

11. GEOLOGY AND SOILS

This Chapter of the EIS identifies, describes and assesses the impact of the proposed development on soils, geology and hydrogeology including the treatment of contaminated marine sediments within Alexander Basin West.

The geological and hydrogeological regime has been established from the results of ground investigations, a review of mapping records and walkover surveys of the site. Marine sediment quality has been established through a comprehensive sampling and analysis programme developed through consultation with the Marine Institute.

11.1 ASSESSMENT METHODOLOGY

Introduction

In the absence of a formal methodology for assessing the extent and degree of impact that the ABR Project may have on geology and hydrogeology, the approach has been based on the document produced by the Institute of Geologists of Ireland, "Geology in Environmental Impact Statements – a guide", September 2002. This document outlines the likely impacts and potential mitigation measures for geological issues by topic, although no importance criteria are given by which the impact can be graded.

Desk Study

A geological desk study was carried out for the development using the following sources of information:

- Ordnance Survey of Ireland, Discovery Series,
- Ordnance Survey of Ireland online historical maps and aerial photographs,
- Environmental Protection Agency online mapping www.epa.ie,
- Geological Survey of Ireland 1:100,000 scale bedrock series geology map Sheet 16 Geology of Kildare-Wicklow, 1994.
- Geological Survey of Ireland online mapping public datasets viewer <http://www.gsi.ie/Mapping.htm>,
- IGSL, Ground Investigation Report, Alexandra Basin Redevelopment, 2014.
- Glover Site Investigations Ltd., Dublin Port Borehole and CPT Contract, Alexandra Quay East. Report No. 06-221-AQ, 2006.

11.2 EXISTING ENVIRONMENT

11.2.1 Solid Geology

Regional Bedrock Geology

The solid (bedrock) geology of the region (Figure 11.1) comprises a sequence of sedimentary rocks that are assigned to the Calp Formation of the Carboniferous era. These Lower Carboniferous strata range in age from Chadian to Brigantian. The Carboniferous sequence indicated by the geological map comprises dark grey fine grained limestones with interbedded, black, poorly fossiliferous shales. Limestone bed thickness, grain size, colour and proportion of shale vary widely whilst Chert is locally common. These rocks were originally deposited as sediments in a marine basin that opened during continental rifting.

To the south of Dublin is located the Leinster Granite batholiths which stretches from Dun Laoghaire to New Ross. It consists of five, generally north northeast-trending plutons, which are individually aligned within the northeast-trending regional foliation in the lower Palaeozoic host rocks. The granite was intruded during the Caledonian deformation. The granites mainly form upland regions, however they are poorly exposed due to rounded contours with a blanket of peat.



Figure 11.1 Geology in and around Dublin Port

Local Bedrock Geology

An investigation carried out by Glover Site Investigations Ltd. in 2006 within the adjacent Alexandra Quay East indicated that the bedrock underlying the local area comprised moderately strong to strong, slightly laminated, grey to dark grey, fine to medium grained LIMESTONE with layers of Shale and occasional calcite veining.

Dublin Port is located entirely on made ground (fill deposits). Therefore there are no natural rock outcrops present on the site.

11.2.2 Drift Geology and Recent Deposits

Drift is a general term applied to all mineral material (clay, sand, silt, boulders) transported by a glacier and deposited directly by or from the ice, or by running water emanating from the glacier. It generally applies to Pleistocene glacial deposits.

The drift geology of the area principally reflects the depositional process of the last glaciation when an extensive ice sheet that extended into the Irish Sea covered the region. Typically during the ice advance boulder clays were deposited sub-glacially as lodgement till over the eroded rock head surface, whilst moraine deposits were laid down at the glacier margins. Subsequently, with the progressive retreat of the ice sheet from the region, fluvio-glacial deposits (sand, gravel and silt) were laid down by melt waters discharging from the front of the glacier. Recent deposition prior to reclamation of the site principally reflects marine erosional and depositional processes, which have modified the glacial deposits.

11.2.3 Site Specific Geology

A site investigation was carried out by IGSL Ltd between December 2013 and February 2014. The investigation comprised 12 Boreholes advanced by cable percussion with follow on rotary drilling. Boreholes were advanced to a maximum depth of 25.0m below ground level (bgl).

Made Ground (Fill Deposits)

Made Ground deposits were encountered from 0.15m bgl to a maximum depth of 10.6m bgl. The Made Ground deposits comprised the following;

- Grey, sandy, gravelly fill with steel/pipe pieces, coal, timber, cobbles and boulders;
- GRAVEL with cobbles and shells;
- Coarse GRAVEL fill with cobbles and boulders;
- Clay, gravel, sand, large cobbles, red and yellow brick fragments, timber, steel, glass and plastic;
- Rubble fill with glass and plastic;
- Black, clayey, fill with metal, timber and glass; and
- Sandy, gravelly fill with shell fragments, cobbles and boulders.

Recent Deposits (Estuarine)

The recent estuarine deposits were generally encountered below the Made Ground deposits and comprised; stiff, grey, black sandy SILT, soft to firm, black sandy SILT and stiff, brown, slightly gravelly, sandy SILT. This horizon ranged in thickness from 0.5m to 4.9m in thickness.

Glacial Deposits

The glacial deposits were generally encountered as fluvio-glacial sands and gravels with Clay at greater depth. The sands were encountered as; Grey silty SAND with cobbles, Loose brown/grey SAND, Medium dense, grey/brown silty SAND, Dense black, slight gravelly SAND with cobbles and Medium dense, grey SAND with cobbles. The sand horizons ranged in thickness from 0.4m to 5.5m in thickness.

The gravel was encountered as; Dense, grey, slightly sandy GRAVEL with cobbles, Dense, grey angular GRAVEL, Dense, fine to coarse, grey, slightly clayey GRAVEL, Dense, fine to coarse, sandy, grey/brown GRAVEL with cobbles and occasional boulders and Medium dense, grey, sandy GRAVEL with cobbles and boulders. The gravel horizons ranged in thickness from 0.7m to 8.8m in thickness.

Possible Boulder Clay was encountered within one borehole only and comprised; hard, black, sandy gravelly CLAY with occasional cobbles. The clay layer was encountered from 19.50m bgl until the end of the borehole at 24.80m bgl and is unproven beyond this depth.

Bedrock

Ground investigations undertaken in Alexander Basin East have shown that the Limestone rock head level in the vicinity of the Alexandra Basin Redevelopment are at circa -35m Chart Datum (CD), 25m below the design dredge level of -10m CD.

11.2.3 Hydrogeology

Hydrogeology is the study of groundwater, including its origin, occurrence, movement and quality. The hydrogeology of the area has been described by the Geological Survey of Ireland as complex and very variable. The Limestone bedrock is generally considered to be indurated and hence dominated by fissure permeability (e.g. joints and faults). Such permeability is likely to be low except where coarse, clean Limestones where present, have been karstified, dolomitised or are highly fractured.

The Quaternary drift is considered the principal medium for groundwater movement in the area. The infiltration capacity of the clay deposits would be limited due to their low permeability and hence groundwater movement is likely to be confined to the fluvio-glacial sand and gravel deposits that overlie the clays.

The Lower Carboniferous rocks that underlie the region have been classified by the Geological Survey of Ireland as "Locally Important Aquifer, bedrock which is moderately productive only in local zones". These locally productive zones are due to the presence of more permeable strata that are encountered in different parts of the outcrop area due to substantial faults, fractures or fissures. The limited groundwater movement within the rock tends to be restricted to the weathered horizons or to non-extensive fractured zones. These zones tend to have a limited hydraulic continuity, low storage capacity and low potential yield.

The potential importance of the Quaternary drift deposits as a groundwater resource is a function of their permeability, thickness and extent. The low permeable fine grained glacial clays represent aquitards that limit infiltration and restrict recharge to bedrock aquifers when sufficiently thick. The overlying fluvio-glacial sand and gravel deposits represent material with a significantly higher permeability. Consequently these deposits have a high potential recharge and storage capacity.

It is generally expected that groundwater levels beneath the site will remain close to sea level and may exhibit tidal variation. During the site investigation, groundwater was encountered during drilling at depths from 3.0m bgl to 5.5m bgl within the Made Ground, Sand and Gravel deposits.

Groundwater at the site is expected to be brackish / saline and unsuitable for potable supply.

11.2.4 Sediments

Sedimentation in the marine environment is a natural phenomenon, occurring by rivers eroding materials in upstream areas and settling suspended matter when the current becomes slower, runoff by lowland rivers or by currents coming from the sea transporting and settling material in protected areas such as ports and harbours.

Marine sediments are not, in themselves polluting substances. However, they can be a sink for contaminants that end up in our harbours and ports, mainly from anthropogenic sources such as sewage discharges, marine traffic, industrial wastewater and historically poor environmental management. Contaminants in sediments can act as a source of long-term environmental pollution. Certain substances can bioaccumulate in benthic organisms resulting in biomagnification at higher levels in the food chain. Some widespread pollutants such as polychlorinated biphenyls (PCB's) are no longer in use but due to their persistence they can still be detected in marine sediments (Gronin, McGovern et al, 2006). It is for this reason that sediments need to be tested prior to dredging so as to determine if any contaminants are present and if so, how they can be dealt with in the arising dredged spoil.

Sediment Quality

The sediment quality and particle size analysis of the marine sediments within Alexandra Basin West and the Navigation Channel from the East Link Bridge to the Dublin Bay Buoy was established through a comprehensive sampling and analysis programme. The Marine Institute advised on the location of the samples and the range of contaminants to be analysed. The sampling programme was undertaken in August 2013 by Hydrographic Surveys Ltd. The sediment quality analysis was undertaken by the National Laboratory Services, Environment Agency for England and Wales. This laboratory is fully accredited for the analysis of the suite of contaminants specified by the Marine Institute.

The location of samples taken within Alexandra Basin West is shown in Figure 11.2 and the location of samples taken in the Navigation Channel is shown in Figures 11.3 and 11.4. The location of samples taken for particle size analysis only are shown on Figure 11.5.

The full results of the sampling programme are presented in Appendix 11.

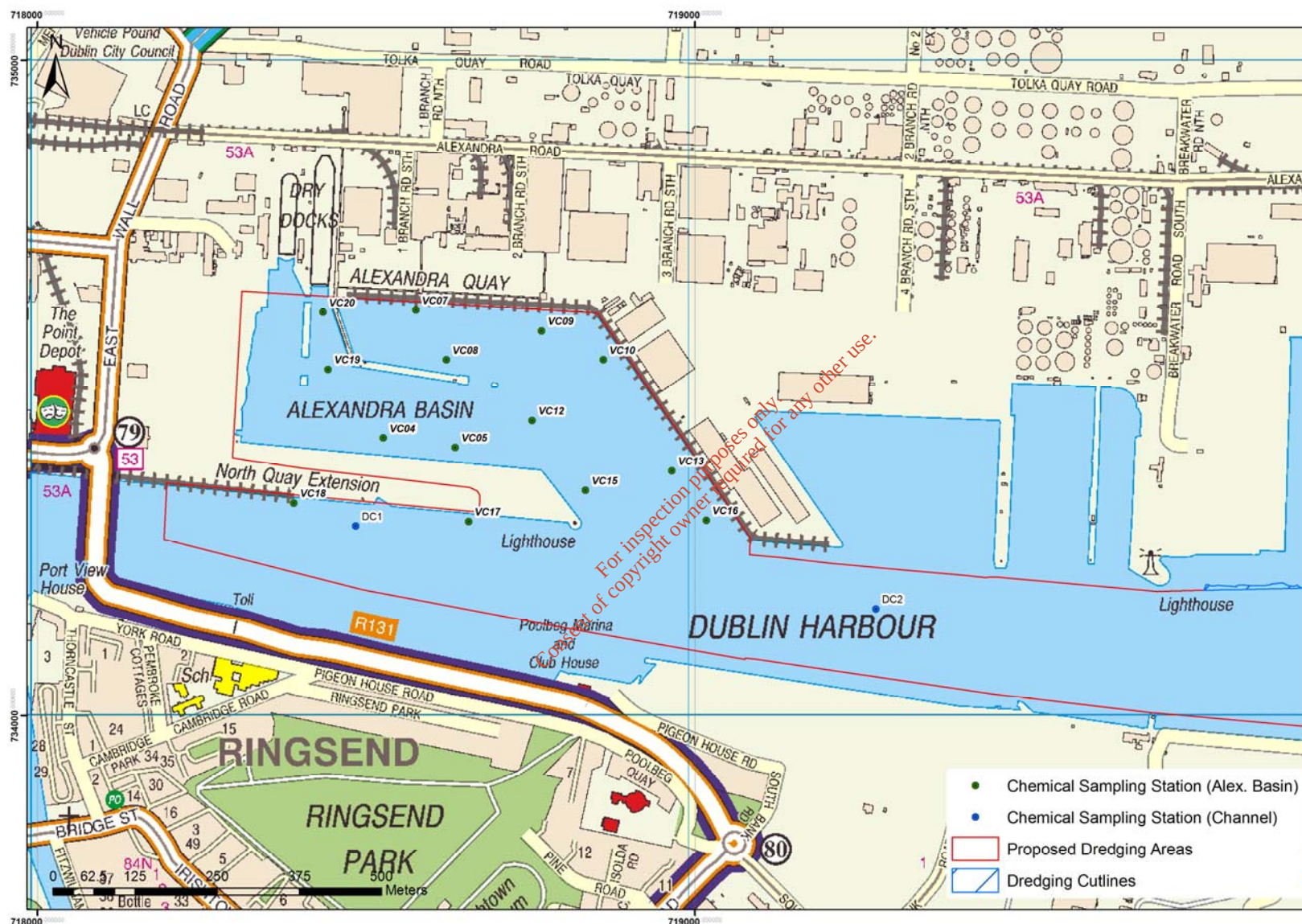


Figure 11.2 Location of samples taken for sediment quality analysis – Alexander Basin West

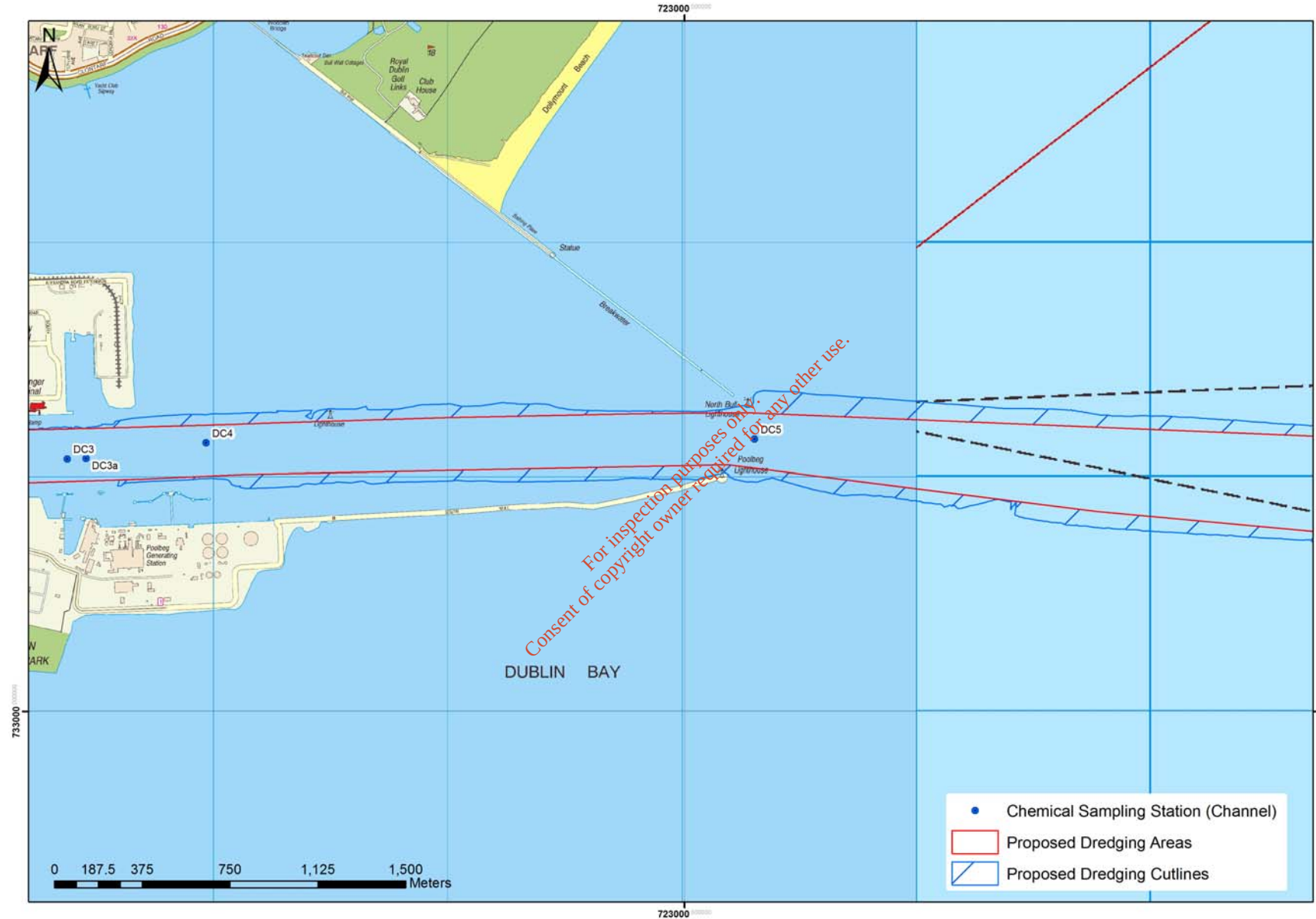


Figure 11.3 Location of samples taken for sediment quality analysis – Navigation Channel

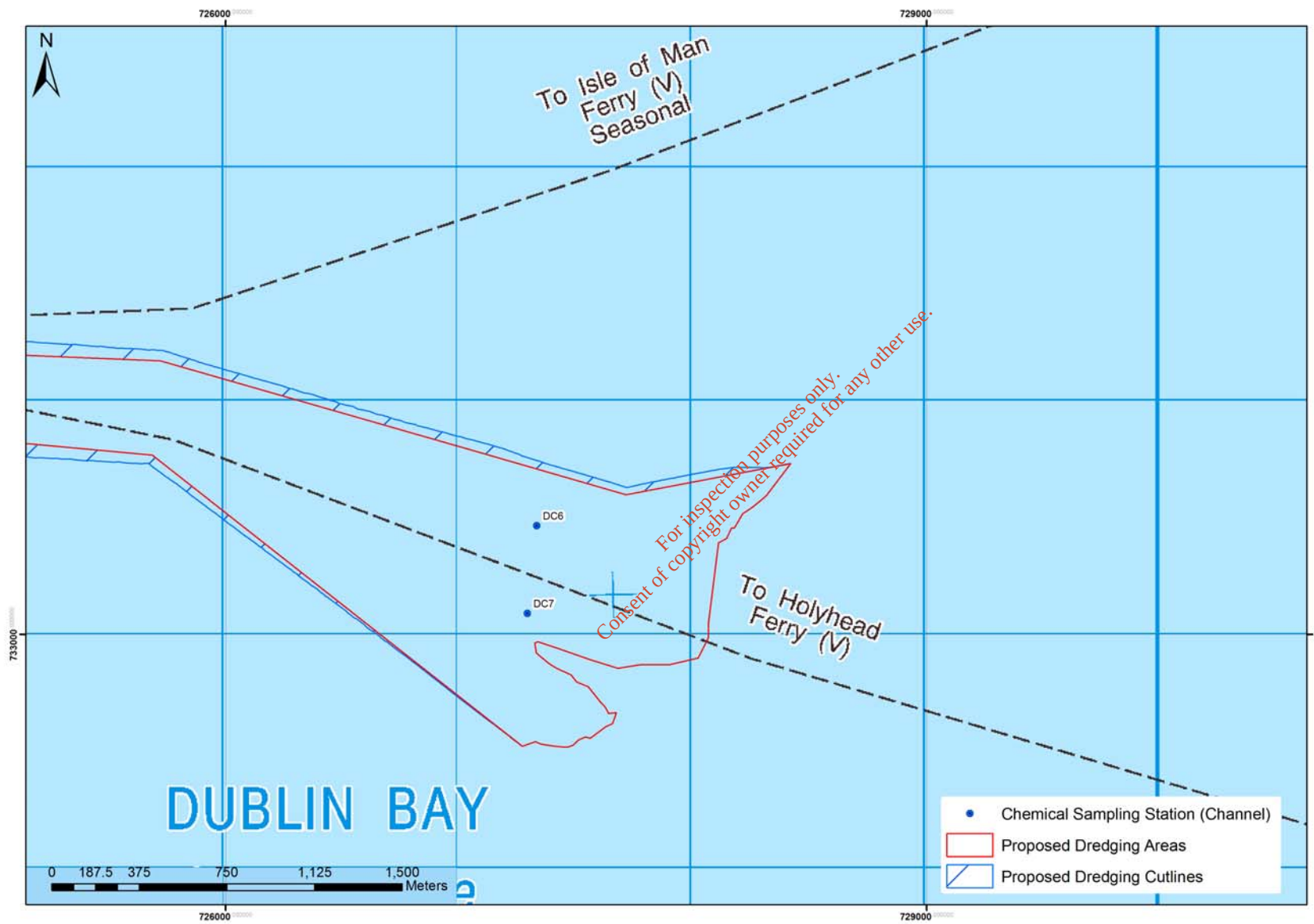


Figure 11.4 Location of samples taken for sediment quality analysis – Navigation Channel



Figure 11.5 Location of Samples taken for Particle Size Analysis

The results of the analysis were compared against Marine Institute Guidelines for the Assessment of Dredge Material for Disposal in Irish Waters (Table 11.1) to assess their suitability for disposal at sea. The results were also sent to the Marine Institute for their independent assessment.

Table 11.1 Guideline values for sediment quality levels

Parameter	Unit (dry wt)	Lower Level Guideline	Upper Level Guideline
Arsenic	mg/kg	9	70
Cadmium	mg/kg	0.7	4.2
Chromium	mg/kg	120	370
Copper	mg/kg	40	110
Lead	mg/kg	60	218
Mercury	mg/kg	0.2	0.7
Nickel	mg/kg	21	60
Zinc	mg/kg	160	410
Sum TBT & DBT	mg/kg	0.1	0.5
γ-HCH (Lindane)	µg/kg	0.3	1
HCB	µg/kg	0.3	1
PCB (individual congeners)	µg/kg	1	180
PCB (sum of 7)	µg/kg	7	1260
PAH (Sum of 16)	µg/kg	4000	
Total Extractable Hydrocarbons	g/kg	1	

Sediment Quality – Alexandra Basin West

The sediments within the Alexandra Basin West were found to be unsuitable for disposal at sea at the majority of locations within the basin.

Parameters which exceeded the upper level guideline were heavy metals (Nickel, Lead, Zinc, Cadmium Copper and Mercury), Tributyltin (TBT), Dibutyltin (DBT) and Total Extractable Hydrocarbons.

Parameters which were between the lower and upper level guideline were Polycyclic Aromatic Hydrocarbons (PAH's) and Polychlorinated biphenyls (PCBs)

The Marine Institute confirmed the results of the assessment and advised that the sediments within the Alexandra Basin West are unsuitable for disposal at sea.

The sediments within the Alexandra Basin West were also assessed with regard to their suitability for use as fill material. Based on the sediment analysis undertaken to date, the sediments do not meet the acceptance criteria for inert waste. Treatment of the sediments is therefore required and proposed prior to use as a fill material within the Berth 52/53 basin and Graving Dock #2.

Treatment of Contaminated Material

Best practice industry techniques will be used to treat the contaminated material yielded from the dredging of the Alexandra Basin. Stabilisation/Solidification (S/S) is a remediation technology that reduces the mobility of contaminants. Immobilisation is achieved by reaction of contaminants with reagents to promote sorption, precipitation or incorporation into crystal lattices, and/or by physically encapsulating the contaminants¹.

The method produces a high strength monolith-like product that physically reduces the mobility and chemically binds contaminants to the produced matrix. The treated mass can then be recovered/recycled to serve as infill material or for beneficial use². This has been undertaken at a number of sites as described in Appendix 11.

The treatment and recovery of the dredging spoil on site will take place in accordance with the conditions of an Industrial Emissions Licence to be obtained from the EPA. Following treatment the material will be placed in Graving Dock #2 and Berth 52/53 as a recovery activity, replacing the need to use virgin materials that would otherwise be required for the development.

Design Mix

The type and amount of binder is to be further explored through an initial laboratory based study to identify the most appropriate binder to be used in the project. Representative samples of the source material will be mixed with the chemical additives to determine the mix proportions required to stabilise the material (bench scale treatability studies). The laboratory testing will determine the percentage of binders to be added to the sediment to be treated. Leaching and diffusion tests on the stabilised material will be compared to the existing baseline background condition (i.e. to ensure that leaching of contaminants from the S/S treated sediment will be less than in the untreated sediment currently in the filling areas). The contaminants in the dredged sediments will be bound to a low-leaching state and will not add to the pollution load on existing water quality in the harbour. The mitigation measures proposed will ensure that the development will not prevent 'Liffey Estuary Lower' transitional water body and 'Dublin Bay' coastal water body from achieving its objectives under the EU Water Framework Directive. This information will be included as part of the Industrial Emissions Licence application to the EPA.

The stabilisation mix used in the dredged treatment will be designed specifically for the sediment at Alexandra Basin. Typical binder quantity values vary from 100 kg/m³ up to 250 kg/m³. The binder can consist of a single substance or be a mixture of various substances like cement or lime etc. Chemical, physical as well as geomechanical properties of the stabilised material largely depend on the type and quantity of binder used³.

The mix is likely to include a combination of the chemicals listed in Table 11.2.

