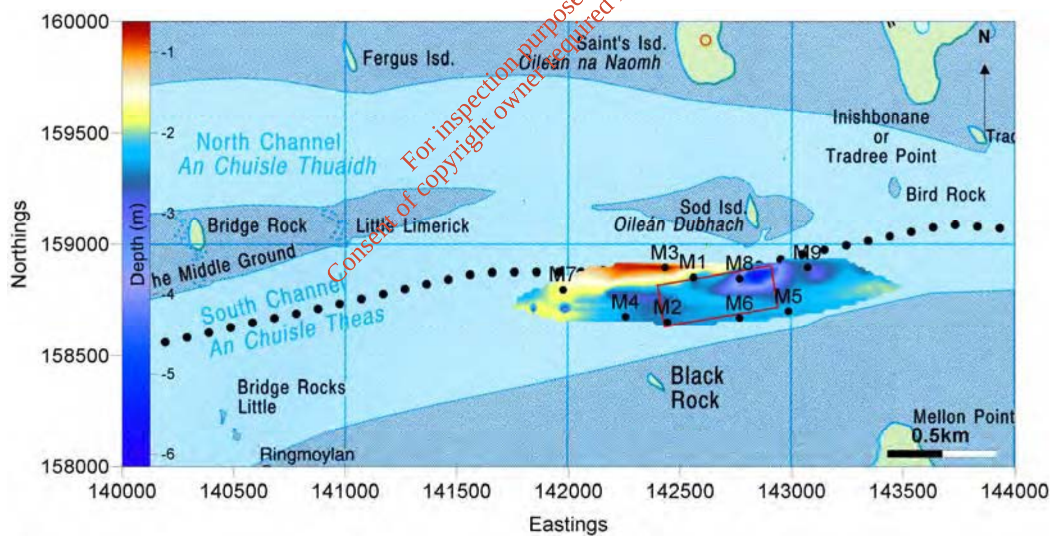

Figure 20: Bathymetry, magnetic anomalies M1-M9 and the development site overlain on Discovery Series Map 65 (OSI, 1999, 2nd Edition) of the Shannon Estuary.

4 CONCLUSIONS

- No sites of archaeological potential are interpreted from 500 kHz side-scan sonar data acquired in the survey of the proposed cable site.

- Nine magnetic anomalies are identified from the site, however only anomalies M2 and M8 are in direct association with the proposed development. With strong indications of extensive anthropogenic activity in the area, and the field of minor deviations, it is likely that the magnetic results reflect cultural debris, which has been buried by sediment accretion processes at the site.

- The proposed development is unlikely to have an adverse effect on any potential buried cultural material, as it will lie on the seabed and involves no invasive activity on the riverbed.

5 RECOMMENDATIONS

- The proposed dump site for dredged material should proceed south of Sod island, Shannon Estuary, Co. Limerick.

- Procedures for archaeological monitoring during engineering works are not required as the development involves no dredging or invasive activity on the riverbed.

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