¹ Bone B., et al (2004); *Guidance on the use of Stabilisation/Solidification for the Treatment of Contaminated Soil Pollution*. Environment Agency

² Suzdalev S.(2012) *Contaminants-Binders-Sediments*, Sustainable Management of Contaminated Sediments Baltic Sea Region Programme Project No #39

³ Suzdalev S.,(2012) *Contaminants-Binders-Sediments*. Baltic Sea Region Programme Project No #39

Table 11.2 Chemicals or reagents that may be used in the treatment process⁴.

Chemicals or reagents that may be used in the treatment process	
Cement	Ash and FGD (end product of flue gas desulphurisation)
Bentonite	Oil shale ash
Lime	Calcium Sulphate Products
Blast furnace slag	Blend of the above

Binder quantities for those projects described in Appendix 11 range from 110kg/ m³ up to 200kg/m³. This would equate to a 20% increase in the volume of contaminated dredge spoil. i.e. 470,000 m³ of contaminated dredge spoil will equate to 564,000 m³ of infill after stabilisation.

Following the determination of the binder(s) to be added and prior to construction a field test will be undertaken to show and verify in-situ the applicability of the S/S with respect to:

- geotechnical and environmental properties of the treated contaminated dredged sediments
- the behaviour of the construction with the treated material in the infill areas
- the influence on the surrounding environment
- the process stabilisation technology

Transport

Dredged material will be transported to the treatment facility by barge.

The contaminated dredged material will be left on the barge overnight to allow for settlement. This method is proposed to remove as much free water from the dredged material as possible⁵. Liquid arising from the solid material settling will be pumped out to an appropriately licensed mobile water treatment plant on site. The dredged material will be off loaded by excavators to the treatment facility.

Mechanically dredged sediments typically have solid content comparable to that of in situ sediments⁶.

Spills from the barges will be prevented by using spill plates.

⁴ Suzdalev S.,(2012) *Contaminants-Binders-Sediments*. Baltic Sea Region Programme Project No #39

⁵ Boskalis, 2013 pers comm. January 2014

⁶ Blažauskas N, Larsson L., Rostmark S., (2012). *Technologies and Solutions for Handling of Contaminated Sediment*. State of the Art Review Sustainable Management of Contaminated Sediments. Baltic Sea Region Programme Project No #39

Treatment Process

Dredging and treatment will be carried out at a rate of approximately 1,000 m³ per day. The sediment handling process is estimated to last approximately 18 months based on the estimated volume to be treated of 470,000 m³ and will be undertaken all year round.

Separation

The contaminated dredged material will be screened to remove extraneous material unsuitable for treatment (e.g. debris). This can be undertaken on the barge by raking or by feeding the material onto a screen. This material will be disposed off at an appropriately licensed landfill.

Separation techniques may be applied (should the material be suitable for this technique) to separate dredge material into fines, sand and gravel in order to separate contaminated fine particles from uncontaminated sediments. Uncontaminated sediment may be used as fill material without the requirement for further treatment. The need for dewatering will be determined by the water requirements of the treatment technology and the solids content of the sediments following removal, transport and screening and separation pre-treatment. The separated sand typically has a solid content around 80 – 85% leaving the process⁷.

Dewatering

Reducing the moisture content reduces the volume to be treated and the volume of additives that may be required for the S/S process.

If required, further dewatering methods will be applied to the fines to return the dredged sediments moisture content as a minimum to that of the insitu material. After screening, the material will be dewatered by mechanical pressing. Dewatering will reduce the dredged material's moisture content and consolidate it to facilitate handling thereby reducing the volume for the subsequent treatment process. Generally, mechanical dewatering technologies can remove free and intestinal water and increase the solids content up to 70 percent by weight⁸.

The dewatering process can be engineered around a large difference in moisture content. For example⁹:

- If dewatering with belt filter presses, the filter cake might have a solid content in the range of 40 – 50% by weight. Belt filter press cake is dry enough for transport but still has some plasticity.
- If membrane presses, the solid content of the filter cake will be between 55 – 70%. Membrane press cake is firm.

⁷ Boskalis, 2013 pers comm. January 2014

⁸ Blažauskas N, Larsson L., Rostmark S., (2012). *Technologies and Solutions for Handling of Contaminated Sediment*. State of the Art Review Sustainable Management of Contaminated Sediments. Baltic Sea Region Programme Project No #39

⁹ Boskalis, 2013, pers comm. January 2014

Flocculants may be required for mechanical dewatering. Water arising from the dewatering process will be removed by pumping and treated in a water treatment plant before being discharged via the designated discharge point in accordance with appropriate consents.

Water Treatment

During the construction phase of works, the contractor will be required to manage any contaminated water arising from the sediment handling process. A water treatment plant will comprise a single lane treatment process to remove suspended solids, product and contaminants (if present) from the waste water produced from the dredging, dewatering and treatment processes. The volume of water to be treated will be determined by the amount of water to be removed prior to the treatment process.

For sediment handling process of 1,000 m³ per day the volume of water to be treated is estimated to be 20-25 m³ per hour¹⁰. The water treatment plant will be sized accordingly.

The waste water will be pumped from the treatment area into a settlement holding tank/lagoon. From the tank/ lagoon water will be pumped through a separator to prevent suspended solids and oil from entering the treatment process. From the separator the remaining water will be pumped through a sand filter to remove further suspended solids and activated carbon vessel to remove the organic contaminants if required before discharged via a designated discharge point in accordance with the appropriate consents.

Sampling points will be included within the pipe work system to allow for the collection of water samples. The proposed sampling and testing schedule will be based on flow and effluent quality prior to discharge. The sand filter and activated carbon will be replaced as required. These will be disposed of to a licensed facility.

Sediment Handling

The sediment handling process will be undertaken in a batching plant in the treatment area. An area of approximately 50m x 100m would be required to facilitate the sediment handling process of approximately 1,000 m³ of contaminated dredge material per day.

The S/S treatment plant will be brought to the treatment area by road on low-loaders or by sea aboard barges and set up. Plant and equipment will be installed on concrete hardstanding areas. If necessary, temporary buildings will be erected to cover the material while it is being stored and treated.

The exact type, number, and specification of the plant and equipment to be installed at the proposed treatment area will be determined by the selected contractor for the works. However conventional mixing techniques, including the use of spaders and screening/mixing buckets are used in the ex-situ application. The plant can be scaled according to the volume to be treated.

¹⁰ Boskalis, 2013, pers comm. January 2014

The key issues that will be taken into consideration when identifying suitable process and plant are¹¹ :

- material characteristics and ground conditions (e.g. bearing capacity);
- quantity of material to be treated and rate of treatment;
- size of treatment area available; and
- compatibility of equipment with proposed binder system;
- the specific requirements for the end-product;
- the ability of the plant to deal with volatile contaminants, if present; and
- movement of materials around the site, before and after treatment.

Filling of Treated Sediments

The treated contaminated dredged material will be recovered for use as infill for Graving Dock #2 and Berth 52/53.

Prior to the filling of Berth 52/53 basin, a cellular cofferdam will be constructed to close off Berth 52/53 from the main navigation channel. This will eliminate surface water flows from the main estuary into the berths. .

The treated sediment will be off loaded (dry dig) by excavators into trucks or pumped from the treatment area to the infill areas. Water quality will be measured in Berth 52/53 during the filling operation to ensure that measured parameters are within agreed limits. If necessary, a controlled outlet from Berth 52/53 will be constructed to control water level/flow. A written record of the types and quantities of material recovered at the infill sites will be maintained.

Ongoing monitoring of the S/S process during the field trial and construction project will consist of the following:

- Geotechnical tests e.g. the permeability (hydraulic conductivity) and the compression strength of the stabilised materials after different strength development periods;
- Environmental testing e.g. batch leaching tests and diffusion testing to measure the leaching of contaminants from the S/S treated material;
- An ongoing monitoring programme will be undertaken prior, during and post the recovery operation (surface water quality in harbour, monitoring of pore water in the construction, toxicity test on S/S samples, sediment samples from the harbour, water levels and groundwater); and
- A Quality Assurance/Quality Control (QA/QC) programme will be established

¹¹ Bone B., et al (2004); *Guidance on the use of Stabilisation/Solidification for the Treatment of Contaminated Soil Pollution* .Environment Agency

Due to nature of the dredging following the treatment process (to be demonstrated by geotechnical and environmental testing), no emission to the environment of significance is expected.

Sediment Quality – Navigation Channel

The sediments within the Navigation Channel were found to be suitable for disposal at sea.

There is however an area immediately adjacent to Alexander Basin West where low levels of contamination have been identified requiring this material to be disposed of at sea only at slack tide and immediately covered by sand or gravel.

It is proposed to dispose of the dredged at the licensed sea disposal site located to the west of the Burford Bank at the entrance to Dublin Bay, subject to the granting of a Dumping at Sea Permit by the EPA (see Chapter 9 – Coastal Processes).

Dredging Requirements

The Alexandra Basin Redevelopment requires a capital dredging scheme to achieve the following design depths:

- Dredging of Alexandra Basin West to -10m CD
- Dredging of the Navigation Channel to -10m CD from circa East Link Bridge to the Dublin Bay Buoy.

The volumes of material to be dredged are outlined in Table 11.3 and the location of these areas are shown in Figure 11.6.

Table 11.3 Dredge Volumes

Source Location	Material Status	Volume (m ³)
Alexandra Basin	Heavily Contaminated	470,000
Navigation Channel	Slightly – moderately Contaminated	500,000
Navigation Channel	Uncontaminated	5,400,000
Total		6,370,000

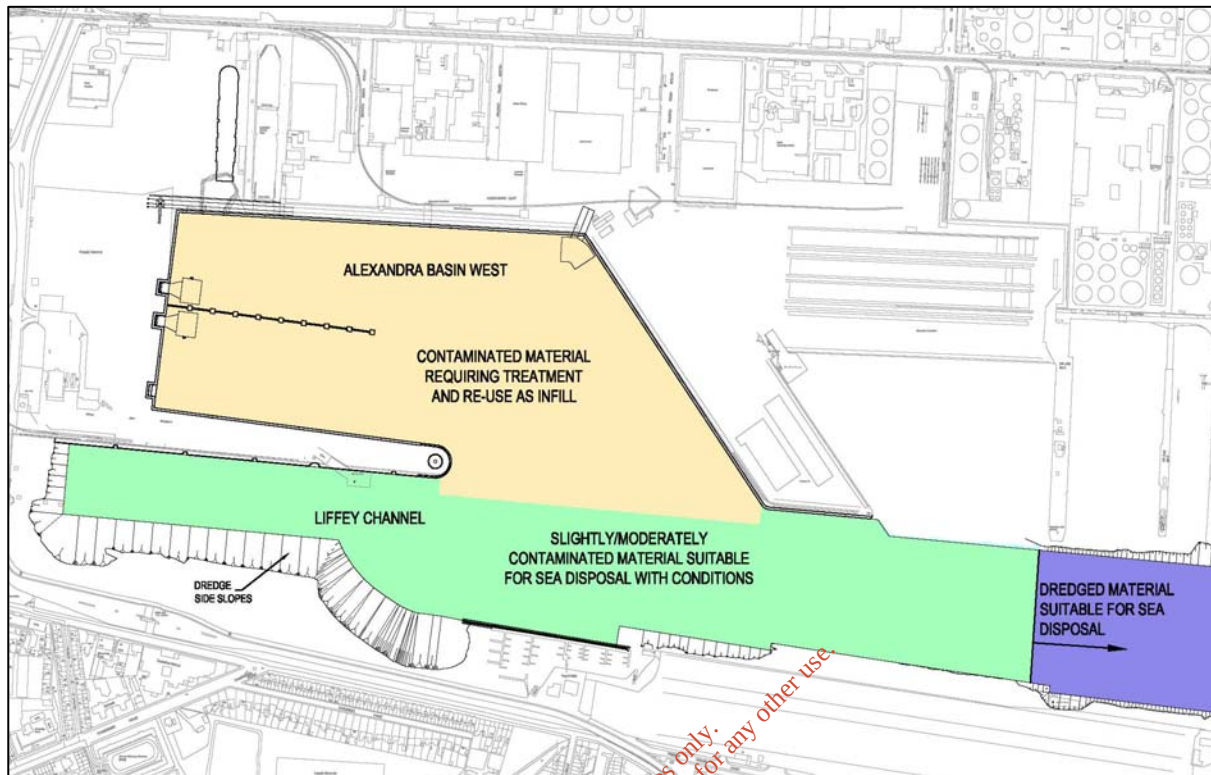


Figure 11.6 Dredge Material Locations

A description of the proposed dredging activities and the timing of the dredging works is presented in Chapter 4.

11.3 POTENTIAL IMPACTS

Construction phase impacts

Temporary impacts on water quality and potentially groundwater can occur during the construction phase of the works. Pollution from mobilised suspended sediment is the prime potential risk.

- Increased suspended sediment levels due to dredging and deposal of dredge spoil;
- Sedimentation due to settling of suspended silt;
- The dispersal and fate of contaminated sediments;
- Water quality impacts associated with works machinery, infrastructure and on-land operations (for example leakages /spillages of fuels, oils, other chemicals and waste water, controlled discharges under licence);
- Impact of piling operations through creation of a vertical pathway in which potentially contaminated soils/sediment and/or groundwater can migrate downwards; and
- Leaching of contaminants from sediments used as fill material.

Operational phase impacts

Operational phase impacts are associated with normal port operations whilst dealing with continued growth. These include potential impacts from:

- Discharges from vessels using the port (ballast water, wastewater, oil spillages, fuel bunkering);
- Discharges from cargo handling (leakages from containers, bulk material spillages, losses from conveyor systems);
- Discharges from cargo storage areas and onward transportation (losses from hoppers, flat bulk stores and HGVs); and
- Long term leaching of contaminants from sediments used as fill material.

Any of these activities have the potential to impact on water quality (including groundwater) and therefore the activities associated with the construction and operation phases of the development require mitigation.

Impact matrix

The impacts described above are rated in according to their severity (major, moderate, minor and neutral) in the absence of any mitigation in Table 11.4.

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Table 11.4 Impact matrix (in the absence of mitigation)

	Navigation Channel (Alexandra Basin West to Bull Wall)	Alexandra Basin West	Navigation Channel (Bull Wall to Dublin Bay Buoy)
Construction phase			
Suspended sediments	Major	Major	Moderate
Sedimentation	Major	Major	Moderate
Pollution from contaminated sediment	Moderate	Major	Minor
Other water quality issues associated with construction works	Moderate	Moderate	Minor
Impact of piling operations	Neutral	Minor	Neutral
Leaching of contaminated sediments used as fill material	Neutral	Major	Neutral
Operational Phase			
Suspended sediments	Neutral (except for maintenance dredging)	Neutral (except for maintenance dredging)	Neutral (except for maintenance dredging)
Sedimentation	Neutral (except for maintenance dredging)	Neutral (except for maintenance dredging)	Neutral (except for maintenance dredging)
Pollution from contaminated sediment	Neutral (except for maintenance dredging)	Neutral (except for maintenance dredging)	Neutral
Other water quality issues associated with construction works	Neutral	Neutral	Neutral
Discharges from vessels using the port	Minor	Minor	Minor
Discharges from cargo handling	Neutral	Moderate	Neutral
Discharges from cargo storage areas and onward transportation	Neutral	Minor	Neutral
Leaching of contaminated sediments used as fill material	Neutral	Major	Neutral

11.4 ASSESSMENT OF POTENTIAL IMPACTS

Construction Phase Impacts

The ABR Project has been designed to minimize the impact on the receiving water environment. This assessment is described in Chapter 10 Water.

The risk of water quality impacts associated with works machinery, infrastructure and on-land operations (for example leakages /spillages of fuels, oils, other chemicals and waste water) can be controlled through good site management and the adherence to codes and practices which limit the risk to within acceptable levels. These are described in Section 11.5 Mitigation.

Operational phase impacts

The new port facilities, when complete, will be subject to the Port's existing Environmental Management Plan. Dublin Port is accredited to ISO 14001 to ensure that all employees undertake their work with due consideration for the environment and that guidance is given to tenants to promote the principles of sustainability.

Dublin Port has been designated an 'Ecoport' at European level, for its environmental management system.

DPC also maintains and operates an emergency management plan and has the emergency management structures and arrangements in place which are compatible with the requirements of the 2006 Framework for Major Emergency Management. These include procedures for dealing with, amongst others: a major oil spill from a vessel, jetty or on land including storage areas; a major spill of hazardous material from a vessel, jetty or on land including storage areas and vehicle accidents involving hazardous material.

Training of staff and exercises are undertaken in line with best practice.

Dublin Port's Environmental Management Plan does not permit any discharges from vessels using the port, or travelling through Dublin Bay, to the receiving waters.

Human beings will not be exposed to treated contaminated sediment as the material will be covered with concrete hard-standing thereby negating any direct contact, ingestion or inhalation pathways.

11.5 MITIGATION MEASURES

Construction Phase Mitigation Measures

Mitigation measures include adherence to the construction techniques and timing of works (outlined in this EIS) which form an integral part of the engineering design and which have been developed to minimize the impact of the project on the receiving water environment.

A Construction Environmental Management Plan (CEMP) will be prepared to capture all mitigation measures within the Environmental Impact Statement together with any conditions imposed by An Bord Pleanála and to provide additional detail in order to develop a practical programme of measures for the Contractor. The CEMP will form part of the specification of the

Contract Documents for the construction stage. The CEMP will include mitigation measures to safeguard the receiving waters including:

- (i) Waste Management Plan
- (ii) Contamination Strategy
- (iii) Water Quality Management Plan
- (iv) Establishment of lines of communication, reporting and actions

The mitigation measures will include the requirements for best practice and adherence to relevant Irish guidelines, or international guidelines where these are not available:

- Good practice guidelines on the control of water pollution from construction sites developed by the Construction Industry Research and Information Association (CIRIA, 2001).
- Pollution prevention guidelines in relation to a variety of activities developed by the Environment Agency (EA), the Scottish Environmental Agency (SEPA) and the Northern Ireland Environment Agency (NIEA).
- Environment Agency Pollution Prevention Guidelines (PPG6);
- Fisheries Guidelines for Local Authority Works. Department of Communications, Marine & Natural Resources, Dublin, (Anonymous, 1998);
- Guidelines on protection of fisheries habitats during construction projects (Eastern Regional Fisheries Board, 2006);
- International Convention for the Prevention of Pollution From Ships, 1973, as modified by the Protocol of 1978 (MARPOL) for domestic waste discharges to the environment;
- International Marine Organisation guidelines;
- Control of Substances Hazardous to Health (COSHH) Handling of Hazardous Materials.

The preparation of the CEMP associated with the receiving waters will require continual engagement with a range of interested parties/stakeholders including Dublin City Council, EPA, National Parks & Wildlife Service, Inland Fisheries Ireland, Dublin Port tenants and local community groups.

A Construction Environmental Monitoring Programme will also be prepared to provide additional safeguards to the receiving environment during the construction phase of the works. The monitoring programme will form part of the specification of the Contract Documents for the construction stage.

The design of the monitoring programme will include the following elements related to the receiving waters:

- (i) An assessment using 3-D hydrodynamic computational modelling and water quality modelling to design the placement of a number of water quality monitoring buoys and telemetry based warning systems
- (ii) The establishment of water quality trigger levels and corresponding actions (including the necessity to temporarily cease construction operations) to safeguard sensitive conservation sites (SPA and SAC) and the operations of other users of the receiving waters (e.g. ESB Poolbeg Power Station).

The preparation of the monitoring programme will require continual engagement with a range of interested parties/stakeholders including Dublin City Council, EPA, National Parks & Wildlife Service, Dublin Port tenants, ESB and local community groups.

A Piling Risk Assessment will also be prepared to assess the potential risk to groundwater and any necessary mitigation measures adopted during construction.

Operational Phase Mitigation Measures

The new port facilities, when complete, will be subject to the Port's existing Environmental Management Plan.

In particularly, the following shall be adhered to with respect to vessels at berth or travelling through Dublin Bay:

- No waste should be disposed of at sea;
- Ballast water should be treated in accordance with MARPOL standards;
- Ballast tanks should be separate from hydrocarbon storage areas and no potentially contaminated streams should be diverted to the ballast tanks;
- De-ballasting should be undertaken offshore in accordance with IMO guidelines;
- Hazardous wastes should be stored in sealed, labelled drums in locked chemical cabinets;
- Vessels should be equipped with oil-water separation systems in accordance with MARPOL requirements;
- Spills on deck should be contained and controlled using absorbing materials;
- Vessels without sewage treatment systems should have suitable holding tanks and will bring waste onshore for treatment by licensed contractors;
- All chemicals used onboard should be handled in compliance with COSHH instructions on handling hazardous materials;
- Chemicals should be stored appropriately in suitably bunded areas and with material safety data sheets;

- All waste discharges should be monitored and recorded as per vessel procedures.

Residual Impacts

Provided appropriate mitigations measures are fully implemented during the construction and operational phases, the impact of the proposed development on the surface water quality and groundwater quality will be neutral to minor as indicated in Table 11.5.

There is no residual impact with regard to geology.

Table 11.5 Residual Impacts (with mitigation)

	Navigation Channel (Alexandra Basin West to Bull Wall)	Alexandra Basin West	Navigation Channel (Bull Wall to Dublin Bay Buoy)
Construction phase			
Suspended sediments	Minor	Minor	Minor
Sedimentation	Minor	Minor	Minor
Pollution from contaminated sediment	Minor	Minor	Minor
Other water quality issues associated with construction works	Minor	Minor	Minor
Impact of piling operations	Neutral	Minor	Neutral
Leaching of contaminated sediments used as fill material	Neutral	Neutral	Neutral
Operational Phase			
Suspended sediments	Neutral (except for maintenance dredging)	Neutral (except for maintenance dredging)	Neutral (except for maintenance dredging)
Sedimentation	Neutral (except for maintenance dredging)	Neutral (except for maintenance dredging)	Neutral (except for maintenance dredging)
Pollution from contaminated sediment	Neutral	Neutral (except for maintenance dredging)	Neutral
Other water quality issues associated with construction works	Neutral	Neutral	Neutral
Discharges from vessels using the port	Neutral	Minor	Neutral
Discharges from cargo handling	Neutral	Minor	Neutral
Discharges from cargo storage areas and onward transportation	Neutral	Minor	Neutral
Leaching of contaminated sediments used as fill material	Neutral	Neutral	Neutral

12. CULTURAL HERITAGE

This chapter of the EIS presents the cultural heritage assessment which was undertaken to identify and record the location, nature, and dimensions of any archaeological and architectural features, fabric or artefacts that may be impacted by the Alexandra Basin Redevelopment (ABR) Project. The assessment includes an examination of existing sources and the acquisition of new data arising from site inspections and surveys. The assessment gauges the level of development impact, and includes detailed recommendations for the mitigation of any archaeology present within the development area.

The cultural heritage assessment was undertaken by Dr Niall Brady of Archaeological Diving Company Ltd (ADCO).

Given the importance of the industrial heritage of the North Wall Quay Extension and Graving Dock #1, this work was supplemented by a Level 2 industrial archaeological heritage study which was undertaken by Dr Colin Rynne, Historic Building Survey Unit, Department of Archaeology, University College Cork.

The cultural heritage assessment included a comprehensive review of existing records and maps and the undertaking of project-related site investigations above and below the waterline, under licence from the Department of Arts, Heritage and the Gaeltacht.

The results and observations are described in this present chapter and detailed descriptions are provided in Appendix 12.

The archaeological survey area extends from the East Link Bridge, approximately 10km east into Dublin Bay, to near the Dublin Bay Buoy. The survey area extends beyond the navigation channel within the Bay area, to reach over 800m in width at the eastern extent. The co-ordinates of the study area are provided in Table 12.1. The extent of the survey area is shown on Figure 12.1.

Table 12.1 Extent of Study Area including co-ordinates within which a marine geophysical survey was conducted

Name	Latitude	Longitude	Easting ITM	Northing ITM
01	53°20.975'N	006°13.650'W	718010	734727
02	53°20.750'N	006°06.730'W	725699	734506
03	53°20.300'N	006°04.430'W	728274	733740
04	53°19.450'N	006°06.325'W	726213	732108
05	53°19.650'N	006°05.250'W	727396	732510
06	53°20.200'N	006°06.900'W	725537	733482
07	53°20.720'N	006°13.650'W	718022	734254

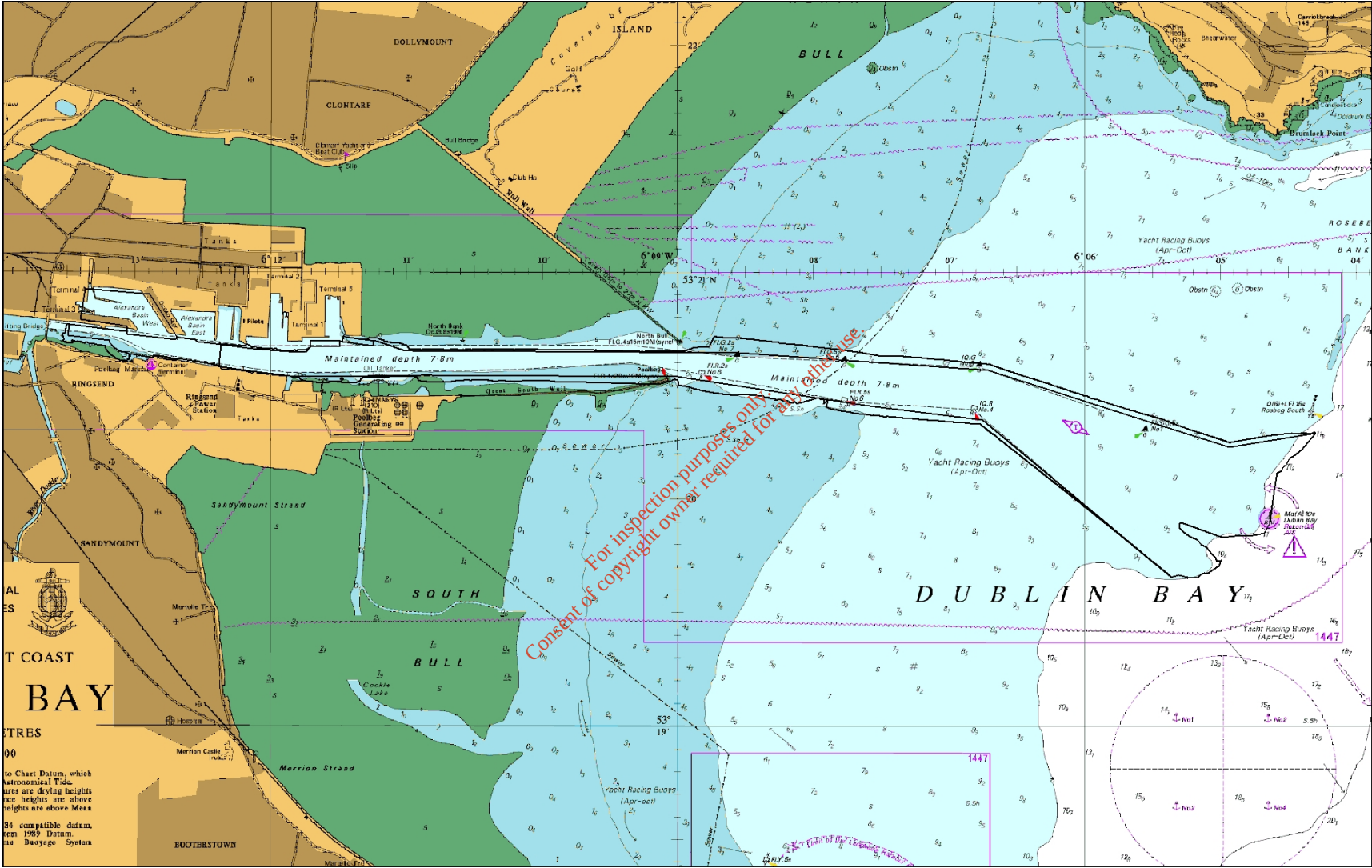


Figure 12.1 Extent of Study Area

12.1 ASSESSMENT METHODOLOGY

A sequence of work has been completed to ensure that the Cultural Heritage assessment has been comprehensive and robust. The work has included a desktop study of known archaeological and architectural sources, a review of site investigations conducted for the wider project, and on-site inspections and surveys which have included walkover surveys of the terrestrial elements, comprehensive marine geophysical survey and archaeological dive inspection.

12.1.1 Consultations

The following sources of information have been consulted:

- The *Irish Antiquities Division of the National Museum of Ireland* (NMI) retains an extensive archive of small finds and objects discovered across Ireland and reported to the Museum and its predecessors since the nineteenth century. It represents a critical resource for archaeological research, where registered objects are recorded by townland in the Topographical Files. For the present project, the following townlands and city districts were assessed: Ringsend; St. Thomas'; North Dock Ward; Alexandra Basin.
- *Department of Arts, Heritage and the Gaeltacht (DAHG) Sites and Monuments Record files*. The information, which is also filed according to townland, provides details relating to specific monuments and sites of archaeological importance that survive or whose site area is recorded. The record generally includes only sites that pre-date c. 1750 AD.
- *DAHG's Historic Shipwreck Inventory files and Places and Ports archive*. This information relates to the archives maintained by the National Monuments Section's Underwater Archaeology Unit for shipwreck and other maritime sites of archaeological interest. The information is located with reference to the nearest topographic locator, such as a town or headland, as well as site-specific grid coordinates where known. For the present project, the following landmarks were considered to be relevant:
 - On the North side: Alexandra Basin; North Wall; Bull Wall; North Spit; North Bull Lighthouse;
 - On the South side: Ringsend; Poolbeg; Pigeon House; and running across North and South: Dublin Harbour; Dublin Bar.
- *National Inventory of Architectural Heritage* at DAHG provides an online register of historic buildings and features/street furniture that retain architectural interest, and is maintained by the DAHG's architectural section. The Inventory is organized by place and townland. The Inventory complements the archaeological inventories by including buildings and features that date from the eighteenth century and more recently.
- The *Irish National Seabed Survey* section of the Geological Survey of Ireland retains site-specific information relating to hydrographic surveys of Dublin Bay, the details of which inform the distribution of known shipwreck sites by providing an indication of the extent of a wreckage feature and its location.

In addition, the following sources and groups of sources have been consulted:

- *Cartographic sources*, including Admiralty Charts and Ordnance Survey First and Second Edition maps. Historic and current topographical maps represent very important sources that can reveal the progress of natural erosion and human development across a landscape/seascape over time. Such mapping in Ireland is metrically accurate from the mid-late nineteenth century. As the country's capital city and port, Dublin and Dublin Bay have been subject to numerous mapping projects, and the present study draws on sources that date from as early as the 1650s.
- *Office of Public Works* Piers and Harbour Structures files, 1708-1922 (OPW/8). This body of state records refer to port improvement works across the country and forms part of the National Archives collection.
- *Excavations Bulletin* is an annual published list of licensed archaeological intervention work conducted across Ireland. It is arranged by county and then by townland, and is currently completed to 2011.

The following relevant published and unpublished sources have also been consulted:

- Dublin City Development Plan, 2011-2017.
- Dublin Docklands Architectural Survey, 2006.
- Dublin Port Company Masterplan, 2012-2040.
- Dublin City Council Industrial Heritage Record (DCIHR).
- Civil Engineering Heritage Archive.
- Dublin City Public Libraries archives.
- Dublin Port Archives.
- Online sources.

12.1.2 Acquisition

The desktop assessment included a review of historic mapping that can reveal the development of the landscape over time, an examination of existing archival information at the NMI and DAHG in relation to the known archaeological objects, features and sites of archaeological, architectural and industrial heritage interest, and a review of archaeological work conducted in the immediate vicinity of the project area from published and unpublished sources. This information combines to establish a baseline data source. The principal findings are described below and the detailed results are presented in Appendix 12.1.

Project-specific site work was commissioned by Dublin Port Company (DPC) to inform the ABR Project. Site investigations were conducted on land and at sea, and the details made available for archaeological review. The principal observations are described in this Chapter, with the archaeological interpretations of these data sets presented in Appendix 12.2.

An archaeological walkover survey of the terrestrial elements was completed, and included an inspection of the current quaysides above the waterline from a boat. The principal observations are described in this Chapter and the detailed results are presented in Appendix 12.3.

A comprehensive programme of marine geophysical survey was conducted across the marine area in 2013, and archaeological diver inspection also commenced in 2013. The work has generated a valuable and extensive resource of new information that informs the EIA. The principal observations are described in this Chapter and the detailed results are presented in Appendix 12.4.

Archaeological dive inspection is taking place of the anomalies identified in the marine geophysical survey. The dive observations are described in this Chapter and are presented in Appendix 12.5. A total of 120 side-scan sonar targets were identified for inspection, 42 of which have been inspected already. The remaining 78 targets will be inspected by May 2014, weather permitting.

12.1.3 Legislation

The following legislation, standards and guidelines with particular reference to Archaeology were consulted for the purposes of this evaluation:

- National Monuments Acts, 1930-2004.
- The Planning and Development (Strategic Infrastructure) Bill, 2006.
- The Heritage Act, 1995.
- Guidelines on the information to be contained in Environmental Impact Statements, 2002, EPA.
- Advice Notes on Current Practice (in preparation of Environmental Impact Statements), 2003, EPA.
- Guidelines for the Assessment of Archaeological Heritage Impacts of National Road Schemes, no date, NRA.
- Frameworks and Principles for the Protection of the Archaeological Heritage, 1999, Department of Arts, Heritage, Gaeltacht and Islands (now the Department of Arts, Heritage and the Gaeltacht).
- Architectural Heritage (National Inventory) and Historic Monuments (Miscellaneous Provisions) Act, 2000 and the Local Government (Planning and Development) Act 2000.
- Code of Practice between Bord Gáis Éireann and the Minister for Arts, Heritage, Gaeltacht and the Islands (now the Department of Arts, Heritage and the Gaeltacht), 2002.

Limitations

The current report is based on desktop review and non-disturbance on-site archaeological assessment only. No intrusive archaeological investigations or excavations have been carried out.

12.1.4 Classification of Impacts

Impacts are generally categorised as either being a direct impact, an indirect impact or as having no predicted impact:

Direct impact occurs when an item of archaeological or architectural heritage is located within the centreline of the proposed route alignment and entails the removal of part, or all, of the monument or feature.

Indirect impact may be caused where a feature or site of archaeological or architectural interest is located in close proximity of the proposed development.

No predicted impact occurs when the proposed route option does not adversely or positively affect an archaeological or architectural heritage site.

These impact categories are further assessed in terms of their quality i.e. positive, negative, neutral (or direct and indirect).

Negative Impact is a change that will detract from or permanently remove an archaeological or architectural monument from the landscape.

Neutral Impact is a change that does not affect the archaeological or architectural heritage.

Positive Impact is a change that improves or enhances the setting of an archaeological or architectural monument.

A significance rating for these impacts is then given i.e. slight, moderate, significant or profound.

Profound applies where mitigation would be unlikely to remove adverse effects. This is reserved for adverse, negative effects only. These effects arise where an archaeological or architectural site is completely and irreversibly destroyed by a proposed development.

Significant is an impact that, by its magnitude, duration or intensity alters an important aspect of the environment. An impact like this would be where the part of a site would be permanently impacted upon leading to a loss of character, integrity and data about the archaeological or architectural feature/site.

Moderate is a moderate direct impact that arises where a change to the site is proposed which, though noticeable, is not such that the archaeological integrity of the site is compromised and which is reversible. This arises where an archaeological or architectural feature can be incorporated into a modern day development without damage and that all procedures used to facilitate this are reversible.

Slight is an impact that causes changes in the character of the environment that are not significant or profound and do not directly impact or affect an archaeological or architectural feature or monument.

Imperceptible is an impact capable of measurement but without noticeable consequences.

In addition, the duration of Impacts is assessed and has been sub-divided into the following categories.

Temporary Impact, where an Impact lasts for one year or less

Short-term Impacts, where an Impact lasts one to seven years

Medium-term Impact, where an Impact lasts seven to fifteen years

Long-term Impact, where an Impact lasts fifteen to sixty years.

Permanent Impact, where an Impact lasts over sixty years.

12.2 EXISTING ENVIRONMENT

12.2.1 Cartographic sources

As the country's principal port and capital city since the Middle Ages, it hardly surprising to find a wealth of early maps and sea charts that record the mouth of the River Liffey and the growing city as it developed eastwards towards the sea (a shortlist of useful maps is presented in Appendix 12.1, Figures 12.2-12.8.). A Dutch military engineer, Bernard de Gomme, created a map of the City and Suburbs of Dublin in 1673 that provides clearly recorded detail of the river mouth, where the future Port would develop. At this point in the late 17th century, much of the estuary remained hazardous to shipping, as indicated by complex sand flats, while various attempts to overcome these restrictions are also recorded, and include the planned (but never realized) construction of a large star-shaped fort out on Ringsend Spit. The presence of the spit helps to explain the slight angle in what became the Great South Wall, which mirrored the Easterly alignment of the channel on the seaward side of the spit, in contrast to its ESE course to the west of the spit. Pigeon House Fort was later built in this area, and it appears from de Gomme's map that there was already a fortification here. The distinctions that reflect the alignment of the Liffey's estuary in the late 1600s are obscured today as reclamation has occurred to the west, but the essential elements remain embedded in the alignment of the South Wall.

When the cartographer John Rocque prepared his map of the City Harbour and Environs in 1757, he provided a detailed perspective on the various sand flats and constraints on shipping, and suggests the extent to which the prosperous city was expanding (Appendix 12, Figures 12.3-12.5). It is an important source of information that provides detailed insight to maritime works along the estuary's mouth. Rocque records a series of navigation markers that highlight the shallows on the north and south sides of the channel as far east as what was then the termination point of the Great South Wall, at what became Pigeon House Fort. The markers appear to be constructed on a basic timber tripod frame, with a more substantial construction close to the terminus of the Wall. This more robust marker, shown with a heap of stone at its base, may highlight the former tip of the Ringsend Spit that was mapped by de Gomme eighty years earlier. The channel at this location in 1757 was much straighter, which suggests a programme of extensive dredging had occurred in the intervening time. A formal buoy, the 'West Buoy' marks the Port side of the harbour entrance further to the east, while a floating buoy or 'Light Ship' marks the starboard side; both of which foreshadow the North Bull light and Poolbeg lighthouse today.

Reclamation of the intertidal areas on the north side of the Liffey downstream of the city was well underway by 1757, and the North Lotts was laid out and parcelled into blocks, terminating

at 'East Quay', which is on the line of East Wall Road today. The site of the future Port remained an undeveloped wedge-shaped sandflat to the east, while further east Rocque's map records the names of individual sand banks, such as 'Brown's Patch', and highlights the extensive footprint of the Clontarf oysterbeds.

In contrast, the south side was much more developed, with construction of the Great South Wall well underway. Commencing in the west at Ringsend Point, the wall had two slipways: Macarell's Slip gave access north into the channel and seems to be on the same location of the later Coastguard slip, east of the present-day Poolbeg Yacht Club; while George's Slip gave access south of the wall onto Sandymount. To the east on the Wall and running at an angle aligned ENE were 'The Piles'. They are recorded as a parallel line of timber-post couplets, and anticipated the line of the later sea wall that extends out to Poolbeg light house.

Rocque portrays the principal hazard to shipping outside the harbour, namely the Dublin Bar, which he records as 'The Barr'. To his eye, this was a great sand shallows that swept across the entrance to the harbour in a generous circular path, extending from the sands on Dollymount almost to Ringsend Spit. The average water depth over the bar was 5' and 6', but there were two openings over which shipping could pass. The North Channel was aligned with the Piles and depths reached 10' and 11'. Its location was marked by the North Buoy. The South Channel lay outside and to the south of Ringsend Spit. It too had depths of 10' and 11' and was marked by the South Buoy, but its passage would have required a delicate manoeuvring, where vessels would have to tack to get inside the channel and tack again to avoid the Spit.

The ships recorded by Rocque are substantial three-masted ocean-going vessels, as one might expect to service this important city. The ships are shown within the area of the Piles, but do not reach further upriver. This is in contrast to Rocque's 1756 map of the City and Suburbs of Dublin, which shows a wealth of shipping along the city's quays, but does not map the area downriver of North Wall Quay and Rogerson's Quay. The point to take from this variation is that on the 1757 map Rocque conveys an indication of the constraints on shipping, insofar as the deepwater vessels did not extend onto the shallower waters upriver and west of the Clontarf Pool. In their place, smaller vessels and ferries were used to convey merchandise into and out of the city.

The mapping of Dublin harbour and Bay attracted a host of different hydrographers, many of whom were commissioned to assist in developing measures to improve navigation along the Liffey. George Semple's charts of 1762 are a case in point, but one of the more important surveys was that by Captain Bligh in 1800. Bligh was appointed by the Admiralty, to report on the Bay, the harbours within it and the problems of shallowness in the approaches to Dublin.¹ Bligh's chart extends across the entire bay as far as the Kish Bank, and provides a comprehensive record of depths and hazards. The port and the approach channel form part of the larger map, and this was the first proper chart of the Bay to be produced. He had recommended that a north wall be built, to assist in improving the fluvial dynamic to reduce siltation along the channel. His north wall was funnel-shaped, and is indicated on his Chart as an idea, rather than an as-built structure, which was begun some years later according to the designs by Halpin.

¹ Gerard Daly, 'Captain Bligh in Dublin, 1800-1801', *Dublin Historical Record* 44.1 (1991): 20-33, at p. 23.

By 1837, when the Ordnance Survey produced the first metrically accurate maps at 6-inch to the mile scales, the developments on the south side of the river were well underway, and the map shows Pigeon House Fort and completion of the Poolbeg light house to the east (Appendix 12, Figure 12.6). It is at this stage too, that we see reclamation works progressing on the seaward side of East Wall road, with the construction of the Patent Slip, and a narrow line of buildings to the south, where the North Wall light house was built.

From this point on, it is possible to see the developing port emerge. The blocky rectangular form of the deepwater port is recorded on Admiralty Chart 1468, which also provides accurate soundings along the channel, reaching out across Dublin Bar to the east of Poolbeg (Appendix 12, Figure 12.7). Any suggestion of a viable South Channel across the Bar, as indicated by Rocque, is now gone and the only approach is from the east, more or less foreshadowing the footprint for the present-day approach channel.

A more detailed record is provided on Admiralty Chart 1447, dated 1880 (Appendix 12, Figure 12.8). Entitled, 'Ireland. Dublin Bar and the River Liffey to Carlisle Bridge', the Chart shows soundings in feet and inches taken between 1878 and 1880 across Dublin Bar outside the harbour, and along the approach channel to what is today O'Connell Bridge. A long linear lobe of deeper water extended beyond the harbour, no doubt representing the dredged channel across the Bar, where depths reached as much as 28' (8.5m), compared with c. 17' (5.1m) outside the channel. Inside the harbour, water depths were on average shallower, and were for the most part under 20'. Localised shallows are also indicated. There were linear pockets of deeper water on the north side where depths reached their mid-20s, and depths alongside and within the deepwater berth and extending upriver to Sir John Rogerson's Quay were also in the mid-20s. The somewhat meandering reach of deeper water that resulted no doubt focussed the access channel for shipping, and reflects the locations and extents of previous dredging campaigns. In recording the deepwater port prior to its official naming, the Chart shows the still unfinished extent of North Quay Extension, which is recorded simply as, 'quay building'.

By 1907, many of the principal features of the deepwater port were established, and Ordnance Survey mapping records the shipbuilding yard, the North Wall graving dock, and the North Quay Extension, which formed the south side of the deepwater facility. The east side was still only being aspired to. The incomplete nature of the North Quay Extension becomes a signature for the port's footprint until it was finally completed in 1932.

The historic cartographic information available for the project area helps to convey the consistent process of development, and the maps that survive include some especially detailed records, which makes them a most useful set of archives to work with.

12.2.2 Prehistoric to post-Medieval indicators

As the historical cartographic record indicates clearly, the project area remained undeveloped from a terrestrial perspective until the 19th century. These sources also demonstrate how the area was integrally tied to sea traffic arriving at the Liffey's mouth to venture inland, or to carry goods and people from the river's hinterland out to sea. The expanses of sand flats along the river's lower reaches would have resembled a delta at its mouth, making travel difficult for deeply-drafted vessels, but quite feasible for shallow craft. It was in the late medieval period that developments occurred in marine architecture to meet the demand for larger markets, by

making deeper-drafted ships, and it is at this stage that we begin to see notices in the historical record that complain about the inaccessibility of the city's quays to shipping.² It is at this time too, that the deepwater pools and havens around the bay become preferred landing areas for cross-channel ships, including Clontarf, Lambay and Dalkey. The importance to the city of these developments is reflected in the series of ordinances issued by the town fathers to control trade at the satellite ports, requiring traders not to sell their products until they had been transported into the city's market places. This economic reality resulted in the establishment of the Ballast Board in subsequent years, charged directly with the task of ensuring deepwater access through the river's mouth up to the city quays.

What is less known is the history of the lower Liffey prior to the realization in the 15th century that the river was no longer 'fit for purpose'. Excavations within the early medieval/Viking age town continue to show evidence for shipping, where reused ship's timbers, clench nails, and related material are common enough finds from investigations that have taken place on both sides of the river in the vicinity of Wood Quay.³ The city seal of 1297 further proclaims the importance of maritime trade to the town, by showing the town's principal trades occupying the length of a ship. These vessels and their predecessors were shallow-drafted forms. Both river- and sea-craft would have worked Ireland's east coast and were well suited to negotiating the silt and sand deposits that are a feature of many of its river estuaries.

When considering still earlier periods, it is possible to identify simpler craft at work. Dredging works in 2002, taking place in advance of the Gas 2025 Interconnector that made landfall at Gormanston, Co. Meath, uncovered a 7m-long oak log boat, some 500m offshore.⁴ The find location is close to the mouth of the River Devlin, and the foreshore in the wider area is filled with material and debris from prehistoric occupation that dates from the Neolithic period. The Devlin gave access inland to a rich agricultural hinterland in what is today north Dublin and south Meath, in much the same way that the River Liffey provides an important corridor into north Kildare but on a much greater scale. The Gormanston logboat has been dated to 1193-1013 cal BC, placing it in the Middle Bronze Age, which is considered a busy moment in Ireland's prehistory, and is witnessed as such in the landscape around Gormanston. The logboat is the first to be found in an active marine context in Ireland, and its presence proves the use of these light craft on coastal waters, as well as along Ireland's rivers and lakes where they are more usually found.

The archaeological potential of the project area is further informed by a series of discoveries made in the wider area. Three objects were recovered from the river channel close to North Quay Extension, and comprise a clay pipe, a shard of pottery and a piece of copper, indicating the potential for material on the riverbed when they were discovered in 1970 (Appendix 10.1, National Museum of Ireland Topographical Files). The area has since been dredged significantly, and there is no further record of material being recovered. More generally, there are no other objects or structures known from the project area aside of the piers and related

² Charles Smith, *Dalkey: society and economy in a small medieval Irish town* (Dublin 1996); Niall Brady, 'Dublin's maritime setting and the archaeology of its medieval harbours', in John Bradley, Alan Fletcher, Anngret Simms (eds), *Dublin in the medieval world. Studies in honour of Howard B. Clarke* ((Four Courts Press, Dublin, 2009), pp 295-315; Margaret Murphy and Michael Potterton, *The Dublin region in the middle ages. Settlement, land-use and economy* (Four Courts Press, Dublin, 2010), p. 398.

³ Seán McGrail, 'The boats and ships of tenth to thirteenth century Dublin; in Seán McGrail, *Maritime Archaeology*, British Archaeological Reports British Series 256 (Oxford 1997).

⁴ Niall Brady, 'Archaeological monitoring and excavation, Gas 2025 Irish Subsea Interconnector, Gormanston landfall Co. Meath, 02E467 02E948, interim report', unpublished report of the Archaeological Diving Company Ltd, 2002.

features of the deepwater port at Alexandra Basin. However the potential for new discovery remains, especially associated with development works that excavate or disturb ground levels that have not been impacted on previously. This possibility was realized most recently with the discovery of the remains of five fish traps during works associated with development at North Wall Quay.⁵ Despite the fact that this area was reclaimed from the intertidal expanse of the Liffey in the 18th century, the traps belonged to a much older period when the foreshore was exploited for fishing. The traps were dated to the Mesolithic period (c. 6100-5720 BC), and reveal the presence of human activity engaged with maritime activities close to the old shoreline at a very early stage, some 6m below current Ordnance Datum. A further trap was identified close by at between -5m and -4.66m OD, dating to the Late Mesolithic period (c. 6000-5840BC) and a Neolithic-period wattle fence was also associated (5980-5760BC), suggesting the duration of these activities over time.

Of less striking news but nonetheless an important indicator of potential, was the discovery of a flint axe-head dating to the subsequent Neolithic period, which was uncovered among foundation material during works at 31 Castle Avenue, Clontarf. A range of other pieces are associated with Clontarf, where flint and bone was found at 'Marino', along with some bronze objects, including an axe head, a sword and a dagger. A log boat or dug-out canoe is associated with Sutton, when it was discovered in a sandbank in 1935.

A boat wreck was also recorded in the shallow waters east of the deepwater port Terminal 5, outside but close to the current project area (Appendix 12.1, wreck reference W01465).⁶ The wreck is partially exposed at Low Water, where a series of timber elements are visible, while the larger portion of the vessel remains buried in the covering sands.

Licensed archaeological work has taken place within the current project area, most notably when archaeological monitoring was conducted of maintenance dredging within the approach channel in 2001.⁷ No material of archaeological significance was observed during that work. Further work conducted as part of the Cross-Bay wastewater pipeline recovered individual timbers and objects (Appendix 12.1, excavation references 01E283, 01E358).

The current project seeks to deepen the approach channel in places by up to 3m. This represents a significant and direct impact on previously unexamined levels of the seabed that crosses the ancient sand flats including the Dublin Bar. Much of the seabed area has however been substantially altered by dredging activities conducted since the 17th century. A record of the recorded dredging campaigns since 1800, for instance, indicates the extent of impact already within the Approach Channel (Table 12.2).

⁵ M. McQuade, 'Final Report of Archaeological Excavation Building C, Spenser Dock, North Wall Quay, Dublin 1', Unpublished report, Margaret Gowen & Co. Ltd, 2003.

⁶ Rex Bangerter, 'Detailed archaeological survey, timber wreck, Dublin Port. 08E497 08D038', unpublished report of the Archaeological Diving Company Ltd, 2008

⁷ Simon O Faolain, 'Dublin Port, docks and shipping fairway, Dublin, 01E1004' in Isabel Bennett (ed.) *Excavations 2001* (Wordwell, Bray, 2003), p. 93.358.

Table 12.2 The deepening of the Approach Channel to Dublin Port since 1800 as a result of induced tidal scour and capital dredging

Year	Depth
1800	2.0m
1819	2.0m
1822	2.6m
1828	2.9m
1838	3.2m
1856	4.0m
1873	4.9m
1939	6.4m
1951	7.0m
1976	7.8m
2013	7.8m

Source: Dublin Port Company

The removal of such a substantial depth of sediments within the Approach Channel does not negate the archaeological risk associated with new capital dredging, but it does help to qualify the low level of associated risk.

12.2.3 Architectural and Industrial Heritage

The features and structures that were built as part of the city's attempts to improve the fluvial dynamic of the Liffey's mouth for shipping are of direct interest to the present study, as are the structures associated with the development of the Port site in what became Alexandra Basin. Details of the sites are presented in Appendix 12.1, where they are tabulated according to the particular archive that refers to them. Table 12.3 simplifies the detail presented in the appendix. A distribution map showing the cultural heritage assets is presented as Figure 12.7 in Appendix 12.1.

Table 12.3 Archaeological, Architectural and Industrial Heritage sites within and in proximity to the ABR Project

Reference	Site type	Status	Impacts from ABR
Alexandra Basin			
GSI 162	Wrecksite	Buried	Overburden will be removed, potentially exposing this site
DCIHR 18-08-079	Port and Docks Depot	Buried	None
DCIHR 18-08-080	Shipbuilding Yard	Buried	None
DCIHR 18-08-081 NCEHD 3024	North Wall Graving Dock	Buried	To be re-opened as part of Heritage Gain
DCIHR 18-08-082	Engine House	Now entrance to Port	None
DCIHR 18-08-083	Flour Mill	Upstanding	None
DCIHR 18-08-084	Grain Silo	Upstanding	None
DCIHR 18-08-085	North Assembly Rd		None
DCIHR 18-08-92	Gasometer	Now a roadway	None
DCIHR 18-08-094, 18-12-089	Quay, East Wall Rd		None
DCIHR 18-08-099	Lighthouse, East Wall Rd	Site of	None
DCIHR 18-08-101	North Wall Graving Dock Pumphouse	Upstanding	To be refurbished as part of Heritage Gain
DCIHR 18-12-005, DCIHR 18-12-084, DCIHR 18-12-091, NCEHD 3253	North Wall Quay Extension (NWQE)	Upstanding	Development works will partially remove and partially bury the quay in the redevelopment of NWQE
DCIHR 18-12-080	Great Southern and Western Rail, section	Buried	None
DCIHR 18-12-082	Harbour Master's Office, East Wall Rd	Buried	None
DCIHR 18-12-083	Goods Shed, North Quay Extension (NWQE)	Site of	Development works will partially remove and partially bury the quay in the redevelopment of NWQE
DCIHR 18-12-085	Goods Shed, NWQE	Site of	Development works will partially remove and partially bury the quay in the redevelopment of NWQE
DCIHR 18-12-086	Goods Shed, NWQE	Site of	Development works will partially remove and partially bury the quay in the redevelopment of NWQE
DCIHR 18-12-087	Revenue Watch House, NWQE	Site of	Development works will partially remove and partially bury the quay in the redevelopment of NWQE

DCIHR 18-12-088	North Wall Lighthouse, NWQE	Upstanding	The lighthouse will be relocated at the terminus of the redeveloped NWQE
DCIHR 18-12-089	Quay, Alexandra Basin	Buried	
DCIHR 18-12-090, NCEHD 3266	Alexandra Quay	Upstanding	
DCIHR 18-12-091	Alexandra Basin	Working Port	Development works will dredge the basin
DCIHR 18-12-092, 93	Lighthouse (site), NWQE	Site of	Development works will partially remove and partially bury the quay in the redevelopment of NWQE
DCIHR 18-12-094	Landing Stage, North Wall Quay/NWQE	Site of	None
DCIHR 19-09-002	Breakwater	Site of	None
DCIHR 19-09-003	Breakwater Light House	Site of	None
NCEHD 3080	Dublin Port		
NCEHD 3138	Alexandra Bridge, East Wall Rd		
North Bull Wall			
DCIHR 19-06-001, DCIHR 19-05-012, NCEHD 3016	North Bull Wall	Upstanding	None
NCEHD 3152	Bull Rock Lighthouse	Upstanding	None
South Bull Wall			
RMP DU019-027, RPS 6794	Blockhouse, Pigeon House Fort	Remnants survive	None
RMP DU019-028	Battery	Swimming pool	None
RMP DU019-029002; RPS 6798	Sea wall. Great South Wall to Poolbeg Lighthouse	Upstanding	None
RPS 6793	St Catherine's Hospital and surviving boundary walls, Pigeon House Rd	Remnants survive	None
RPS 6795	Former Pigeon House Hotel, Pigeon House Rd		None
RPS 6796	Pigeon House Rd		None
RPS 6797	Pigeon House Power Station, former red-brick generating station, Pigeon House Rd	Upstanding	None

RPS 6798, NCEHD 3051, RPS 6798	Poolbeg Lighthouse, Great South Wall, Poolbeg	Upstanding	Foundations of Great South Wall terminus will be reinforced with further rock armouring due to deeper dredge design level
DCIHR 18-12-151	Syphon House	Derelict	None
DCIHR 18-12-152	Dublin Main Drainage Pumping Station, Pigeon House Rd	Upstanding	None
DCIHR 19-09-001	Boat slip , Pigeon House Rd		None
DCIHR 19-09-004	Outfall works, Pigeon House Rd		None
DCIHR 19-09-005	Lifeboat House , Pigeon House Rd		None
DCIHR 19-09-006, NCEHD 3271	Electricity works/Power Station , Pigeon House Rd	Upstanding	None
DCIHR 19-09-007	Cooling water intake dolphin ramp, Dublin Harbour	Upstanding	None
DCIHR 19-09-008	Lifeboat House, South Wall		None
DCIHR 19-09-009	Sluice House, South Wall		None
DCIHR 19-09-010	Causeway, South Wall		None
DCIHR 19-09-011	Slip, South Wall		None
DCIHR 19-09-012	Landing slip, Pigeon House Rd		None
DCIHR 19-09-015	Poolbeg Generating Station chimneys, Pigeon House	Upstanding	None
Approach Channel			
W1551	Wrecksite	Not visible	Location will be dredged
W1552	Wrecksite	Not visible	Location will be dredged
W1553	Wrecksite	Not visible	Location will be dredged
W1554	Wrecksite	Not visible	Location will be dredged

Note: RMP-Record of Monuments and Places; RPS-Record of Protected Structures; DCIHR-Dublin City Industrial Heritage Record; NCEHD-National Civil Engineering Database; W-Historic Shipwreck Inventory.

The majority of sites and features are of relatively modern date, dating from the 19th century and more recently, and refer to the Industrial Heritage of the river and the port. In recent years, Industrial Heritage has grown in significance, and Dublin City Council has championed the recording of sites as part of its Industrial Heritage Record (the DCIHR). All of the sites within Alexandra Basin, for instance, belong to this category, as do the sprinkling of features from the North Bull wall. The School of Engineering at Trinity College Dublin maintains a database of sites they regard as having a heritage value. Of the 275 sites listed nationwide, 12 are within the project area or in proximity to it. A small selection of sites is recognized in the

archaeological record, and these refer to 18th-century structures and include and form part of the Great South Wall. There are no archaeological sites within Alexandra Basin. There is some overlap between the heritage databases, and these locations are highlighted in Table 12.3.

Navigation

The origins of the modern port date to the 18th century with the foundation of the Ballast Office in 1707. The committee of directors, appointed by the City Council, initiated a long-term process of land-reclamation. The initial work focussed on the area upriver of the current project area, and consisted of the construction of the North Wall (1710-1718), facing the river channel, and the East Wall (1718-1729), running northwards along the line of the present day East Wall Road (Appendix 12, Figure 12.3). These constructions provided a tidal barrier behind which extensive land reclamation could take place in what was known as the 'North Lotts', a process that lasted until the early part of the 19th century and significantly extended the land mass on the north side of the River Liffey. A total of 263 plots of land were created and sold by the City Council, ranging in size from three-and-a-half acres to one acre.⁸

In addition, the board was responsible for a number of initiatives to improve anchorage within Dublin Bay, as the bay was susceptible to shifting sand bars, frequent squalls and high winds. In certain wind conditions the approach to the River Liffey was considered un-navigable. In response, the board instigated a major programme of engineering works that included dredging and widening the approach channel to Dublin (1707); construction of an embankment between the City and Ringsend (1711); and building the Great South Wall, begun in 1716 and designed to protect shipping from south to south-easterly gales. The wall also prevented the sands from the South Bull and Ringsend Spit from encroaching into the approach channel. The wall was completed by 1786 and runs 5km eastwards from the harbour at Ringsend to its terminus at Poolbeg Light house (Appendix 12, Figure 12.3). The initial structure was formed using timber piles with gravel in-fill, later being replaced by a cut-stone (granite) revetment. The granite was quarried near Dalkey and shipped in barges across Dublin Bay. The wall is an archaeological monument (Appendix 12.1 DAHG, Sites and Monuments Record, DU019-02902) as is the fort on Pigeon House Road (DU019-027) and the battery on the south wall (DU019-028).

By 1786, an Act of the Irish Parliament passed responsibility for the reclamation work from the Ballast Office to the Corporation for Preserving and Improving the Port of Dublin (the Ballast Board). While the Ballast Board oversaw the conclusion of the reclamation works, largely completed by 1838, it also initiated several developments within the port area. This included the construction of a new Custom House in 1791; Custom House Dock in 1796 (DU18-020564A); a boat-building/repair yard and Patent Slipway (completed in 1833 and recorded on the 1837 Ordnance Survey 6-inch map, Figure 12.4 in Appendix 12.1). The construction of Dublin's first dry-dock was completed in 1860. Prior to these constructions, the majority of the port trade took place on the south side of the river, however, the establishment of the Custom House and associated quayside structures facilitated a lasting shift in port development to the north side.

The most significant development instigated by the Ballast Board was the construction of the North Bull Wall. The wall was constructed on recommendations made by Captain William

⁸ J. W. De Courcy, *Anna Liffey. The River of Dublin*, (O'Brien Press, Dublin, 1988), p. 47.

Bligh, following his survey of Dublin Bay in 1800. Shifting sands and the presence of large sand bars hindered larger vessels from accessing the port. It was also clear that shallows persisted east of the Poolbeg light house, requiring deep-drafted vessels to remain outside the protection of the South Wall until high water permitted them over the Dublin Bar. Bligh was critical of the dredging practices of the time, and had encouraged consideration of a north wall that would run parallel to the Great South Wall, to limit sediment build-up within the harbour and create a natural scouring effect that would eventually deepen the approach-channel. Bligh's wall was aligned to present a funnel shape arrangement of training walls, expanding from c. 700 feet in width at Ringsend to more than 2000 feet wide at the Poolbeg light.⁹ He advised the construction of a smooth wall, uninterrupted by changes in direction or protruding steps or other features that might interrupt and reduce the speed of water flow, as he believed the works at Pigeon House harbour on the South Wall were prone to doing.

It is perhaps within this context that mention can be made of a series of leases that survive, relating to an Oyster bed at Poolbeg.¹⁰ Dating between 1705 and 1832, the leases provide rights to the Oysters to named individuals of the city. The formulaic nature of the leases extended the rights all along the river:

All that their right to the fishing of the River Ann Liffey and Poolbeg from the millstone near Island Bridge eastwards with the city liberty...with the full of three years...to pay yearly...£80 sterling by two even and equal half-yearly payments, that is to say, on every 29th day of March...and also yielding and giving in each year to the Lord Mayor and Sheriff...two salmon each or twenty shillings to each of them in lieu thereof according to ancient custom at the election of the said lord mayor and sheriffs.¹¹

As part of the lease, the lessors were required to permit the free citizens of the city to fish on their fishery with their boats and nets, provided such fishing was for private use and not for sale. The lease of 1832 provides a map that shows the location of the oyster bed. It occupied a 262x262 yard area occupying 13 acres, 3 roods and 13 perches, and lay immediately outside the retaining wall of the harbour at Pigeon House Fort.¹² This places the fishery directly within approach channel. Water depths or soundings are not provided in any of the leases, but one can imagine how such features would contribute frustration to a marine engineer seeking to create an efficient water-scour flow along the Liffey to aid shipping. The remains of the fishery would have disappeared long ago as a result of dredging activities and development activities on the site.

Bligh's proposals for his north wall and for improvements along the South Wall were not accepted, but in their place the Ballast Board approved an existing idea to construct a training wall from Clontarf seawards in the direction of Poolbeg. This had the advantage of including Clontarf in developments relating to the future of the Port, a position that Clontarf had long enjoyed. In contrast, Bligh's proposal would have excluded Clontarf most directly from the Port, as his wall would have been built directly across any natural ingress through the sand flats that served the outlying village. The Great North Wall, or the North Bull wall, was built between 1819 and 1824 under the direction of George Halpin, inspector of works for the Ballast Board. The works were deemed successful, when it was found that the channel was

⁹ Daly, Captain Bligh in Dublin', p. 30.

¹⁰ The records survive among the Expired Leases 1462-1869, that form part of the Dublin City Archives, and date to 1705, 1790, 1795, 1799, 1803 and 1832, references exp/1252, exp/1151a, exp/1151, exp/1152b, exp/1152, and exp/1152c respectively.

¹¹ Exp1151 (1795).

¹² Exp 1152c (1832).

deepened in places by 20 feet and that the Dublin Bar had been pushed 5,000 feet seawards by 1828, and a further 1,500 feet seawards by 1856.¹³ A near contemporary source by the assistant engineer of the Dublin Port and Docks Board describes the 19th-century observations and details, and provides useful insight to the depth of dredging and scour achieved at the time.¹⁴ From 1814, the Port began to use steam dredging as well, and this more mechanized process began to replace the manual dredging operations with a more efficient system. Over time, sediment accumulated along the side of the North Bull wall to form the present-day Bull Island. As indicated in Table 2.2 of this chapter, it is possible to chart the progress of dredging campaigns within the Approach Channel since 1800, and it appears that an accumulated depth of c. 5.8m of sediment has been removed since then.

The structures and features relating to the North and South Bull walls are sites that retain archaeological and architectural heritage protection. Works associated with the present project will take account of their cultural heritage aspects.

The Deepwater Port

With the principal issues associated with navigation along the approach channel being dealt with, attention came to focus on the port facilities. Shipping had been moored along the city quays when tidal access permitted, and the river banks from as far upriver at Gravel Walk Slip/Blackhall Place, included small inlets that served for boat-building and repair areas. The development of quays as we know them today removed these earlier sites, partly to assist in the vision to provide an efficient fluvial conduit to aid in self-scouring and reduce siltation. It was also the case that with the development of steam ships and the demand for increased sea traffic, such older resources were no longer adequate to meet the needs of the modern age, and attention was turned to the as-yet undeveloped north side of the Liffey at East Quay as the principal location for attending to ship repair and maintenance.

As revealed through the early maps, the process of establishing landing facilities and port operations can be traced from the mid-1800s. The lighthouse recorded on the 1837 Ordnance Survey map was established on the North Quay at the 'Point' in 1809, marking the first 'hard point' on the north side of the channel, directing traffic towards the quays. In 1826, a Scottish shipbuilder, Thomas Morton, was engaged to build a slipway capable of handling 300-tonne weight vessels. He had recently patented such a design, for winching vessels up along an iron framework. His slip was built parallel with the East Quay, and is recorded but not named on the 1837 map. Morton was commissioned again and built a second 'Patent slip' in 1832 that was capable of lifting 900-tonne vessels. That site was located some distance from the East Quay, and a small pier was built to connect with the more massive slip, as is recorded on the 1837 map. Both of Morton's slips were infilled in the 1990s. In association with the slips, a 30m-long timber graving frame was constructed on the sands, to which smaller vessels could be attached and serviced when they would be exposed at Low Water. The frame was extended to 60m in length in 1847, before being built on as part of the North Quay Extension some years later.¹⁵

These were early stages in the development of the port facilities, whose plans quickly grew in design and ambition. Some indication of a wider enclosure is indicated on the 1837 Ordnance

¹³ Daly, Captain Bligh in Dublin', p. 32.

¹⁴ I. J. Mann, *River Bars. Notes on the causes of their formation, and on their treatment by 'induced tidal scour', with a description of the successful reduction by the method of the bar at Dublin*. London, 1881.

¹⁵ De Courcy 1996; O'Connor 2013, p. 42.

Survey map, which shows a structured shingle breakwater to the east of the second patent slip. Any plans to further enclose a sea area for the port began to be realized when it was decided to extend a retaining wall 700m east along what became Tolka Quay. The works reclaimed land between the retaining wall and the second patent slip, providing a wide working platform. The 'Breakwater' formed the north side of North Wall Basin. A second retaining bank was built to form its east side, enclosing a sea area that was dredged to allow steam ships moor safely alongside. The area became known as Halpin's Pond, after the Port's engineer, and was later absorbed into the larger deepwater facility of Alexandra Basin. The interior of the North Wall Basin was populated by a timber wharf, to facilitate steam packet ships. This later became the 'Crossberth'. To retain a connection with the development of the basin, the ABR Project will refer to the new quay where the Ro-Ro jetty is to be located as the 'Crossberth Quay'.

The demands on the patent slips became such that it was clear a new facility was required, and in 1853 William Dargan was commissioned to construct what became Graving Dock 1, on the reclaimed land that formed part of the breakwater. The construction project was the first significant task the young assistant engineer, Bindon Blood Stoney, was assigned to. The dock was built 410 feet long and 80 feet wide. It was constructed using granite ashlar blocks to form a stepped façade down its sides, and was curved at its north end. The dock was dewatered in four hours using steam pumps, which were later replaced by an electrically-powered facility that achieved the result in one hour. A dedicated pump house was built on the east side of the dock to house the electric equipment. The dock was closed in 1989, and filled in in 2008 under archaeological supervision. The pump house still stands (Appendix 12.1, DCIHR 18-08-101) and will be refurbished as part of the ABR Project as part of the re-opening of the Graving Dock (DCIHR 18-08-081)

Through the Dublin Ballast Board, the port continued to infill and extend its growing facility, but the single most ambitious aspect was undoubtedly the development of the deepwater berth, whose opening in 1885 by the Prince and Princess of Wales, the later King Edward VII and his Queen, gave their name to Alexandra Basin. The footprint for Alexandra Basin absorbed the preceding developments. It was a grand design that extended from the East Quay on its north side eastwards along what is now Tolka Quay Road to the Eastern Breakwater, that was built between 1858 and 1884 on what is now Breakwater Road at its eastern extent, where the Basin ran south towards the channel. The Port Control centre occupies the riverside terminus of the Eastern Breakwater. This large enclosed space was to be retained by an extension of North Wall Quay, and the interior was dredged to permit depths of 38 feet (11.5m) at High Tide and 24 feet (7.3m) at Low Tide, giving ample access to shipping at the time. The works were overseen by the young assistant engineer, Bindon Blood Stoney, who had answered an advertisement in 1856, to help the port's work and that of its Inspector of Works, or chief engineer, George Halpin.¹⁶ Stoney had a radical idea to build the principal works on the deepwater berth using Portland cement to help construct foundation blocks, which would be floated into position and lowered to the seabed. His ideas were in contrast to the traditional method of using cofferdams and manually laying stonework within. In 1861, when the ideas were developed, he met with opposition from his senior, but Halpin's retirement in 1862 left the way open for Stoney and the Ballast Board to work together on the new design. When the

¹⁶ Stoney's works are well studied and commented on. What follows is taken from these sources, and is supplemented by reference to drawings in the Ports Archives. Stoney's primary biographer is Ronald Cox, *Bindon Blood Stoney, Biography of a Port Engineer* (Dublin Institute of Engineers, 1990). Other studies draw on Cox's work and include: Dictionary of Irish Architects, 1720-1940, Irish Architectural Archive online source <http://www.dia.ie/>; Cormac F. Lowth, 'The Dublin Port diving bell', *The International Journal of Diving History*, Volume 3, Number 1, July 2010, available online via <http://lagnad.ie/>; Turtle Bunbury, http://www.turtlebunbury.com/published/published_books/docklands/heroes/pub_books_docklands_stoney.html.

Ballast Board was reconstituted in 1869 as the Dublin Port and Docks, Stoney was its chief engineer, a post he held until his retirement in 1898.

Stoney's contribution to the Port was significant. He was responsible for designing improved dredging techniques; for rebuilding works on the Essex and Carlisle Bridges; and the construction of the Beresford (or Butt) Swing Bridge. He is also associated with converting half the quays along the Liffey into deep-water quays. His work on the quays was informed by the novel method of underwater construction which he had first advocated in 1861. Works got underway in 1871. Massive concrete blocks, weighing 350 tons each, were made on a block wharf located on the north side of the basin, and then moved to their destination by means of specially designed floating shears. The blocks were lowered into position on the river bed, which had been previously levelled by workmen using a special diving bell which Stoney devised for this purpose, and which survives today as part of the street architecture on Sir John Rogerson's Quay.

Stoney's innovation was not the foundation blocks *per se*, but rather the size and scale of the blocks he designed and used. Harland and Wolff in Belfast built the shear float, and Grendon and Co. of Drogheda built the diving bell. The foundation blocks were cast on the specially built block wharf and allowed to cure for several weeks. Large cast iron girders were incorporated into the bottom of the blocks and wrought iron lifting bars were attached to these. Large granite stones were used in the construction to bulk out the cast concrete. The stones were edge-set side-by-side. Large rebates were cast into the blocks to take stone facing blocks for the new piers and in some instances, part of the stone facing work was completed on the blocks while they were still on dry land. Each block measured 21'4" wide at its base. It seems that there was some variation in height, between 26' and 29' high, and each block had a stepped profile in cross-section that was recessed by 3'6" at the rear, and was of varied height, between 9'6" and 13'.¹⁷

In preparation for the foundation blocks, the overburden would be dredged prior to the positioning of the diving bell. A six-man crew would work inside the bell, levelling the ground surface to ensure that the caissons would lie accurately. Building records show cross sections through the as-built quay and in some instances the section indicates a bed of gravel underneath the caissons. This suggests that the divers may have purpose laid gravel beds where necessary in advance of the caisson being dropped.¹⁸

The shear float would then lower the foundation blocks in place. Grooves cast into the blocks were subsequently filled with concrete to key them together. The blocks were laid in parallel rows where berthage was required on either side of the new quay walls and space between was filled with spoil from the dredging operations. The walls above water were then built up in

¹⁷ Port Archives Ms 8415 provides an elevation drawing of the North Wall Quay Extension, showing the progress of building between December 1871 and June 1880, and including two cross-sections, at 100 feet and 700 feet along the build respectively. Ms 7933 shows an example of a caisson in cross section from the north face of the quay, dated 1875.

¹⁸ Port Archives Ms 7096 (K1047) 'North Quay Extension, progress of wall sections', includes a range of cross-sections with a key-plan to indicate where the sections relate to. Two sections with defined gravel beds are located close to the terminus of Stoney's quay, sections D-E and E-F respectively. In other instances, the caisson is shown lying on an undifferentiated bed.

the conventional manner, and details survive in the Port Archives showing the level of detail given to the granite facades.¹⁹

The method was used for the extension of the North Wall Quay and for the foundations of the North Bull lighthouse. Known as the North Wall Quay Extension, construction commenced in 1871 and was terminated in 1885, when some 700m length of the quay was built. The necessities of the port demanded attention to other matters, leaving the North Wall Quay Extension unfinished, and with its tell-tale irregular terminus. The quay was nevertheless very much in use, and the North Quay lighthouse was re-established at its terminus. The North Wall Quay Extension was completed in the 20th century, as part of preparations for the Eucharistic Congress of 1932. By this time, a new form of caisson design had been developed for works in the Port, and it fell to the then engineer Joseph Mallagh to complete. The caissons were somewhat simpler in design but effective. The caissons were cast in concrete and, floated into position before being filled up and sunk, to give a solid quay frontage. The North Quay lighthouse was moved into its current position at the terminal of North Wall Quay Extension in 1937.

Alexandra Basin has remained a key focus of the Port as it has continued to develop. It has served as the principal landing place for numerous events, some of which have wider narratives across the city, including the Dublin Lockout 1913-14; as a marshalling yard for British Army needs during WWI and during the Easter Rising; it was from here that the British Army withdrew from Dublin in 1922; and it was here that ships associated with the Eucharistic Congress in 1932 berthed.²⁰ In this, the port of Dublin has remained at the centre of important economic and cultural moments, the dynamic of which is embodied in the ever changing and growing nature of the port. Alexandra Quay was built in the 1920s (placed along the north side of Alexandra Basin) and Alexandra Quay East, Ocean Pier, and a number of Oil Jetties were completed by 1955. In addition, a new phase of reclamation works was initiated at this time and pushed the boundaries of the port northwards, along the East Wall, towards the Clontarf shoreline. Further reclamation works to the east define the current extent of Dublin Port.

Within the present study, the North Wall Quay Extension is a primary focus for development works. The Port archives retain considerable detail about the construction of North Wall Quay Extension, as well as information on the layout of the marshalling yards that were subsequently built on its surface. It remains to be described in detail, as an archaeological and architectural feature, and such work will be carried out prior to works proceeding as part of the current proposals. Further detail on the North Wall Quay Extension and its particular importance from an industrial archaeological heritage perspective is provided in Section 12.8 of this Chapter of the EIS.

12.2.4 Historic Shipwreck Inventory

Dublin Bay and the approaches to Dublin Port are considered to be a seascape that retains very high archaeological potential. The shallow sandy reaches of the Bay have proved hazardous to shipping, and during the later medieval period were considered problematic enough to limit access of deepwater craft to the city's quays. The Dublin Bar, which forms across the entrance to the harbour, has been a principal concern for channel improvement

¹⁹ Port Archives Ms 7929 'North Quay Extension. Section of river wall showing small blocks and ashlar work', dated 1879.

²⁰ A more detailed account of recent events associated with Dublin Port and Alexandra Basin is described in O'Connor, 'Cultural heritage', pp 48-70.

schemes, and it was during the 18th century that the Ballast Office was able to marshal the resources to establish the North and South Walls. The current navigation channel passes the bar east of Buoys 5 and 6.

The number of recorded shipwrecking events associated with the wider Bay area and the approaches to the Port approximates 600, of which almost 300 are associated with Dublin Bar. The events are based on historic accounts that have only been systematically noted since c. 1750 AD.²¹ It represents the single greatest concentration of documented shipwreck incidents in Ireland (which are believed to number more than 13,000 in total), and highlights the importance of the Bay and the country's principal port. The details provided in the Inventory describe the type of vessel, the journey it foundered on, and information on the ultimate plight of the vessel and its crew, where possible. In describing the wrecking event, the records will locate the incident in relation to the nearest headland or other topographic marker where known. This is not a record of where the wreckage lies, however, since the historic records generally only deal with the vessel before it sank. Such finer details emerge from other sources, such as fishermen's records of snag points and diver's records of sites located under water.

The number of known wreck sites is much smaller. Thirty wreck and wreckage locations can be charted within the area of the Approach Channel to the Port (Figure 12.10, Appendix 12.1). These include: 12 wrecks that are recorded on historic maps (including eight wrecks recorded on a 'Map of Clontarf, the Estate of John Vernon', dated to the 1790s, and four recorded on Captain Bligh's map of Dublin Bay in 1803); six entries of seabed anomalies detected during the Irish National Seabed Survey; and nine recorded locations for wreckage associated with the loss of the *Kilkenny* cargo ship in 1991. There are also four instances where timber wreckage has been recorded in recent times (wreck references W01544, W01465, W01540, W01734). Wrecksite W01734, known as the 'Ringsend Wreck' after its nearest named place of loss, was subject to archaeological recovery, and timbers have been redeposited on the seabed at known and recorded locations following analysis.

A new wrecksite has been recorded close to the harbour entrance and southeast of Poolbeg lighthouse (Appendix 12.1 W018522). It was located during marine geophysical survey carried out as part of the proposals for the Ringsend Outfall project. The site is well-defined in a multi-beam data trace, which shows a clearly shaped linear wreck, perhaps with its bow facing southeast, and with an indication of linear elements along its side, suggestive of planking. While the wrecksite will not be directly impacted by the ABR Project, consideration is given to it in the event that there may be indirect impacts resulting from shifts in sedimentation as a result of the proposed dredging works.

There are five instances of known wreck locations that occur within the proposed impact area for the ABR Project, as well as W018522 that occurs just outside the survey area (Table 12.4, Figure 12.7 in Appendix 12.1). One wreck location occurs within Alexandra Basin West, and refers to a poorly defined wrecksite that was observed during seabed surveys in a location that has since been buried by infill beside the Lead-in jetty. As part of the ABR works, the fill will be removed, and this work may re-expose the seabed at the recorded wreck location.

²¹ The source of this information is collated in the Historic Shipwreck Inventory of Ireland, maintained by the National Monuments Section at the Department of Arts, Heritage and Local Government. The records for Dublin are published by the Department in Karl Brady, *Shipwreck Inventory of Ireland. Louth, Meath, Dublin and Wicklow* (Stationary Office, Dublin 2008), pp 215-298.

The remaining four sites that occur within the ABR area are located close together at the southeastern extent of the dredge area (wreck references W01551-W01554). All four sites are described in a similar manner, being 3m long, 3m wide and standing 3m above the seabed. Multi-beam survey of the seabed some years ago failed to highlight any indication of wreckage in the four locations. It is possible that the sites have become buried by sediment, and it is also possible that the coordinates recording their positions are inaccurate as they are historic observations noted in early seabed surveys carried out by the UK Hydrographic Survey office. The positioning employed in those early surveys is often subject to refinement in modern surveys. All four locations will be subject to dredging as part of the ABR Project.

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Table 12.4 Recorded wreck sites within and immediately adjacent to the proposed impact area

Name	Detail	Latitude	Longitude	Easting ITM	Northing ITM
GSI 162	Geophysical anomaly, now buried under fill material introduced to Alexandra Basin West in 2008, beside the Lead-in jetty. The fill will be removed as part of the ABR Project, potentially re-exposing this features	053 20 54.24	006 13 22.26	718323.519	734603.239
W01551	INSS G160, possible wreck, measuring 3m long, 3m wide, 3m high off the seabed, in a general depth of 9m. Location lies within impact and survey area and is 160m S of W01552.	053 19 55.48	006 05 21.48	727263.029	733016.95
W01552	INSS G161a possible wreck, measuring 3m long, 3m wide, 3m high off the seabed, in a general depth of 8m. Location lies within impact and survey area. Lies 15m S of W01553.	053 20 01.572	006 05 21.984	727248.743	733204.908
W01553	INSS G161b possible wreck, measuring 3m long, 3m wide, 3m high off the seabed, in a general depth of 8m. Location lies within impact and survey area. Lies 30m S of W01554.	053 20 02.436	006 05 22.524	727238.043	733231.219
W01554	INSS G161c possible wreck, measuring 3m long, 3m wide, 3m high off the seabed, in a general depth of 8m. Location lies within impact and survey area	053 20 03.552	006 05 22.02	727246.366	733266.079
W018522	Lies 350m SE of Poolbeg Lighthouse. It is a clearly defined linear shape with both ends intact and perhaps the bow section facing Southeast. Short linears distinguishable on the side of the vessel may indicate timbering			723444	733771

Source: DAHG. Coordinates given in Lat/Long, converted to ITM

12.2.5 Licensed Archaeological Work

Certain archaeological work has been carried out (Appendix 12.1, Licensed archaeological intervention; Figure 12.7). The work has included a survey of the shipwreck W01465, located north of the Approach Channel and east of Terminal 5 (Licence 08R497), and various small-scale berth improvements works have been monitored, revealing natural substrate underlying reclamation fill (for example at Berth 50A, licence 04E560, and Berth 51A, licence 01E288). Dredging work in advance of Poolbeg Marina was also monitored, revealing modern material over grey silt substrate (04E740). Archaeological work has monitored larger-scale dredging programmes. In 2001, maintenance dredging by the Port of Dublin along the extent of the Approach Channel did not reveal material of archaeological significance (04E1004). In contrast, capital dredging in the same year associated with the cross-bay wastewater pipeline between Ringsend and Sutton, recovered 229 objects, many of which were former ships' timbers (01E283, 01E358). A first phase of dredging focussed on the diverted shipping channel to accommodate the larger project. 109 objects were recovered in that episode. In a later stage of work, a shipwreck was discovered near Sutton Creek. The cross-bay pipeline was buried 4-8m below current bed level, and crosses beneath the Approach Channel between Buoys 5 and 6.

Overall, the archaeological work completed to date helps to confirm aspects of the Port's development that are indicated in the cartographic and historical records. They also demonstrate the high archaeological potential that lies in those parts of the bay which have not been disturbed previously by dredging. The areas of greatest potential for new discoveries appear to be the sand flats and sand bars that populate larger areas of the Bay, as emphasised by the recent observation of the new wrecksite recorded close to the Poolbeg lighthouse. The dredgings conducted previously within the Port and along the Approach Channel will have effectively removed these surface deposits that elsewhere retain shipwreck. This helps to qualify the archaeological low risk associated with new dredging within the Approach Channel.

12.2.6 Site Investigations data

Terrestrial Site Investigations

A programme of site investigations was carried out on the quaysides within Alexandra Basin and at Berths 52/53 (Appendix 12.2). Of twelve core locations identified, investigations were possible at eight sites, three of which were positioned on the North Wall Quay Extension. The purpose of the investigations was to ascertain the nature of the stratigraphic structure of the materials below the present-day surfaces. An archaeological inspection of the site investigations was conducted on 4 November 2013, while Core C1 was being sunk on North Quay Extension.

The project drawings dating to Stoney's era indicate that the height of the quay above the seabed was approximately 13m. Cores C1, C1a, C3 and C4 were positioned along North Quay Extension. C1 was located close to the terminus of North Wall Quay Extension, on an area that would have been reclaimed in the late 1920s to facilitate the completion of the quay by Joseph Mallagh. Reinforced steel was encountered at a depth of 7m and terminated the investigation. C1a was able to penetrate more deeply, to 11.5m using the shell and auger borehole, and to 24m using a rotary core. It appears that the shell and auger was able to penetrate through to the base of the quay, or close to it, and revealed a depth of spoil throughout. This is to be expected as the core is located quite centrally within the quay. The rotary core was able to achieve a depth of 24m, and revealed a sequence of layers of clay and

gravel over silty clay that at 22m encountered a c. 1m thick dark clay, which lies above gravelly clay with the occasional boulder. This may be a naturally occurring sequence, and the presence of clay at such a depth could indicate an outwash layer of clay deposited by the river in former times.

C3 was located midway along North Wall Quay Extension, and within the footprint of Stoney's work. The central location of the core within the quay is too far removed from either façade to encounter the foundation caissons. It is understood that the space between the foundation blocks was filled with dredged spoil. The core revealed landfill in the upper 7m, which overlay layers of silt and sand that continued to c. 17m. This stratigraphy suggests that dredged spoil was used to fill the lower levels of the quay, but that more formal building rubble was sought for the upper half or third of the quay. The clay and clay with cobbles that was encountered below 17m may be considered naturally deposited fluvial layers.

C4 was positioned close to the south-facing façade of North Wall Quay Extension, well within the footprint of Stoney's work, and where one might expect to encounter the foundation caissons. There was no clear indication of the foundation caisson, but it is noted that the upper 6.5m was made up of relatively light fill material, including clay rich sand and gravel and sand and cobbles. This overlay a gravel with cobbles and boulders, which continued to the base of core at 14.2m. The cross-sections of Stoney's caissons indicate a stepped recess at their rear side that could be up to c. 8m deep. It may be that what C4 reveals is the layers of fill added above the mass concrete foundation. If this is the case, the presence of a gravel with cobbles and boulders may indicate that the concrete block has deteriorated.

C5 confirmed the nature of the filled that was dumped in the recent past at this location beside the Lead-in Jetty as reclamation works.

C6, located on the west end of Alexandra Quay, reveals the extent of fill material used in the construction of the quay. The image is similar to the results from C8, located at the east end of the quay. In this instance it was possible to penetrate more deeply, and the layers beneath the quay appear to correspond with estuarine clays and gravels, as one might expect to have formed part of the sand flat that underlies the Port area in this location.

C10 was positioned close to the terminus of Ocean Pier. It was not able to penetrate deeper than 7m, and so is unlikely to have achieved the base of the quay structure. Nevertheless, the presence of gravel and cobbles below c. 4m, and building rubble above, suggests a similar construction technique to that observed on North Wall Quay Extension, where dredged spoil serves as a foundation with rubble providing a firmer underlay beneath the working surface.

C11 was located at Berths 52/53. In this instance, it is clear that the reclamation has built up the current surfaces from the natural seabed, some 11.8m below surface, which is formed from sands and gravels.

The site investigations have revealed a sequence of information that confirms aspects of the constructions used in the building up of the quays. No issues or material of archaeological concern were noted.

12.3 TERRESTRIAL INSPECTION

The proposed terrestrial working area of the ABR Project was inspected. The results are presented in Appendix 12.3 and are described below.

12.3.1 Berths 52/53

Berths 52/53 occupy a basin of newly reclaimed land at the east end of the Port area referred to as Terminal 5. Ro-Ro ramps 7 and 8 are situated at the head of the inlet, to the North. Two stretches of mass concrete-constructed quay walls exist within the inlet; one forming the terminus on the southwest side, the other on the east side where it serves as Berth 53. Elsewhere, the sides of the inlet are represented by a rockarmour finish. A line of dolphin ramps supported on concrete pile-clusters extends into the basin from the rock armour on the west side, presenting a suitable platform for Berth 52. The southeast terminus of the inlet south of Berth 53 is defined by roughly-formed rockarmour. There are no archaeologically-relevant or architecturally/industrially-relevant heritage issues associated with the standing remains.

12.3.2 Alexandra Basin West

Many of the features associated with the early development of the port area adjacent to East Wall Road have been absorbed within port development works. The area today accommodates the main Port offices building, and Terminals 3 and 4. In 2008, Graving Dock No. 1 was filled in, and a lobe of sea area within the basin to the south beside the lead-in jetty was filled with rubble. The quays that form the Working Basin today are a mixture of old and new elements, most of which remains in constant use.

Despite the 20th-century developments which have buried areas of the early port, there are elements that survive at ground level. In addition to the pump house used to accommodate the electrically-powered pump for dewatering Graving Dock No. 1, there are lesser features visible along and inside the East Wall Road boundary wall, where coping stones remain exposed on the surface and trace the lines of some of the early quays, while iron rings and related 'furniture' still attached to the boundary wall, reflect some of the former mooring arrangements. It is understood that none of these lesser elements will be impacted upon by the ABR Project. A detailed record of their location, and a description of their form, would provide a useful gazetteer of heritage elements within the port area.

North Wall Quay Extension

Since Joseph Mallagh's completion of North Wall Quay Extension in 1931, the quay has been in constant use but perhaps the single greatest impact has been the Port's works of the 1980s which resulted in the construction of Terminal 3, as this would have buried a substantial section of the quay on its basin side, and this section remains concealed from view today.

The exposed facades of the quay survive largely untouched, with some sections of repair or adaptation clearly visible. The original mooring-rings set into the quay walls are retained, and the elegantly-cut stone steps are still in use. The granite blocks of the quay wall are however in various states of deterioration. On the quay's deck area, the coping stones survive in place along most of the quay edge, and there are the tracks of former rail lines visible at the west end of the quay that formerly ran along the entire quay to assist in loading and unloading activities. The interior surface of the deck is otherwise masked in a cobble-lock brick that

conceals indications of earlier features on the quay's working surface, such as the Goods Sheds and the Revenue Watch House that are clearly recorded on the 1912-era Ordnance Survey maps.

The North Quay light house is of steel construction and is accessible. It retains an ocular on its first floor level that magnifies a set view across the river channel. Various apparatus associated with its early use occupies the interior of the Light house. When the Light house was moved the short distance from the former terminal of the quay to its current position in 1937, it is understood that the structure was moved on a light rail. There is no indication of the rail today, but it is possible that this is concealed by the cobble-lock brickwork that covers the deck area.

12.4 MARINE GEOPHYSICAL SURVEY

12.4.1 Project Strategy

The principal aim of the marine geophysical survey was to acquire detailed insight to the nature of the seabed and its sediments within the development area.

Dublin Bay may be regarded as retaining the very high archaeological potential for shipwreck discovery. It may also retain indications of palaeo surfaces and inundated shorelines.

The marine geophysical survey would help to assess the archaeological risk and to highlight particular areas of archaeological potential in advance of development works, so that the archaeological risk can be managed.

The combination of side-scan sonar, magnetometry and sub-bottom or seismic survey would provide a robust suite of devices to detect anomalies on the seabed and within its sedimentary levels.

The site-specific survey work would complement existing knowledge that is derived in part from desktop survey and from multi-beam survey conducted by the Irish National Seabed Survey.

The survey specifications are informed by the requirements of the Department of Arts, Heritage and the Gaeltacht.²² Condition 3 observed:

Due to the high archaeological potential of the area, it is recommended that the geophysical survey is carried out at a high resolution and at line spacings of not less than 20m. The geophysical survey should include side scan sonar, magnetometer and sub-bottom profiling systems. Anomalies identified in the surveys should be dived by an archaeologist licensed under the National Monuments Acts 1930-2004²³

²² As set out in correspondence reference G Pre00148/2013, dated 14 May 2013, between the DAHG and RPS.

²³ G Pre00148/2013, condition 3.

12.4.2 Constraints on archaeological method

The survey area is a busy Port area. Site-work needed to be programmed in conjunction with ship movements and was also subject to weather conditions, which were monitored daily by the marine hydrographer in liaison with the Port Operations Centre.

12.4.3 Project Team

The survey work and data processing was conducted by Hydrographic Surveys Ltd (HS). ADCO liaised with HS to ensure conditions were met during survey work. ADCO monitored the survey work directly by conducting a series of site inspection visits. ADCO reviewed the primary data files once HS completed processing, and prepared an archaeological interpretation of the geo-data acquired.

12.4.4 Equipment List

Navigation

Trimble AgDGPS 132. This unit provides sub-metre differential position accuracy. The L-band satellite receiver uses a Trimble developed, sensitive design to provide coverage across the entire satellite footprint.

Bathymetry

The bathymetry data for inside the existing navigational channel is derived from the most recent bathymetric survey (June-July 2013) carried out by HS for Dublin Port. HS proposed to carry out a bathymetry survey in conjunction with the sub-bottom survey in areas that lie outside the existing navigational channel. Survey lines would be along the same sub-bottom profile lines.

Sounding would be obtained by ODOM hydrotrac echo sounder, frequency 200 KHz outputting both digital and analogue data using a side-mounted transducer. The instrument outputs depth to the nearest centimetre and logs raw depths to Hypack. Calibration of the ODOM was by bar-check over the full water depth at the time of the survey. A bar check was undertaken prior to and post each day's surveying. During calibration, variation in water velocities are accounted for, which are controlled by water temperature and salinity.

Tidal Recording

HS used a Valeport Model 740 tide gauge. The instrument records to the nearest millimetre. The tide gauge is calibrated by measuring from a TBM to the waterline over varying tidal conditions. The gauge is considered to be a very stable instrument and the HS gauges are set to record every 5 minutes.

Side-scan sonar

The side-scan sonar survey was obtained using the C-Max digital, dual frequency, sonar. Data was logged using a Rugged CM2 Sonar transceiver connected to a PC running MaxView

acquisition software. The DGPS signal was interfaced in Maxview and Hypack survey software.

Magnetometer

HS used a Marine Magnetics Seaspy Overhauser sensor magnetometer to undertake the survey. The Overhauser sensors have a high absolute accuracy of 0.2nT. The magnetometer was interfaced with the DGPS.

Seismic/Sub-bottom Profiling

Sub-bottom information was obtained using a Boomer-based system (C-Boom). It operates with a dominant frequency of 1760Hz. All profile lines were interfaced with continuous dGPS output for accurate positioning. Data output is in digital SEG-Y format.

12.4.5 Operational

The survey was conducted using survey vessels and skippers provided by Dublin Port. A Marine Mammal Observer was employed by HS to conduct marine mammal observations during the survey work.

The surveys were conducted in two mobilizations: the first carried out the sub-bottom and bathymetric survey, which occurred between 06/06-03/07/2013; the second carried out the side-scan sonar and magnetometer surveys, which occurred between 15-19/07/2013.

ADCO monitored the on-site survey work on two occasions, on 28/06/2013 and on 18/07/2013.

The following data was provided to ADCO for review:

- Side-scan sonar raw data
- Magnetometer raw data
- Sub-bottom raw data
- Field-sheets for side-scan sonar, magnetometer and sub-bottom profile surveys
- Project drawings HS99-1/13, and HS100-1/13, showing bathymetry data and tracklines
- Project drawings HS71_13, showing side-scan sonar and magnetometer tracklines, magnetometer profiles, and sub-bottom profile tracklines.

The marine geophysical survey data acquired has been reviewed and assessed from an archaeological perspective.

12.4.6 Nature of the Record

The record is comprehensive. The data amounts to an intensive survey of the study area that meets the survey requirements. The survey has provided side-scan sonar overlap and the

ability to view the same areas of seabed from different directions. The survey has sought to maximize the potential to identify material that may retain archaeological interest.

12.4.7 Survey Grid

The area was surveyed comprehensively by Hydrographic Surveys Ltd. The surveys were conducted in a manner that meets the 20m line-spacing requirement set by the DAHG. Maps showing the survey tracklines and details of the site work completed are all contained within Hydrographic Survey's report on the survey work of Summer 2013 (Hydrographic Surveys, 2013 Report no. PH 13003).

The side-scan sonar and magnetometry survey tracklines shared the same grid. A series of East-West-aligned survey lines formed the principal tracklines at 20m intervals, extending downstream from the East Link Bridge and out to sea at the survey terminus. North-South lines were set at 250m intervals to provide a sequence of perspectives at right angles to the principal lines. The survey was conducted in a 'zig-zag' method, extending along one axis for one survey line, and returning in the opposite direction along an adjacent survey line. For side-scan sonar work this technique has the advantage of recording the same areas of seabed from opposite directions. This method increases the possibility of identifying targets precisely and in imaging their shape and extent. The opportunity for further directional perspectives is provided by the crosslines. The range for side-scan survey was set at 50m. Combined with the 20m-line spacing and zig-zag method of data acquisition, the survey exceeds 100% coverage and overlap within the survey footprint.

The sub-bottom profile survey was conducted on a different grid, to maximize the observation of potential sedimentary contrasts on the seabed outside the training walls. The area that lies within the training wall is constrained by the training wall, and line orientation was parallel to the channel, with cross lines running perpendicular to the channel. The area that lies in open water east of the training wall had principal line orientation running perpendicular to the channel, and cross lines running parallel to the channel. This was to maximise the possibility of data recovery, since sedimentary variation tends to be at a maximum perpendicular to the shore. Sub-bottom profile survey was also carried out for geotechnical purposes at 50m intervals, aligned along the channel.

12.4.8 Bathymetry Survey

The bathymetry survey within Alexandra Basin West reveals a consistent depth of -8m CD to c. -9.5m CD (Chart Datum) in its main central area and along the Alexandra Quay West and Ocean Pier. The depths are somewhat shallower beneath the bulk jetty at c. -7m CD, while at the western end of the Basin they are c. -6m CD, and alongside North Quay Extension the depths are deepest at c. -7m CD at the Ro-Ro Ramp No. 4, and become progressively shallower as one proceeds East and out of the Basin, with depths reaching -4.4m CD at the terminus.

The main channel area reveals deeper depths alongside the principal quays, and shallower elsewhere, reflecting the recurrent dredging activities of the port. Below the East Link Bridge, water levels are comparatively shallow, varying between -6.7 and -7.2m CD on the north side of the channel, and rising to -2.1m CD and even shallower on the south side of the channel as far east as the Poolbeg Yacht Club. The activities of the Port take over eastwards, and depth across the channel varies between c. -8m and -9.5m CD. The bed is not entirely level but there is a consistency that approximates this. The central channel area is distinctly evident at -8m CD, with some deepening to -9m CD, while the slopes are clearly present with shallower

depths. The side slopes show localized steepening on the north side and also on the south side. Some shallowing is evident on the south side of the channel opposite Berth 45 and the Oil Tank Jetty where depths are in the -7m CD range, although there is a distinct deepening to -9m CD alongside the berth and jetty.

At the entrance to the harbour, the central channel drops to -10m CD, reflecting the intense fluvial dynamic at this point. The profile of the navigation channel is distinct proceeding eastwards, with a consistent depth of -9m CD progressing to -10m CD. A noticeable recess occurs at one location on the south side of the channel, west of No. 6 Buoy. Where the channel is aligned to the Southeast, between No. 3 and No. 4 Buoy, the central area of the channel deepens to -11m CD with a more restricted linear depth of -12m CD over a shorter strip. The average depth of -10m CD is re-established to the east. Where the survey area expands in width, reaching out beyond the eastern terminus of the navigation channel, the depths shallow progressively, with an area of c. -8m CD occurring at the southern perimeter of the survey area.

Overall, the bathymetry data reveals the imprint of the dredge depths required to date to service the activities within the port and to provide access to shipping along the navigation channel. The natural seabed levels immediately adjacent to the navigation channel are also recorded, and show the progressive deepening from -2m CD at Poolbeg Yacht Club, to -4m CD outside the training walls, to -8m CD at the eastern limit of the survey area. While it is necessary to account for sedimentation processes as a contributory factor in establishing these shallow depths, the contrast with the dredged depths is in the order of c. 5m along much of the course of the navigation channel, and indicates the level of impact that has taken place already. At the eastern terminus, the impact has been less, in the order of 2m.

12.4.9 Side-scan Sonar Survey

Side-scan sonar survey is a key marine geophysical survey technique employed to acquire an image of the seabed surface and for detecting the presence of features or objects that may lie exposed on the surface. It is most useful for constructing an understanding of the surface layer of the seabed. It is less useful for gaining an understanding of the underlying deposits, since side-scan sonar is unable to detect features that lie underneath the covering seabed layer.

The sonar operates by emitting sonic pulses, which extend from below the device and reach across a swathe on either side that is set at a pre-determined range or distance from the device. The sonar can be operated at a variety of frequencies that are adjusted to suit the extent of coverage and the quality of the seabed images. The requirement of the present survey was for high resolution, which means that the device should be set to image a relatively narrow band of the seabed so that the data detected can be viewed in clear detail. The range was set at 50m. With the survey line-spacing of 20m, this resulted in multiple overlap, and a very comprehensive imaging of the seabed.

The side-scan sonar data reveals a consistent seabed type that is dominated by soft sand/mud, with consistent elements that suggest linear variations in the base mud, caused either by dredging or by propeller wash (Figures 6.8 – 6.9 in Appendix 12.4).

The survey highlights quay-side and Port-related features, such as jetties, piles and passing shipping (Figures 6.10 – 6.13 in Appendix 12.4). None of these elements represent archaeological features, but they have been included on occasion in Appendix 6.4, which includes a list of some 301 anomalies and features that are captured in the side-scan sonar traces (the observations are summarized in Table 12.5). The navigation buoys and channel

markers are clearly visible, and the sonar traces capture images of the same object on several occasions. The buoys are most often represented by indication of a mooring anchor, to which is attached to a length of cable or chain that lies on the seabed forming a sinuous plan.

Table 12.5 Summary of the nature of anomalies detected in the side-scan sonar survey

Item	Number including multiple views	Number excluding multiple views	Number that require further consideration
Recorded anomalies that appear as obvious shipwreck material	0	0	0
Recorded anomalies that are considered to retain high archaeological potential	0	0	0
Recorded anomalies that are considered to retain medium archaeological potential	5	2	1
Recorded anomalies that are considered to retain low archaeological potential	297	184	119
Total	302	186	120

Source: Appendix 12.4.

There are no clearly or obviously defined anomalies indicative of shipwreck. There are no boat-shaped features lying on the seabed, and there are no obvious composite features indicative of areas of timber-framing suggestive of ship's structure. Nor are there indications of fishtraps or related shore-based maritime exploitation within the proposed dredge area, such as kelp beds. This is not surprising given the extent of channel deepening that has occurred, and which can be quantified since 1800 (as described in Table 2.2 of this Chapter above).

One complex feature (reference 24_2 [i.e. survey line 24, anomaly 2]) was identified, other than obvious modern port-related items. It is a bow-shape cable array located on the north side of the navigation channel and just outside the proposed dredge impact area. It is not an archaeological feature, and is identified as a length of abandoned cable that formerly served the lighthouse buoy. It lies outside the proposed impact area, and requires no further assessment.

Particular attention was paid to the charted locations of recorded wreckage within the survey area, namely the positions of W01551-W01554, close to the south-eastern terminus of the dredge area. No indications of anomalies were observed (Figure 12.14 in Appendix 12.4). This supports the GSI's own coverage of the seabed based on multi-beam survey. The sonar traces show a silty seabed with occasional indication of small rock, and some linear variation that is probably an exposure of underlying mud. There is no indication of clearly defined anomalies measuring 3m x 3m in size as recorded in the GSI's historic datasets. Despite the absence of apparent anomalies in these four contiguous locations, further consideration should be given to this data to help to clarify the original record by additional seabed inspection.

There are a large number of features throughout the survey area that cannot be readily explained as artefacts of the modern port and its apparatus. These features include isolated

objects and sometimes quite small features on the seabed, as well as less well defined anomalies that may be localized mud formations but cannot be clearly identified as such from the data gathered. Where such features occur within the area proposed to be impacted by dredging, they constitute a body of anomalies that warrant further consideration. There are 120 of these anomalies, as summarized in Table 12.5 and as described in Appendix 12.4. They are distributed throughout the survey area and do not form particular or obvious spatial clusters or groupings (Figures 6.15 – 6.20 in Appendix 12.4).

Prior to a programme of dive inspection, a single target was considered to retain archaeological potential (anomaly 1_9). It is a well-defined rectangular feature on the sonar traces that measures c. 5m in length, is orientated East-West, and appears to have an associated area of scour. It is located within the Navigation Channel on its south side and downstream of Pigeon House Dock. It is shown on corresponding sonar traces (7_2, 17_1, 100_2, 159_3, 170_3), highlighting the fact that it is clearly defined. The location was also highlighted as a localized magnetometer anomaly (mg20_6), indicating the possibility that it retained a ferrous metal content. The clear definition of this feature warranted further assessment, which was completed as part of the dive inspections. That work, which is discussed in Section 12.5, did not observe an anomaly in the location. Instead it records a hard gravel surface, and concludes that the side-scan sonar anomaly 1_9 is a naturally formed feature and is not of archaeological significance.

A second anomaly is deemed to be of medium archaeological potential (19_1). It is defined as a linear feature that extends some 15m in length. It is also indicated on other traces (30_1, 37_7), where the linear element appears more complex and it may represent a localized snag that has become festooned with netting and rope. There is no distinctive magnetic anomaly indicated here, suggesting that if it is an object there is no significant ferrous metal component. Dive inspection is scheduled to take place here when weather permits.

The remaining 118 features identified on the sonar traces within the proposed impact area are considered to be of low archaeological potential. They lack discerning features, and in instances appear to be localized mud formations, perhaps derived from propeller scour or from maintenance dredging. They are included because they stand out from the ambient seabed as being different but they are not considered to retain a high archaeological value. They cannot however be entirely removed from consideration based on the information to hand. Correspondence with the magnetometer and the sub-bottom profile surveys can add some clarification, and a programme of dive inspection is ongoing to provide further assessment (see Section 12.5).

12.4.10 Magnetometer Survey

The magnetometer is specifically designed to detect fluctuations in the background magnetic field. It can be a useful tool to chart variations in the underlying geology of an area of seabed that are revealed in large-scale and continuous shifts in the magnetic signature, measured in nanotesla (nT). It is also useful for detecting metal objects, which can be indicated as sharply-defined localized and relatively small-scale variations in the magnetic signature. In contrast to side-scan sonar, the magnetometer only acquires data from directly underneath the survey instrument; it does not have the swathe capability of sonar and consequently it is most useful to have closely-spaced survey lines, to maximize the information return. Magnetometry has the advantage over sonar that it can penetrate below the seabed surface, and consequently it can detect objects and formations that are buried. It cannot reveal the depth of burial however. It is also subject to interference from adjacent highly magnetic elements, such as passing shipping and ambient quays and jetties, both of which are relevant in the current instance, and both of which can make it difficult to isolate useful data.

The magnetometer survey which is presented in Hydrographic Surveys report of 2013 show the surveyed tracklines of both the magnetometer and the side-scan sonar surveys. At the level of variation shown, only the extremes are indicated. The presence of berthed vessels is clearly indicated within Alexandra Basin, and on the north and south quays as one progresses eastwards from the Port. Beyond the training walls, however, the suggestion of fluctuations is muted, and very few significant variations are indicated; those that occur are explained by the presence of the navigation buoys, with the suggestion also of the cross-Bay sewer pipeline.

Further insight is achieved by sifting the data for smaller-scale fluctuations, in the order of 10-20 nT. These are apparent when the data is presented in profile format, where the presence of sharply-defined spikes and dips highlights the presence of a localized anomaly. The individual magnetic anomalies are presented in Appendix 12.4 Magnetometer Survey. At this level of detail, the natural variation of the magnetic field is also apparent, and as the profiles reveal, the consistent pattern across the survey area shows a lot of variation, with the localized spikes occurring as additional fluctuations. The lines within Alexandra Basin West and alongside the quays are removed because of the intense fluctuations caused by proximity to the quays and to berthing vessels.

There are numerous small-scale variations on the remaining East-West lines (Figures 6.20-6.25 in Appendix 12.4). A noticeable cluster occurs across the channel adjacent to Berth 45 and the Oil Tank jetty, and no doubt reflects the activities of metal recycling conducted off the south quays in this area.

There is a moderate recurrence of magnetic anomalies along the approach channel out to the harbour entrance. A distinct Northeast-Southwest trend is apparent to the east of the training walls and extending across the channel between Buoys 5 and 6. This charts the route of the cross-Bay Sutton-Ringsend Sewer pipe, laid in 2003. It is a 1.42m-diameter steel pipe that is buried 4-8m below current seabed level. The track of the pipeline allows us to remove from further archaeological consideration any anomalies associated with its footprint. Further out, there are few magnetometer anomalies detected.

In the charted location of the four sites of wreckage recorded in the GSI data (W01551-W01554), there is no clear indication of a magnetometer anomaly. This observation is however tempered by the fact that a series of small readings identified at mg52_5, mg53_4 and mg54_3 are indicated slightly to the north forming a similar cluster pattern as W01552-W01554. Given the inaccuracy of historically-recorded wrecksite coordinates, this cluster of magnetometer anomalies to the north suggests an interest, although it is in a location for which there are no side-scan sonar anomalies recorded (compare Figures 6.20 and 6.26 in Appendix 12.4).

12.4.11 Sub-Bottom Profile Survey

The sub-bottom profiler is designed to determine the nature of buried stratigraphy, and is of use for detecting variations in the underlying geology of seabed. It can distinguish between hard deposits such as rock and soft deposits such as clays. It can also distinguish variations within soft deposits, where sands and silts may overlie clays. From an archaeological perspective, sub-bottom profiling can discern cuts into the deposits, where a sand or silt may fill a void in a clay deposit. The profiler can also reveal the presence of shipwreck, where the wrecksite is substantial enough to return a strong signal. Small-scale craft, such as typically-sized logboats or small skiffs, are unlikely to be identified because they lack the volume of timber and the hard-object cargo that otherwise provides the strength of signal needed to be visible in the datasets. In common with the magnetometer, the sub-bottom profiler only

acquires data from directly underneath the survey instrument. It is therefore most useful to have closely-spaced survey lines, to maximize the information return. This has informed the 20m spacing required for the present project. As noted above, the survey area inside the training walls determined the orientation of survey lines. Outside the harbour, such constraints did not exist, and the principal lines were orientated North-South, to run across the navigation channel in order to maximise the possibility for data recovery because sedimentary variation tends to be at a maximum perpendicular to the shore.

Overall results of the sub-bottom profile survey are presented in the Hydrographic Surveys report of Summer 2013 (Report no. PH 13003), which show cross-sectional interpretation of the data acquired on a representative selection of 71 of the survey lines. Lines 1-11 show the detail along the principal East-West survey lines within the harbour. Lines 12-60 show the detail along the principal North-South survey lines outside the harbour. Lines 61-68 consider Alexandra Basin West, and Lines 69-71 cover Terminal 5, Berths 52/53.

The survey penetrated to c. 20m below seabed level within the approach channel inside the harbour. The stratigraphy is principally a series of soft layers comprising of 0-1m of surface silts overlying sandy silts (varying 3-5m in depth), which overly silty sandy gravelly clays (5-10m deep). These in turn lie above boulder clay (3-10m deep), which is over rock. The silts, sands and clays are consistently recorded throughout the surveyed extent, but rock is only detectable in places, occurring on the north side of the channel by Alexandra Basin, and recurs on the south side of the channel up- and downriver of the Sludge jetty.

Within Alexandra Basin West, the deposits are principally silts overlying sandy silts, over gravelly clays, over boulder clay, with the exception of the south side of the basin, where a defined rock layer is recorded at c. -20m CD (interpreted survey lines 65, 66, HS 74A-11X/13). The rock disappears at the entrance to the basin. Although the rock is not clearly evident immediately beside North Wall Quay Extension on the basin side, the presence of rock levels in the main channel outside the basin, suggests the possibility that rock may well extend at depth under North Wall Quay Extension. One can note here that an overlay of Alexandra Basin with Rocque's map of 1757 shows a correspondence between the entrance to the basin today and the line of an inlet. Furthermore, there is correspondence between the spit of sandbank that extended out to the inlet and where NWQE came to be built (Figure 12.5 in Appendix 12.1). It serves as a useful supporting indication of the solid ground upon which NWQE was founded.

The stratigraphic profile revealed by the sub-bottom profile survey within the inlet at Terminal 5 shows similar stratigraphy to that which occurs more generally, with rock occurring 15-20m below seabed level.

The sub-bottom profile survey penetrated to c. 15m below seabed level outside the harbour. A similar stratigraphy is revealed of silts overlying sandy silts, over gravelly clays, over boulder clay. In the area immediately outside the harbour entrance, the profile of the current channel is conveyed at the surface level with gently sloping sides. The underlying layers also reflect the presence of a channel but the slopes are not necessarily in synch with the surface slopes, nor are they always so gently angled (for example, interpreted survey lines 12-14, HS 74A-3X/13). There is a consistency to these images over several of the North-South survey lines, showing a more dramatic slope particularly at the boulder clay level. It suggests the presence of historic or indeed ancient alignments of the river channel that presumably predate any dredging experiences on the river, and is the clearest indication in the dataset for the possibility of palaeo-channels. The channel may have been positioned somewhat to the south of its current alignment, by the order of c. 25m. If this interpretation is correct, it is also the case that the variations in the boulder clay level indicate narrows as well as wider expanses, and this is in

keeping with a natural estuary or delta, where the river would have followed various channels through its lower reaches to the sea.

To the east, and between lines 16 and 25 (which is coterminous with Buoys 5 and 6), the distinctions of channel sides are much less defined, and the image is one of relatively flat stratigraphic layering. It is within this area that the Cross-Bay Sewer traverses the approach channel, but there is no clear indication of a trench-cut, and there is no suggestion of the 1.42m-diameter pipe, unlike in the magnetometer dataset which shows the line of the pipe very clearly. The clarity of the stratigraphy as recorded in the sub-bottom data is blurred and this indicates the disturbances that occurred as a result of the dredging, where the backfilled sediments are a general mix of ambient material.

Lines 25 and 26 characterise other lines to the east, in showing how modern dredging has removed the denser sandy silt that otherwise lies underneath the surface silt, and indeed how the sandy gravelly clay has been intruded into in the central channel area. The underlying deposits are left intact, and these can retain variations once again that are suggestive of former channels at depth.

Between lines 28 and 46, rock is evident beneath the boulder clay. This extends almost to the eastern extent of the survey area. At its highest, the rock lies at c. -18m CD, some 10m beneath current seabed level, but drops slowly eastwards to an average depth of -22m CD.

From an archaeological perspective, one can expect the potential for shipwreck material in the upper zone of sandy silt and gravel, which can reach 7-10m in thickness outside the harbour. It is in this layer, for instance, that the known shipwrecks in the wider bay area have been seen, whether as the timber wreck W01465 recorded to the east of Terminal 5, or as the 'wreck observed during the multi-beam survey south of Poolbeg Light house, W018522.

In places, such as Lines 25-26, modern dredging has all but removed the layer from the Approach Channel, but in other places it remains in place. The potential of this layer to retain archaeological material within the works area is indicated on Line 29, where two discontinuous internal reflectors occur and have been highlight as being archaeological targets, one on either side of the channel's side slopes (HS 74A-5X/13).

A number of discontinuous internal reflectors exist in the larger dataset. A list of 30 anomalies is presented in Appendix 12.4 Sub-Bottom Profile Survey. It should be emphasised that the reflectors are indicative of archaeological potential only; in no case does any of the reflectors present unqualified evidence for a wrecksite or other significant feature. No reflectors were observed at the charted locations of wrecksites W01551-W01554. This is a further indication that the charted locations may be erroneous.

In six instances, the reflector appears to be at or immediately beneath the surface (sb2, sb3, sb4, sb14, sb17, sb18). Dive inspection of these locations may provide further insight to what they are.

In three instances, the reflector occurs within the sandy silts that are considered ideal entrapment areas for wreckage (sb12, sb15, sb16). Anomalies sb15 and sb16 are located outside the dredge area, and no further action is required in these instances. However, sb12 which occurs within the area to be dredged, and is located close to the eastern extent of the dredge area. The location should be dive-inspected prior to dredging.

In the majority of cases the sub-bottom reflector lies buried in the covering sands, making further assessment prior to dredging impractical. These reflectors include markers that highlight the possibility of palaeo-channels (sb19, sb22-sb28). The presence of deep reflectors emphasises the need for archaeological monitoring during construction, as it is at this stage that the anomaly and any associated material may be exposed and recovered to the surface.

12.4.12 Correspondences between Side-scan sonar, Magnetometry and Sub-Bottom Profile data

There is an association between some of the anomalies in the different datasets. This association is between side-scan sonar and magnetometer anomalies. There is no instance of a direct overlap with sub-bottom profile anomalies.

The association between side-scan sonar anomalies and magnetometer anomalies indicates that the former have a ferrous metal (iron/steel) content, and that the anomalies are man-made in origin. The combination, for instance, highlights the anomalies associated with the present-day navigation buoys.

The association should not detract from the archaeological potential of side-scan sonar targets that do not have a corresponding magnetic signature, it merely indicates that those side-scan sonar targets are unlikely to have a significant metal content and may be represented by organic remains only, such as rope or timber, if they are not naturally-formed features.

Equally, in those instances where the magnetometer anomaly is not associated with a side-scan sonar feature, the conclusion is that, either the surface indicator is too small to register in the sonar trace, or the anomaly is buried. It is not possible to estimate the depth of burial from the evidence recovered. As detail relating to the Cross-Bay sewer pipe reveals, that feature is buried 4-8m below the seabed surface. Such potential features in other contexts that indicate they are buried would not generally be subject to further pre-disturbance assessment. The exception would be those anomalies (mg52_5, mg53_4 and mg54_3) that lie close to and share a similar clustering that distinguishes the distribution of the charted wreck features W01552, W01553 and W01554. To date, based on the marine surveys completed, it appears that the wrecks may not be at their charted location. It is necessary to be open to the suggestion that the coordinates are wrong, and that side-scan sonar and magnetometry surveys commissioned by Dublin Port as part of the EIS will contribute useful information in clarifying the actual position of these features.

More generally, the presence of the magnetometer anomalies informs the construction stage in much the same way as buried sub-bottom profile reflectors, and signals the need for monitoring of the dredging process to seek to recover such buried objects at that time.

Despite the absence of direct overlap with sub-bottom profile targets across the datasets, there are three cases where sub-bottom profile anomalies lie close to side-scan sonar anomalies and anomaly clusters. Sub-bottom sb6 lies 18m from side-scan target 143_1; sb10 lies 30m from the cluster associated with 53_1; and sb12 lies 45m from 36_2, 46_4. Although the latter is some distance away, the relative attention to this anomaly is raised on the basis that dive inspection has observed metal fragments at the sonar anomalies.

12.4.13 Concluding observations

The marine geophysical surveys completed for the ABR Project have been very comprehensive and thorough. The work has produced a significant sequence of datasets that inform the present study and will be useful to future work and research of Dublin Bay's sedimentary history.

No shipwrecks or related significant archaeological material have been definitively identified in the datasets. A large number of possible indicators of cultural remains have been recorded and positioned.

The sand-banks through which the Approach Channel is aligned retain the highest potential for the discovery of new archaeological sites, as attested by the existing information. The silty sand layer that forms the uppermost significant deposit is an ideal entrapment level for wreckage and related remains.

Within the Approach Channel, large sections of the upper silty sand layer have been removed by the effects of induced tidal scour and by capital dredging campaigns that extend back several centuries. The marine geophysical surveys have identified anomalies on the seabed and these are subject to an ongoing programme of dive inspection. To date, no material of obvious archaeological significance has been identified.

12.5 UNDERWATER INSPECTION/DIVER TRUTHING

Condition 3 of the DAHG observation on the proposed marine geophysical survey states the 'anomalies identified in the surveys should be dived by an archaeologist licensed under the National Monuments Acts 1930-2004'.²⁴ The DAHG has acknowledged that dive inspections should proceed as weather dictates. The DAHG further acknowledges that this process can continue after submission of the EIS but should be completed prior to Oral Hearing, so that An Bord Pleanála can be informed fully of the archaeological potential before making its decisions.²⁵ Archaeological inspection surveys occurred on 26-29/11/2013 and 18/12/2013, achieving 36 separate dives and inspecting 42 individual side-scan sonar targets. The results are absorbed into the side-scan sonar data in Appendix 12.4, and are presented in Appendix 12.5.

12.5.1 Observations

The dive inspections have focussed on the side-scan sonar anomalies or targets, as these anomalies are by default exposed on the seabed and therefore visible to the diver. Magnetometer targets, where they are represented in isolation and without a corresponding side-scan sonar signature, may be buried in the seabed deposit. In such circumstances, the target would be inaccessible and invisible to the diver. Sub-bottom profile targets can also lie buried and as such are inaccessible for dive inspection, although there are certain instances where appears that the reflectors lie at or just below the seabed surface. Consideration can be given to inspecting those locations as well, where they lie within the proposed impact areas.

²⁴ G Pre00148/2013, condition 3.

²⁵ This point was made at a meeting of the Project Team with DAHG on 06/11/2013.

The dive work has sought to assess individual targets across the survey area, to provide insight to the varied type of anomaly encountered along the length of the Approach Channel, on its side slopes, and at locations that remain outside the proposed direct impact zones for dredging.

The dive work has helped to clarify the archaeological potential of the anomalies inspected. Prior to the inspections, the side-scan sonar data indicated one potential high-value target within the survey area. Anomaly 1_9 presented an image of a substantial rectangular target lying on the seabed, measuring c. 5m long by c. 2m wide. The anomaly was identified on several corresponding data traces. However, no target was identified when inspected by diving. The seabed is a hard gravel bed in this location. There was no indication of objects such as metal or timber, and it is determined that the side-scan sonar anomaly represents a natural formation in the gravel bed.

Overall, the dive inspections have confirmed the low archaeological potential of the targets inspected, clarifying that the targets are modern objects such as tyres, mooring blocks or pieces or navigation buoys, or that they are natural features, such as gravel ridges or concentrations of cobbles. There are also several instances where the dive inspection was not able to identify any feature on the seabed.

There are two instances where material was identified that warrants consideration. At side-scan sonar anomaly 158_2, located on the northern slope of the approach channel, a 1m-diameter iron/steel flanged pipe was observed protruding from the slope, at a depth of c. 3m from the top of the slope. The pipe is twisted and bent from previous damage, having been grabbed and buckled. It remains possible that further remains are buried in the sands behind the side slope. The metal pipe appears to be comparatively modern. The appropriate mitigation is archaeological monitoring during dredging.

The second instance lies close to the eastern extremity of the survey area, at side-scan sonar anomalies 36_2, 46_4. The side-scan sonar data indicated a localised hard object. Dive inspection observed a series of exposed sections of iron on the seabed, measuring 1.4m long, 5cm wide, and 8cm thick. The iron is covered in marine growth but the metal appears to be of modern origin. The surrounding seabed is composed of compact clay. It is possible that the metal is part of a structure that is buried in the seabed at this location. It is notable that the anomaly occurs to the east of the cluster of plotted wrecksites W01552-1554, which have left no clear marine geophysical signature. Given the locational inaccuracy of historic wrecksite coordinates, it is possible in the present instance that the dive inspection has identified the actual location of one of these sites. Further inspection and assessment is planned.

Additional dive work will take place in the Spring of 2014 as weather permits. The results of this work will form an Addendum to the EIS.

12.6 IMPACT ASSESSMENT ²⁶

Impacts and mitigations are summarised in Table 12.6, and described below.

Table 12.6 Summary of assessed archaeological and architectural heritage impacts and mitigations associated with the ABR Project

Reference	Site type	Impacts from ABR	Mitigation
DCIHR 18-08-081, NCEHD 3024	Graving Dock No. 1	To be re-opened as part of Heritage Gain	Re-exposure to be achieved as an archaeological operation
DCIHR 18-12-005, DCIHR 18-12-084, DCIHR 18-12-091, NCEHD 3253	North Wall Quay Extension	Development works will partially remove and partially bury the quay in the redevelopment of NWQE	- Archaeological recording in advance of development - Archaeological investigation of former deck feature - Preservation by record - Archaeological monitoring during development
DCIHR 18-12-083	Goods Shed, NWQE, site of	Potentially demolished by development works	- Archaeological investigation of former deck feature - Preservation by record - Archaeological monitoring during development
DCIHR 18-12-085	Goods Shed, NWQE, site of	Potentially demolished by development works	- Archaeological investigation of former deck feature - Preservation by record - Archaeological monitoring during development
DCIHR -12-086	Good Shed, NWQE, site of	Potentially demolished by development works	- Archaeological investigation of former deck feature - Preservation by record - Archaeological monitoring during development
DCIHR 18-12-087	Revenue Watch House, NWQE, site of	Potentially demolished by development works	- Archaeological investigation of former deck feature - Preservation by record - Archaeological monitoring during development
DCIHR 18-12-088	North Wall Light house, NWQE, site of	n/a as this feature was already relocated in 1937	Archaeological monitoring during development

²⁶ This section does not purport to relate precise engineering details but is rather an attempt to understand the nature of the impact on the potential archaeological environment, based on the data supplied by RPS.

Reference	Site type	Impacts from ABR	Mitigation
DCIHR 18-12-090	Alexandra Basin	Dredging of basin silts	Archaeological monitoring during dredging
DCIHR 18-12-092, 93	North Wall Light house, NWQE	To be relocated as part of the development works	- Detailed record to be made of light house prior to removal - Management plan to be devised to protect light house during development works - Re-deployment to be achieved as an archaeological operation
NCEHD 3051	Poolbeg Lighthouse, Great South Wall, Poolbeg	Foundations of Great South Wall terminus will be reinforced with further rock armouring due to deeper dredge design level	Archaeological monitoring
NMI 1970:190-192	Objects dredged from seabed at NWQE	Area will be re-dredged	Archaeological monitoring
GSI 162	Recorded wreck feature, possibly an abandoned vessel or part thereof close to former shipyard	Rubble fill overburden will be removed, potentially re-exposing the feature	- Archaeological monitoring - Underwater inspection and preservation by record if necessary
W01551	INSS G160 possible wreck, measuring 3m long, 3m wide, 3m high	Area will be dredged	- Underwater inspection and recording will take place as part of EIS - Preservation by record if necessary - Archaeological monitoring
W01552	INSS G161a possible wreck, measuring 3m long, 3m wide, 3m high	Area will be dredged	- Underwater inspection and recording will take place as part of EIS - Preservation by record if necessary - Archaeological monitoring
W01553	INSS G161b possible wreck, measuring 3m long, 3m wide, 3m high	Area will be dredged	- Underwater inspection and recording will take place as part of EIS - Preservation by record if necessary - Archaeological monitoring
W01554	INSS G161c possible wreck, measuring 3m long, 3m wide, 3m high	Area will be dredged	- Underwater inspection and recording will take place as part of EIS - Preservation by record if necessary - Archaeological monitoring
Various	Marine Geophysical Survey anomalies and seabed, Alexandra Basin and the Approach Channel	Locations will be dredged	- Underwater inspection and recording will take place as part of EIS - Preservation by record if necessary - Archaeological monitoring

Note: Only sites where direct impacts are indicated are included in the table. Marine Geophysical anomalies are grouped as one entry. For specific sites on land and at sea, and for all other locations mentioned in the assessment, see Appendices 12.1-12.4.

12.6.1 Impacts during Construction Phase

Berths 52/53

The proposed impacts will be to infill the open-water area, using material derived from the dredgings that will form part of the larger project.

The structure of Berths 52/53 is not of interest from a cultural heritage perspective.

No direct excavation disturbance of the seabed is envisaged within the inlet of Terminal 5.

The ABR Project works associated with filling-in Berths 52/53 will have no impacts relating to archaeology or architectural heritage.

Alexandra Basin West

The following principal impacts are proposed within Alexandra Basin West, excluding North Quay Extension, which is considered separately below:

- Fill in Graving Dock No. 2
- Demolish the Lead-in Jetty
- Remove the recent infill beside the Lead-in jetty
- Relocate the ore loading facility
- Demolish the Bulk Jetty
- Re-open Graving Dock No. 1 as an initiative related to heritage gain.

Removal of the recent infill beside the Lead-in jetty will serve to reinstate an element of the former footprint of Alexandra Basin. One of the historic shipwreck sites associated with the Port and the Approach Channel is located under this area of recent infill (GSI 162). Given that this location is close to the old shipbuilding and repair yards, it is possible that remains of a vessel were abandoned here. The process of removing the modern overburden will be monitored archaeologically. Once it is established that wreckage remains are identified, an underwater inspection will take place to assess the nature and extent of the remains. That work will report to the Port and to the regulatory authorities with a mitigation proposal to preserve by record the integrity of the site, and remove the remains for further recording and/or disposal as may be deemed necessary.

The re-opening of Graving Dock No. 1 will be a heritage-gain that will re-expose an important engineering structure of mid-19th century date (DCIHR 18-08-081, NCEHD 3024). Such work will need to be completed under archaeological and architectural heritage guidance to ensure that due care is taken to preserve the integrity and authenticity of the original structure.

North Wall Quay Extension

The works required on the North Wall Quay Extension are described in detail in Chapter 4 of the EIS. North Wall Quay Extension is an important cultural heritage asset that continues to serve an important role as a working asset of the Port's key infrastructure. As with all assets of the Port it requires maintenance and development to continue to serve the broad range of social and economic activities that are central to the Port's existence.

The works required on North Wall Quay Extension as part of the ABR Project will relocate Ramp No. 4, which is currently located next to the quay at its westernmost basin side; and demolish Ramp No. 6, which is located on the riverside of the quay. It will also demolish portion of the quay, by removing the basin-side of the active quay area and the easternmost c. 150m of the quay. The latter constitutes most of Mallagh's completion works of 1931. The original western extent of the quay on the basin side that is now concealed beneath Terminal 3 will not be affected.

Associated dredging works will deepen the seabed along the riverside and within the basin so that the new bed level will lie below the base of the quay. The current bed level is -7.3m CD on the basin side and -8.5m on the channel side. The existing foundations on the basin side within the works area will be removed. The surviving section of the foundation on the channel side extends to c. -7.05m CD. The proposed new dredge depth within the basin and along the channel will be -10m CD, with the potential future dredge depth within the channel to -15m CD.

To ensure that the surviving element of the quay remains secure, a combi-wall will be inserted along the basin side, retaining the existing fill of the quay, and sheet-piling along the length of the channel side will extend to below the possible future dredge depth of -15m CD, to secure the footings of the quay.

The quay itself will be retained within a composite casing structure that includes vertically-placed steel ties which extend from a reinforced concrete deck to the steel shutting below, and horizontally-placed steel ties that run through the quay wall at specified intervals. It is anticipated that the framework will leave sections of the quay's river façade fully exposed, and that the coping stones will be reused as coping stones on the new concrete deck, thereby retaining as much as possible of the 19th-century quay within the visible elements of the new work.

The North Quay lighthouse will be relocated to the terminus of the rebuilt quay.

These works represent a significant, permanent, direct negative impact on the North Wall Quay Extension as built by Bindon Blood Stoney and completed by Joseph Mallagh. A process of archaeological mitigation will be carried out to comprehensively preserve by record the quay structure, and will include those elements that will be removed during construction, and those elements that will be concealed during construction.

Given the importance of the industrial heritage of the North Wall Quay Extension a Level 2 industrial archaeological heritage study has been undertaken and presented in Section 12.8 of this Chapter of the EIS.

Approach Channel

In addition to the works to be conducted on the terrestrial elements of the ABR Project, there will be remediation of contamination on the bed of the Alexandra Basin West, capital dredging to deepen the basin and to achieve specified depths of up to -10m CD at the new berths, construction of a new river berth, and deepening of the fairway and approach channel to Dublin Port to increase the ruling depth from -7m CD to -10m CD. A breakwater will be constructed on the side of channel by Poolbeg marina, to protect the marina against prop-wash from turning vessels

These works represent direct permanent impacts on the seabed and will include capital dredging and the disposal of dredged spoil.

The dredging works will take place in a phased progression over a six year period.

The deepening of the approach channel will present indirect impacts on the existing side slopes and associated areas. Hydrodynamic modelling for the project (Chapter 9) anticipates that the impacts will be restricted to the channel area and its immediate environs and that additional rock-armoured protection may be required at the seaward end of the Great South Wall.

The locations of wreck sites W01551-W01554 will be impacted directly by dredging. The direct impact resulting from this work will expose the wreck features if they exist. Dive inspections of these locations will take place to clarify whether there is any indication of the sites. If the dive inspections support the indications from the marine geophysical survey data that the location coordinates are incorrect, further mitigation will occur as archaeological monitoring of the dredging works. However, if the current dive work establishes that wreckage remains are identifiable, underwater inspection will assess the nature and extent of the remains. Should it not be possible to avoid direct impacts during dredging, the mitigation will be to preserve by record the integrity of the site/s, and remove the remains for further recording and/or disposal as may be deemed necessary,

The locations of the various marine geophysical survey anomalies detected on the seabed surface within the dredge area will be impacted directly by the works, and will be exposed and removed. The dive inspections are currently assessing the archaeological significance of these anomalies. Anomalies that lie buried within the upper metres will be subject to being exposed during dredging and removed. Archaeological monitoring will take place during dredging work.

Contaminated dredged spoil from Alexander Basin West will be treated and then use as fill material in Berths 52/53e treated dredge material will also be used to fill Graving Dock No. 2. Dredged material from the navigation channel will be disposed of at a licensed offshore disposal site located to the west of the Burford Bank (subject to the granting of a Dumping at Sea Permit from the EPA).

12.6.2 Impacts during Operation and Aftercare

Berths 52/53

There will be no impacts associated with the operation and aftercare at Berths 52/53 that require cultural heritage input.

Alexandra Basin West

The re-opening of Graving Dock # 1 and the refurbishing of the Pump House will necessitate a long-term maintenance programme that considers issues associated with access and structural maintenance and these issues will take account of cultural heritage issues as well as on-site management issues.

North Wall Quay Extension

The elements of the North Wall Quay Extension that will be concealed beneath the new deck area will remain secure into the future.

The elements of the North Wall Quay Extension that will remain exposed to view, which will include the Channel-side façade and the coping stones that will be reused on the new deck may require maintenance and repair, as part of ongoing building maintenance schedules.

Any ashlar blocks that cannot be re-used in the new design will be stored securely within the Port property for future re-use in appropriate manners.

It is proposed to recover elements of the foundation blocks used to construct the base of the quay between 1871 and 1885. Details of the conservation management plan to ensure that the integrity of the section/s recovered is maintained in a suitable context and environment is presented in the Conservation Strategy (under separate cover).

Approach Channel

Chapter 9 of the EIS – Coastal Processes, describes an extensive programme of model simulations which has been undertaken to evaluate how the ABR Project's capital dredging element would impact the coastal processes and the stability of the approach channel as well as to investigate the disposal of dredged spoil at the existing licensed offshore spoil site within Dublin Bay.

The results from the morphological simulations of the existing and proposed approach channel show that the proposed channel will perform in a similar manner to the existing channel. As with the existing channel there will be a tendency for the northern bank of the approach channel, seaward of the North Bull Wall, to migrate south under storm conditions. Similarly it is expected that there will be siltation along the banks of the approach channel landward of the Bull Walls with a tendency for these banks to migrate in towards the channel. It is expected that the new channel will require maintenance dredging of a similar magnitude to that required with the existing channel. There will however be a higher rate of siltation at the western end of the Liffey channel in the harbour, seaward of the East Link Bridge, due to the increased dredged depth in this area.

The results also show that there will be no significant impact on the sediment transport regime within Dublin Bay and estuary outside the approach channel area as a result of the capital dredging scheme.

12.7 MITIGATING MEASURES

Mitigation measures are summarised in Table 12.6, and described below.

12.7.1 Pre-construction Measures

Berths 52/53

It is not expected that there will be any archaeological requirement associated with this aspect of the project works.

Alexander Basin West

It is expected pre-construction mitigations within Alexander Basin West will be required at North Wall Quay Extension.

North Wall Quay Extension

Subject to the granting of permission for the ABR Project, archaeological and architectural/industrial heritage pre-construction mitigation will include a metrically-accurate stone-by-stone survey of North Wall Quay Extension above and below the waterline, to create a permanent record of the quay in its present state. The work will be able to prepare detailed scaled elevation drawings, long- and cross-sections, and plan views of the quay. Consideration will be given to achieving this work using digital scan technology.

Coping stones and façade stones to be reused in the new quay will be numbered and recorded in advance of demolition works, to ensure accurate replacement.

North Wall Lighthouse should be recorded in detail and a management plan devised to ensure its safe custody during construction and its safe repositioning post-construction.

Further detail is presented in the Level 2 industrial archaeological heritage study in Section 12.8 of this Chapter of the EIS.

Approach Channel

Archaeological underwater inspection is ongoing to assess the nature and extent of anomalies and seabed features detected in the marine geophysical survey. In the event that such work identifies features of archaeological significance, these features will be examined to clarify their nature and extent, and may be subject to further archaeological mitigation in advance of dredging works.

12.7.2 Construction Phase Measures

Berths 52/53

It is not expected that there will be any archaeological requirement associated with this aspect of the project works.

Alexander Basin West

All activity associated with removing infill within the basin will be archaeologically monitored, as will all demolition works and dredging works, to safeguard the possibility of uncovering material of archaeological interest during construction. Particular archaeological requirements pertain to works at North Wall Quay Extension.

Once it is established that wreckage remains are identified below the overburden beside the Lead-in jetty, an underwater inspection will take place to assess the nature and extent of the remains. That work will report to the Port and to the regulatory authorities with a mitigation proposal to preserve by record the integrity of the site, and remove the remains for further recording and/or disposal as may be deemed necessary.

North Wall Quay Extension

Archaeological investigations will be conducted on the deck area of North Wall Quay Extension, to assess the presence and extent of features that relate to the early use of the quay, which may be buried beneath the current working surface. Archaeological investigations are licensed by the Department of Arts, Heritage and the Gaeltacht. In the event that the investigations observe remains of the features, they will be preserved by record.

Demolition works will be archaeologically monitored under licence from the DAHG, and the opportunities will be taken to record more fully the nature of the quay's construction.

An exemplar of Bindon Blood Stoney's foundation blocks will be retained for public view as part of the Port's cultural heritage assets. Further detail is presented in the Level 2 industrial archaeological heritage study in Section 12.8 of this Chapter of the EIS and within the Conservation Strategy (under separate cover).

Approach Channel

Archaeological monitoring of all dredging activities conducted within the Approach Channel will be carried out, with the provision to resolve fully any material of archaeological significance observed at that point.

12.7.3 Archaeological Management Measures

RETAINING AN ARCHAEOLOGIST/S. An archaeologist experienced in maritime archaeology will be retained for the duration of the relevant works.

RETAINING A HERITAGE ARCHITECT or ENGINEER. A heritage architect or Engineer experienced in industrial and maritime architectural heritage will be retained for the duration of

the relevant works, to advise specifically in relation to works associated with North Wall Quay Extension.

ARCHAEOLOGICAL LICENCES will be required to conduct the on-site archaeological works. Licence applications require the inclusion of detailed method statements, which outline the rationale for the works, and the means by which the works will be resolved. Licence applications take a MINIMUM OF THREE WEEKS to process through the Department, and advance planning is required to ensure that the necessary permits are in place before site works commence. One can anticipate that the following licence types will be required: Excavation, to cover monitoring and investigations works; Detection, to cover the use of metal-detectors; and Dive Survey, to cover the possibility of having to conduct underwater inspections.

ARCHAEOLOGICAL MONITORING will be carried out by suitably qualified and experienced maritime archaeological personnel licensed by the Department of Arts, Heritage and the Gaeltacht. Archaeological monitoring is conducted during all terrestrial, inter-tidal/foreshore and seabed disturbances associated with the development. Licence applications.

The monitoring will be undertaken in a safe working environment that will facilitate archaeological observation and the retrieval of objects that may be observed and that require consideration during the course of the works.

The monitoring will include a finds retrieval strategy that is in compliance with the requirements of the National Museum of Ireland.

THE TIME SCALE for the construction phase will be made available to the archaeologist, with information on where and when ground disturbances will take place.

DISCOVERY OF ARCHAEOLOGICAL MATERIAL. In the event of archaeologically significant features or material being uncovered during the construction phase, machine work will cease in the immediate area to allow the archaeologist/s to inspect any such material.

ARCHAEOLOGICAL MATERIAL. Once the presence of archaeologically significant material is established, full archaeological recording of such material will be recommended. If it is not possible for the construction works to avoid the material, full excavation will be recommended. The extent and duration of excavation will be a matter for discussion between the client and the licensing authorities.

ARCHAEOLOGICAL TEAM. It is recommended that the core of a suitable archaeological team be on standby to deal with any such rescue excavation. This would be complimented in the event of a full excavation.

ARCHAEOLOGICAL DIVE TEAM. It is recommended that an archaeological dive team is retained on standby for the duration of any in-water disturbance works on the basis of a twenty-four or forty-eight hour call-out response schedule, to deal with any archaeologically significant/potential material that is identified in the course of the seabed disturbance activities.

A SITE OFFICE and facilities will be provided by the Dublin Port Company on site for use by archaeologists.

SECURE WET STORAGE facilities will be provided on site by the Dublin Port Company to facilitate the temporary storage of artefacts that may be recorded during the course of the site work.

BOUYING/FENCING of any such areas of discovery will be necessary if discovered and during excavation.

MACHINERY TRAFFIC during construction will be restricted to avoid any identified archaeological site/s and their environs.

SPOIL will not be dumped on any of the selected sites or their environs.

POST-CONSTRUCTION PROJECT REPORT AND ARCHIVE. It is a condition of archaeological licensing that a detailed project report is lodged with the DAHG within 12 months of completion of site works. The report should be to publication standard and should include a full account, suitably illustrated, of all archaeological features, finds and stratigraphy, along with a discussion and specialist reports. Artefacts recovered during the works need to meet the requirements of the National Museum of Ireland.

PLEASE NOTE: the above recommendations are subject to the approval of the National Monuments Section at the Department of Arts, Heritage and the Gaeltacht.

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12.8 LEVEL 2 INDUSTRIAL ARCHAEOLOGICAL HERITAGE STUDY

The following survey is a *level-two* industrial archaeological inventory of the historic docklands landscape in the area of Alexandra Basin West in Dublin Port, conducted by the Historic Building Survey Unit, Department of Archaeology, University College Cork. Its primary aim is to enhance the present understanding of the industrial archaeological importance of this feature, with the results of this survey intended to inform the EIS and overall conservation strategy for it as an *historic place*, as defined by the Burra Charter.

12.8.1 Baseline Environment

The legislative and institutional context

The principal Irish legislation, international charters, local development plans and guidelines relating to the protection, recording and enhancement of archaeology and the historic built environment in general may be summarised as follows:

Irish legislation

- National Monuments Act 1930-2004 (amended)
- Heritage Act, 1995
- National Cultural Institutions Act, 1997 (amended)
- Planning and Development Acts 2000-2013
- Architectural Heritage and Historic Properties Act, 1999

International Charters and Conventions

- Valetta Convention on the Protection of the Archaeological Heritage, 1992
- Joint ICOMOS-TICCIH Principles for the Conservation of Industrial Heritage Sites, Structures, Areas and Landscapes (The Dublin Principles), 2011
- The Burra Charter for Places of Cultural Significance, 1999
- The International Council on Monuments and Sites (ICOMOS), advisory body to UNESCO concerning protection of sites and recommendation, 1992

Local Authority Development Plans & Other Plans

- Dublin City Heritage Plan 2002-2006 (2002)
- Dublin City Council Development Plan 2011 – 2017
- Dublin Port Company Masterplan, 2012 – 2040
- Dublin Docklands Area Master Plan, 2008

Heritage Plans & Guidelines

- The National Heritage Plan (2002)
- Dublin City Heritage Plan 2002-2006 (2002)
- Office of Public Works Statement of Strategy, 2005-2008
- Guidelines on the information to be contained in Environmental Impact Statements, 2002
- Advice notes on Current Practice (in the preparation of Environmental Impact Statements), 2003
- Architectural Heritage Protection: Guidelines for Planning Authorities, 2011
- The Framework and Principles for the Protection of the Archaeological Heritage, 1999.

12.8.2 Assessment methodology

The overview and archaeological evaluation of the site that follows was preceded by a desk-based assessment. Its primary aims are fivefold:

1. To record all surviving features of archaeological, techno-historical and architectural significance;
2. To appraise and evaluate its industrial, archaeological/architectural/techno-historical significance, and to identify immediate conservation priorities (as deemed appropriate).
3. To provide an archaeological inventory of the features identified within the assessment area
4. To assess the impact of the proposed scheme
5. To propose mitigation measures

The principal sources consulted were as follows:

- Record of Monuments and Places (RMP)
- Sites and Monuments Record
- National Museum of Ireland (NMI) Topographical files
- The Irish Railway Record Society Archive, Heuston Station
- The Dublin City Industrial Heritage Record
- The Dublin Docklands Architectural Survey
- Historic map collections
- Historic photographic collections

- Primary written sources, e.g. the Griffith Valuation Housebooks for the survey area in the National Archives, Dublin
- Secondary sources (e.g. archaeological and architectural journals).
- www.excavations.ie

12.8.3 Previous archaeological survey work in the study area

Recorded Archaeological Monuments and Places: Despite the undisputed presence of site of national significance there are no recorded monuments in the RMP or in the Dublin City Record of Protected Structures within the study area. There are no recorded finds from the study in the NMI topographical files, nor have any test excavations been conducted within the area under assessment here. In 2013, however, an extensive Cultural Heritage Environmental Report, for the proposed Alexandra Basin Redevelopment, North Wall Quay Extension, was undertaken by Magnus Archaeology for the Dublin Port Authority. This includes a detailed study of the shipwrecks associated with the study area and its environs.

12.8.4 The receiving environment

The physical development of the north Dublin city docklands in general mirrors that of other important European ports in the 18th and 19th centuries. Almost invariably, port facilities were expanded upstream from a medieval core, to accommodate both a growing demand for additional quay space and the need for specialised berths, such as oil terminals, roll on roll off facilities and later, in 1960s, standard size 'inter modal' container terminals. Indeed, as in Dublin's Alexandra Basin, the need for additional berths led to construction of branch docks at right angles to main basin. Similar trends were in evidence in English ports, such as at Huskisson Dock and Langton to Alexandra group of docks at Liverpool in 1860s and 1870s, and also at Tilbury dock on lower Thames in 1884. In Dublin, these were increasingly built downstream as size of ships increases, and its scale of operations and expansion can be paralleled with Liverpool and London docks

The rapid expansion of Ireland's maritime trade in the 18th century, and the commercial and economic development associated with it, brought increased political pressure for improvements to existing port facilities. No Irish port, indeed, was so favourably circumstanced that it could hope expand without major improvements to its approaches. Dublin harbour was naturally disadvantaged by a sand bar at its mouth, formed by the silt discharged from the mouths of the rivers Dodder, Liffey and Tolka into Dublin Bay, whilst its quaysides were quite shallow. Between 1786 and 1867, a Corporation for the Improvement of Dublin (replaced by Dublin Port and Docks Board in 1867) was the principal institutional framework responsible for the development of the port of Dublin. During the nineteenth century, the development of steam packet ferries in the Irish Sea area also led to the creation of new port facilities, as did direct government intervention (through the Board of Public Works) in western fishing harbours. Shallow shipping channels and the silting up of harbours presented the single biggest problem to port development in the 18th and early 19th centuries, and invariably required both an institutional response and a considerable cash outlay. Before the advent of the steam dredger, little could be profitably achieved by spoon dredging. In 1815, the Dublin Ballast Board began work with a steam dredger, purchased on the advice of their engineer, George Halpin, who had familiarised himself with recent developments in other countries. The dredger, Patrick, was built by Anthony Hill's Dublin yard and its engine which, after contemporary English practice, powered an endless chain of buckets, was supplied by Fenton, Murray and Wood of Leeds.ⁱ However, although Patrick had to be towed into position, it could manoeuvre in a limited fashion by pulling against its front anchors. The material or dredge stuff excavated by it

was carried out to sea in four newly commissioned lighters of 35 tons each. In 1830, Patrick was replaced by a new dredger, a self-propelled vessel built by a Scottish firm at Leith, which was capable of excavating some 1,500 tons of dredge stuff each week.ⁱⁱ Hopper barges were used in conjunction with the bucket dredger, Greenore, in 1867, during the removal of the sand bar at Carlingford, county Louth, while the new technology was quickly adopted in Dublin port where, between 1869 and 1871, over £500,000 was expended on new dredging plant, which included a new dredger and three steam hopper barges. These latter were designed by the Dublin Port Engineer, Bindon Blood Stoney, each of which had a capacity of 850-1,000 tons of dredge stuff.ⁱⁱⁱ For the greater part of the 19th century, steam-powered bucket dredgers operated in Irish ports but, in 1895, the Port of Dublin contracted a Dutch firm to provide it with suction dredging plant. This innovation had first been employed by Libby in the American port of Charleston in 1855, and was adopted and further developed in Europe, in Holland and France during the 1870s. Suction dredgers were used at Liverpool in 1893 and were first operated in Ireland, at Dublin, in 1896, where they demonstrated their superiority in the removal of sand and mud.^{iv}

The accumulation of river-borne debris and sea sand within shipping channels, it was clear, required constant attention. Yet dredging alone could not, in the long term, be relied upon to remove or even check natural obstructions created by riverine deposition at estuaries. Such problems were particularly severe within the environs of Dublin Bay and its notorious sand bar, whose improvement John Rennie remarked was 'perhaps one of the most difficult subjects which has ever come under the consideration of the civil engineer'.^v The material deposited by the Liffey, Tolka and Dodder rivers formed two large sand banks, known as the North and South Bulls, which formed constantly shifting and consequently dangerous channels for shipping. Works to remedy this problem were begun at a relatively early period, in 1711, commencing with the construction of a timber jetty that was to form the northern side of a straight channel leading from Dublin Bay to the city quaysides. The northern arm of the new channel extended for a distance of 7,938 ft (2.419 km) from Ringsend to the Pigeon House Fort, and from the latter for a distance of 9,816 ft (2.991 km) to the eastern spit of the South Bull. The jetty was constructed with timber caissons, which were assembled at Ringsend and floated to the site where, after being filled with rubble, they were sunk into position. In 1748, the first section between Ringsend and the Pigeon House Fort was rebuilt as a double line of masonry retaining walls with a sand-filled core. Prior to the construction of the channel, navigation to the Dublin quaysides could often be difficult, obliging larger ships to transfer their cargoes to lighters near Dalkey.^{vi}

In the long term, however, the sand bar in Dublin Bay would, if not properly dealt with, continue to create problems for shipping. Captain William Bligh, of HMS Bounty fame, was commissioned in 1800 to make a detailed survey of Dublin Bay with a view to its improvement, and in his recommendations became one of the first to suggest that a breakwater be constructed on the north side. This, he argued, would create a scouring action in which sand would be washed away from the harbour mouth, by augmenting the flow of the river. This same concept was later proposed by Chapman, Corniellie and John Rennie, but came nowhere near realisation until Francis Giles and George Halpin suggested, in 1819, that a masonry breakwater be constructed from the north shore at Clontarf to a point opposite Poolbeg lighthouse. This latter, the North Bull Wall, some 5,500 ft (1.676 km) long, was completed between 1820 and 1825. It was built with limestone and granite rubblestone masonry, and effectively formed an artificial mouth for the River Liffey. The scouring effect created by the wall dramatically reduced the level of the sand bar, while at the same time preventing sand from the North Bull from being deposited in the river channel. Before the construction of the North Bull breakwater, the depth at low water during the spring tides was only 6 ft (1.82 m); by 1873, it was over 16 ft (4.87 m).^{vii} The first parapet walls along the Liffey quays were built in the late 18th and early 19th centuries, and were generally of bonded rubble with cut stone granite façades. The costs of preparing quay walls below water could be

prohibitive, in 1863, the engineer of Dublin port, Bindon Blood Stoney, had begun to evaluate the relative costs of both masonry and concrete for this purpose. Stoney undertook a series of tests which established that concrete was actually some 50% cheaper, and he proposed to manufacture monolithic blocks of concrete, up to 350 tons in weight, which would be laid on the river bed as the foundations of quay walls. He was not, however, the first to carry out such a scheme in Ireland.viii In 1870 James Barton (who designed the Boyne viaduct), had already begun to lay 100 ton concrete blocks for the below water section of an 800 yard (731.52 m) quay wall at Greenore Harbour, at the entrance to Carlingford Lough, constructed to serve the new Dundalk, Newry and Greenore Railway.ix

Yet for all that, Stoney's scheme to provide new quay walls on the north side of the estuary of the River Liffey was novel in its execution. The conventional method of laying the foundations of quay walls involved the construction of expensive coffer dams, which were continually pumped dry to facilitate building work. However, in Stoney's scheme, the foundations for the concrete monoliths were first excavated by a dredger, while the final levelling off work was carried out on the river bed by men working within a massive diving bell, supplied with compressed air. This latter, which was some 20 ft (6.09 m) square and had a vertical access shaft protected by an airlock, was manufactured by Grendon of Drogheda in 1869. The enormous concrete blocks, which were fabricated nearby, were lifted by a floating crane built by Harland and Wolff in 1866 (the lifting machinery was supplied by Courtney and Stephens of Dublin), and the first of these was lowered into position in 1871. Stoney's method proved to be both expeditious and cheap, and by 1882, over 2,000 ft (609.6 m) of new quay wall, with a depth of 22 ft (6.70 m), had been laid by this means. The exterior face of the wall below water was then faced with Dublin calplimestone, that above water was finished in the usual way with granite ashlar coped with granite blocks.x

Cranes and hoists, both manually operated and steam-powered, were a relatively common feature of Ireland's ports during the later 19th century. The availability of electricity at Poolbeg during the late 19th century led to the erection of electric cranes, which included a 100 ton example, completed in 1903 and dismantled in 1987. A small generating station was constructed on the North Wall extension in 1903, where four, four-ton electric cranes were erected, along with electric capstans for hauling wagons.xi However, while electricity had become a vital part of the late nineteenth-century infrastructure of the port of Belfast where, in 1892, a generating station was opened at the Abercorn basin, there were no electric cranes employed there until 1918. Yet in a wider context, the developments in the ports of Dublin and Belfast are remarkable. Indeed, there was no electricity on docks at Liverpool until 1912.

12.8.5 Assessment of impacts

Assessing individual site/monument significance

Owing to a general lack of both documentary evidence and thematic archaeological surveys, the manner in which the importance of pre- AD 1700 archaeological sites in a small study area are assessed can often be a subjective process. In the period from about 1800 to the present, however, site or monument value/importance can more readily be assessed, based on the increasing availability of written sources such as business records, correspondence, newspaper accounts and, of course pre- and ordnance survey cartographic sources. Other factors such as rarity, group value, condition and historic, cultural or scientific associations are also important (Table 12.8.1).

Table 12.8.1 Assessment of significance and expected type of mitigation

International significant (protected structure)	National significant (protected structure)	Regional significance (unprotected)	Local significance Or not rated
<i>To be avoided</i>	<i>To be avoided</i>	<i>Avoidance recommended</i>	<i>Avoidance unnecessary</i>

After a full consideration of the available evidence for the structures and features to be directly impacted upon by the proposed development, the assessment of their significance is summarised in Table 12.8.2. None of the structures are rated and the following ratings are the opinion of Dr Colin Rynne.

Table 12.8.2 Assessment of significance of structures and features within study area

SITE NO.	NGR	SITE	DESCRIPTION	CONSTRUCTION PERIOD	SIGNIFICANCE
DP.01	718451, 734367	North Wall Quay Extension	Quayside constructed with mass concrete block system developed by Bindon Blood Stoney	1869-1884	Not rated but construction technology considered by Dr Colin Rynne to be international
DP.02	718587, 734388	Goods transit shed No. 3 ('Island Shed'), North Wall Quay Extension	No visible remains but foundations likely to survive under present surface	19 th century	NOT RATED
DP.03	718536, 734581	Goods transit shed No. 1 ('Island Shed'), North Wall Quay Extension	No visible remains but foundations likely to survive under present surface	19 th century	NOT RATED
DP.04	718691, 734362	Goods transit shed No. 2 ('Island Shed'), North Wall Quay Extension	No visible remains but foundations likely to survive under present surface	19 th century	NOT RATED
DP.05	718752, 734319	North Wall Light	Light house in steel, rivetted sections (replaces earlier light of 1809)	1906, moved to present position c. 1937	Not rated but considered Regional
DP.06	718072, 734613	Crossberth Quay	Constructed by Bindon Blood Stoney	1885	Not rated but considered Regional

SITE NO.	NGR	SITE	DESCRIPTION	CONSTRUCTION PERIOD	SIGNIFICANCE
DP.07	718595, 743658	Alexandra Wharf	Originally constructed for Anglo-American Oil Co.	1889	NOT RATED
DP.08	718316, 734789	Graving Dock No. 1	Constructed by Bindon Blood Stoney	1860	Not rated but considered National
DP.09	718336, 734733	'Pump House' (Graving Dock No. 1)	Single storey, two room brick engine house	1900s	Not rated but considered Regional
DP.10	718370, 734789	Graving Dock No. 2		1951-59	Not rated but considered Regional
DP.11	718343, 734589	Lead-in jetty		1950s	NOT RATED
DP.12	718605, 734671	Alexandra Quay West	Quay constructed with Joseph Mallagh's concrete caissons	1921-32	Not rated but construction technology considered by Dr Colin Rynne to be international
DP.13	718460, 734556	Goulding's (Tara Mines) Jetty		1969-67	NOT RATED
DP.14	718500, 734550	P&O Ramp No. 4		1970s	NOT RATED
DP.15	718091, 734448	P&O Head Offices		1970s	NOT RATED
DP.16	718139, 734423	P&O Terminal Building		1970s	NOT RATED
DP.17	718080, 734553	VMU Building		1970s	NOT RATED
DP.18	718066, 734578	Control building (P&O)		1970s	NOT RATED
DP.19	718307, 734878	Store, Graving Dock 2		1960s	NOT RATED
DP. 20	718341, 734891	Store, Graving Dock 2		1960s	NOT RATED
DP. 21	718351, 734891	Store, Graving Dock 2		1960s	Not rated but considered Regional

SITE NO.	NGR	SITE	DESCRIPTION	CONSTRUCTION PERIOD	SIGNIFICANCE
DP. 22	718337, 734872	Workshop, Graving Dock 2		1970s	Not rated but construction technology considered by Dr Colin Rynne to be international
DP. 23	718339, 734854	Store, Graving Dock 2		1960s	NOT RATED
DP. 24	718391, 743479	Grain conveyor building		1960s	NOT RATED
DP. 25	718399, 734742	Grain conveyor building		1960s	NOT RATED

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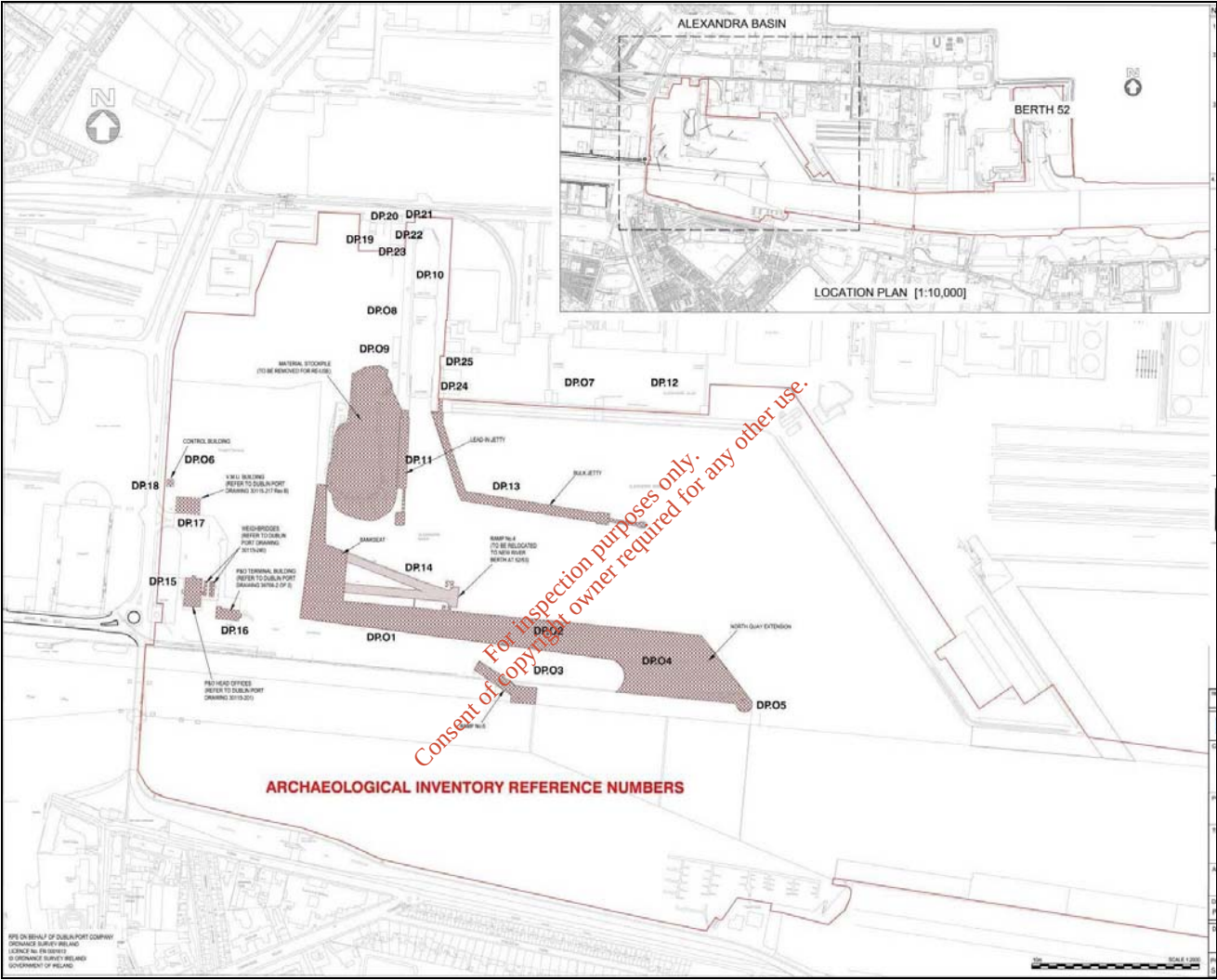


Figure 12.8.1 Location of industrial archaeological sites in survey area

12.8.6 Assessment of impacts within study area

In accordance with the existing EPA Guidelines (2005) the predicted degree of impact can be:

- Profound
- Significant
- Moderate
- Slight
- Imperceptible

In addition these can either be positive or negative.

The proposed development will involve the following works:

- The infilling of Graving Dock # 2 having an area of 6,055 sq m.
- The excavation and restoration of historic Graving Dock #1 together with the restoration of the associated pump house and lighting standard in conservation zone H
- The removal of an area of infill material of c. 9,000 sq m within Alexandra Basin West
- The relocation of the ore concentrates loading system within Alexandra Basin West
- The relocation of double deck ramp No. 4 to the proposed new river berth at existing Berths Nos. 52 and 53

The demolition and removal of

- The bulk jetty and grain conveyor having an area of c. 3,200 sq m.
- 4 no. buildings housing offices, terminal, control and V.M.U. functions having a total area of c. 1,200 sq m.
- A floating ramp on the Liffey side
- A lead-in jetty within the Basin
- Part of North Wall Quay Extension to the north and east having a total area of c. 21,700 sq m.

The construction of

- New quay walls at North Wall Extension of circa 910 metres with the conservation of the remainder of the quay behind the new quay walls. The quay walls to the Liffey frontage to be built in sections with the existing quay wall exposed in 5 zones for conservation purposes in conservation zones A to F
- An extension of Alexandra Quay of circa 145m in length.

- A reconfigured rounded quay end using salvaged stone material from demolished sections of quay in Interpretive Zone 2
- Interpretive glass pavilions having an area of c. 36 sq m. on the west of the reconfigured North Wall Quay Extension and the reconstruction and presentation of a salvaged historic concrete caisson from the demolished section of quay in interpretive zone 1
- 300 m long Ro-Ro jetty and provision of 3 no. Ro-Ro ramps
- The taking down of the existing lighthouse and its reconstruction at the end of the newly configured North Wall Quay Extension in interpretive zone 2
- Rebuilding of existing quay walls in the remainder of Alexandra Basin having an aggregate length of c. 1,220 m.
- The provision of Conservation zone G involving the conservation of the western iron gates, boundary wall, the original quay wall together with the hexagonal entrance building to the tunnel

The expected impact on the features and structures identified above are summarised below in Table 12.8.3.

Table 12.8.3 Summary of likely impacts of development on industrial archaeological features and built environment of the study area

Site no.	Ngr	Site	Significance	Impact type	Impact assessment
DP.01	718451, 734367	North Wall Quay Extension	Not rated but construction technology considered International	Direct	Negative: Significant
DP.02	718587, 734388	Goods transit shed No. 3 ('Island Shed'), North Wall Quay Extension	Not rated	Direct	Negative: Profound and irreversible
DP.03	718536, 734581	Goods transit shed No. 1 ('Island Shed'), North Wall Quay Extension	Not rated	Direct	Negative: Profound and irreversible
DP.04	718691, 734362	Goods transit shed No. 2, North Wall Quay Extension	Not rated	Direct	Negative: Profound and irreversible
DP.05	718752, 734319	North Wall Lighthouse	Not rated but considered Regional	Direct	Significant/positive
DP.06	718072,	Crossberth	Not rated but	Direct	Significant/positive

Site no.	Ngr	Site	Significance	Impact type	Impact assessment
	734613	Quay	considered Regional		
DP.07	718595, 734658	Alexandra Wharf	NOT RATED	Direct	Significant/positive
DP.08	718316, 734789	Graving Dock No. 1	Not rated but considered National	Direct	Moderate/positive
DP.09	718336, 734733	'Pump House' (Graving Dock No. 1)	Not rated but considered Regional	Direct	Moderate/positive
DP.10	718370, 734789	Graving Dock No. 2	Not rated but considered Regional	Direct	Moderate but reversible/positive
DP.11	718343, 734589	Lead-in jetty	NOT RATED	Direct	Profound and irreversible
DP.12	718605, 734671	Alexandra Quay West	Not rated but construction technology considered by Dr Colin Rynne to be international	Direct	Negative: Significant
DP.13	718460, 734556	Goulding's (Tara Mines) Jetty	NOT RATED	Direct	Negative: Profound and irreversible
DP.14	718500, 734550	PO Ramp No. 4	NOT RATED	Direct	Negative: Profound and irreversible
DP. 21	718351, 734891	Store, Graving Dock 2	NOT RATED	Direct	Negative: Profound and irreversible
DP. 22	718337, 734872	Workshop, Graving Dock 2	NOT RATED	Direct	Negative: Profound and irreversible
DP. 23	718339, 734854	Store, Graving Dock 2	NOT RATED	Direct	Negative: Profound and irreversible
DP. 24	718391, 73479	Grain conveyor building	NOT RATED	Direct	Negative: Profound and irreversible
DP. 25	718399, 734742	Grain conveyor building	NOT RATED	Direct	Negative: Profound and irreversible

12.8.7 Mitigation measures

Archaeological recording

- All buildings and features which will experience potential impacts, regardless of significance or the extent of that impact, will be recorded to level three inventory standard. This will include full measured, written, drawn and photographic surveys of all buildings and features of interest identified within the survey area.
- In addition, all of these features, including quay furniture affected by the development, such as bollards, mooring rings, crane tramway lines, standard gauge (i.e. 5ft 3in) railway tracks and limestone paving sets, will be 3D laser scanned, to produce a point cloud, and thus an accurate 3D rendering, 'as found', of the entire dock landscape associated with Alexandra basin.
- A comprehensive 3D photographic survey of the Alexandra Basin using a drone.
- Structural analysis and condition surveys will be undertaken on all structures and features of industrial archaeological interest identified within the study area. By this means potentially negative impacts may be minimised, while positive impacts such as the conservation of standing buildings may be enhanced.

An integrated conservation strategy for Alexandra Basin West

A detailed Conservation Strategy has been formulated for all sections of the proposed alteration to the basin, by Southgate Associates in association with MOLA Architecture (under separate cover). The internationally significant North Wall Quay Extension, for example, has been divided into five conservation zones which will facilitate legibility of the original quay wall, conservation of a 55 m length of quay in its original state in conservation zone A, a visual appreciation of the original mooring rings through specially designed opening in the proposed new, concrete quay wall in conservation zones BCD and F. A central staircase is to be shown in a designed opening in conservation zone E. The present North Wall Light will be dismantled and relocated on a granite plinth reconstructed from the original curved granite blocks located at the western extremity of the new quay in interpretation zone 2. This strategy involves policies based on ICOMOS Dublin Principles (2011/2012).

The engineering design intervention has been detailed to a high standard in a contemporary manner to be legible against conserved historic fabric.

The stone-lined graving dock (No. 1) built by Stoney in 1860, but filled in 2008, will be emptied of fill and be put on public display. A conservation proposal for the early twentieth-century 'pump house' adjacent to the graving dock has also been prepared as part of the proposed development, this has been designed with due regard to interpretive potential use in the future.

Important features of Graving Dock No. 2 such as the electrically powered capstans will be relocated elsewhere on the site, whilst the 1950s electric jib crane, which survives in situ next to the dock, along with two further examples, one on Alexandra Quay West and the other on South Bank Quay (outside the project area), will be dismantled and fully re-erected near the dock basin. Similar cranes have been successfully preserved at Bristol Industrial Museum. Other 1950s examples survive as exhibits at the India Dock, London, on Manchester's Salford Quays and on the Manchester Ship canal.

An Interpretive scheme (INTERPRETIVE ZONE 1)

An interpretive scheme to promote the built heritage of the Alexandra Basin West area, incorporating the research conducted to date on the history and industrial archaeology of the site, has been developed by MOLA Architecture. This includes on site interpretation of the area's heritage along with public access to selected areas of it. As part of this programme, Bindon Stoney's original diving bell, currently on Sir John Rogerson's Quay, is being conserved to facilitate public appreciation of this remarkable survival. (This initiative is happening independently of the ABR Project and is not part of the ABR Project application to An Bord Pleanála).

The implementation of this scheme will significantly enhance public access, physically and intellectually, to the unique industrial landscape. In addition, a central feature of the Conservation Strategy is the creation of a public realm scheme (see below) in which one of Bindon Blood Stoney's original concrete blocks will be on public display in interpretation zone 1 while a pedestrian priority zone will provide public access to the newly relocated lighthouse in Interpretation Zone 2.

Policy of Interpretive zones

The Public Access to the curtilage of the ABR Project is will demonstrate DPC's commitment to integrate its heritage with the City.

The proposal to erect an architectural set-piece, in a publicly accessible "zone", inspired by the engineering history and legacy of the Alexandra Basin is central to the strategy. This proposal complements the DPC's funded "Diving Bell" project on Sir John Rogerson's Quay (which is due to go to construction at the time of writing and is not part of the ABR Project planning application).

Salvaging an intact "Block" from the reconfigured North Wall Quay Extension, is a central "conservation" objective, and measures will be put in place at construction stage to maximise the possibility of intact salvage.

Policy of Public Access

Areas of the Basin and Port properties will be fully publicly accessible, under DPC's supervision, including "controlled" access to the conserved Graving Dock No. 1, the Pump House and its immediate curtilage.

Policy of soft values

DPC's "Soft Values" Strategic Framework includes policy measures for representation of Bindon Blood Stoney's Diving Bell, which was an essential enabler of the construction of the Basin. This initiative will be complemented in the Basin in the proposal interpretive set piece in the publicly accessible area/zone of the Basin.

Ground Plane policy North Wall Quay Extension

This delineates and proposes a detailed design which links the Publicly Accessible "Zones 1 and 2" with circulation routes for controlled supervised public access.

Lighting Strategy

MOLA Architecture has developed lighting proposals relating to the conservation strategy focussed on conveying the essential substance of the conservation strategy in night-time, with particular reference to its legibility from vantage points in the city.

Salvage

As a result of dismantling a section of the quay a considerable quantity of 19th century durable granite blocks will become available. A quantity of 10% can be reused on the scheme and the remainder will be stockpiled for future schemes.

Salvage Policy

DPC will consider proposals from worthy conservation projects requiring granite blocks for repair of significant historic structures. This will be influenced by advice from Local Authority, Heritage Council, DAHG etc.

12.8.8 Residual impacts

When the various mitigation measures outlined in the previous section have been carried the only residual impacts will effect features and buildings which have been either fully or partially preserved *in situ*. These include:

Table 12.8.4 Residual impacts of development on industrial archaeological features and built environment of the study area

Area	Piling/ Construction Stage	Decay (Long term issues)
Lighthouse	Low	Low
North Wall Quay Extension	Low	Low
Alexandra Wharf	Low	Low
Alexandra Quay West	Low	Low
Pumphouse,	N/A	Low
Graving Dock # 1	N/A	Low
Graving Dock # 2	Low	Low
Crossberth Quay	N/A	Low

Discussion of Residual impacts:

Lighthouse

The lighthouse has responded well to being moved in the past and the residual impact is expected to be low.

Mitigation

The lighthouse is to be moved in one piece by a special lifting frame as shown in the Southgate Associates Conservation Strategy report. The lighthouse corrosion treatment is to be carried out in accordance with the specification in the conservation strategy document. The final lifting method statement is to be approved by a conservation engineer and a final condition record with maintenance plan is to be issued at the end of the project.

North Wall Quay Extension

Piling within 3m of North Wall Quay Extension will have low impacts on the massive 350 tonne Stoney blocks. Exposure to fill rather than salt water would have low residual impact. The wall is to be isolated from the fill to allow for reversibility and to avoid damage to the granite.

Regarding decay

Decay is noted in the granite as a result of wetting and drying cycles (Freeze /thaw and crypto efflorescence) and this will reduce in the buried condition.

Mitigation

Construction piling method statement will be approved by a Conservation Engineer and monitored. The piling operations on the North Wall Quay Extension will be monitored for vibration to ensure that the limits recommended in BS5228-2:2009 are not exceeded.

Alexandra Quay West, Alexandra Wharf, Crossberth Quay

Piling within 3m of North Wall Quay Extension will have low impacts on the caisson constructions. Exposure to fill rather than sea would have low residual impact.

Regarding decay

Decay is not anticipated in the concrete with less exposure to atmosphere (ie carbonation frost and other corrosive effects).

Mitigation

Construction piling method statement will be approved by a Conservation Engineer and monitored. The piling operations will be monitored for vibration to ensure that the limits recommended in BS5228-2:2009 are not exceeded.

Graving Dock #1

This will be re exposed to atmospheric pollution, vegetation growth and general exposure for which the durable Dalkey granite appears extremely resistant.

Mitigation

Methodology for excavation to avoid damage by mechanical equipment is recommended together with condition record and maintenance plan to be produced by a conservation engineer (see Conservation Strategy).

Pump House

This will be conserved in the project

Mitigation

Methodology for conservation is recommended in the conservation strategy (under separate cover). Works to be supervised by a conservation engineer and final condition record issued to the planning authority with a maintenance plan.

Graving Dock #2

The existing pair of lock gates will be positioned at the intermediate gate positions within the dock and the entrance to Alexandra Basin West will be closed by the new quay wall. A structural deck slab, supported on tubular piles, will form the new quay surface and transfer imposed loading from harbour cranes, loading hoppers and conveyors, through piles to the underlying bedrock. The suspended quay slab will also provide stability to the quay wall while protecting the underlying dock from these substantial imposed loads.

The tubular piles will be installed at locations to minimise impact on the existing dock structure through isolation sleeves; these are cored through the dock floor in advance, to minimise the impact of piling operations and future loading on the existing structure. Inclined ground anchors will be installed from the deck slab through the dock floor to provide additional stability to the primary quay wall.

If required in the future, these works can be reversed to return the graving dock to its current condition, with minimal impact on the structural fabric of the dock.

Regarding decay

Decay is not anticipated in the concrete with less exposure to atmosphere, carbonation, frost and other corrosive effects.

Mitigation

In line with the conservation strategy it is proposed to infill Graving Dock #2 with material removed from Alexandra Basin West. The material will be stabilised and then placed in the dock on a suitable separation medium, such as a sand and geotextile layer, to facilitate any future reversal of the infilling process.

Filling construction methodology to be approved by Conservation Engineer and monitored. The piling operations on the North Wall Quay Extension will be monitored for vibration to ensure that the limits recommended in BS5228-2:2009 are not exceeded.

Notes

ⁱSkempton 1975, 97-116.

ⁱⁱGilligan 1988, p. 130.

ⁱⁱⁱCox 1990, pp. 23-6.

^{iv}Cox 1990, p. 27.

^vdeCourcy 1996, p. 24.

^{vi}Cox and Gould 1998, p. 13.

^{vii}Cox and Gould 1998, pp. 13-14; O'Flaherty 1988, Purser Griffith 1879.

^{viii}See Cox 1990, p. 19.

^{ix}O'Mahony 1993, p. 269.

^xCox 1990, p. 19.

^{xi}Gilligan 1988, p. 147-8.

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13. HUMAN BEINGS

The well-being of the local and wider community within the Dublin Port area has been comprehensively addressed throughout this EIS. This chapter of the EIS details the human environment of the hinterland surrounding Dublin Port in terms of population profile and trends, employment and community aspects.

It also discusses the impact of the proposed Alexandra Basin Redevelopment (ABR) Project on tourism.

Other potential impacts on human beings are assessed within this EIS including:

- Impact on commercial fishing activities – Chapter 5
- Impact of landscape and visual intrusion, including lighting – Chapter 6
- Impact of noise & vibration and of air quality & climate – Chapter 7
- Impact of traffic – Chapter 8

The potential impacts of the ABR Project are described in detail within these chapters and, where appropriate, mitigation measures are presented.

13.1 BASELINE INFORMATION

Data Sources

The following main sources of information were used for this study:

- Central Statistics Office, Census Data;
- Jim Power Economics, The socio-economic aspects of the proposed Alexandra Basin Redevelopment Project;
- Dublin Docklands Development Authority, Masterplan 2008;
- Fáilte Ireland, Destination Dublin: A Collective Strategy for Tourism Growth to 2020;
- Fáilte Ireland, Tourism Facts 2012;
- Bermello, Ajamil & Partners, Inc., Preparation of a Plan for the Development of Cruise Tourism in Dublin;
- Irish Exporters Association (2012), Trade and Transport Analysis; and
- The Competition Authority (2013), Competition in the Irish Ports Sector.

Study Area

The Dublin Port Estate forms part of the North Dock B District Electoral Division (DED). There are seven neighbouring DEDs shown in Figure 13.1 and listed below:

- Clontarf East B
- Clontarf East C
- Clontarf East D
- Clontarf West C
- Clontarf West D
- North Dock A
- Pembroke East A

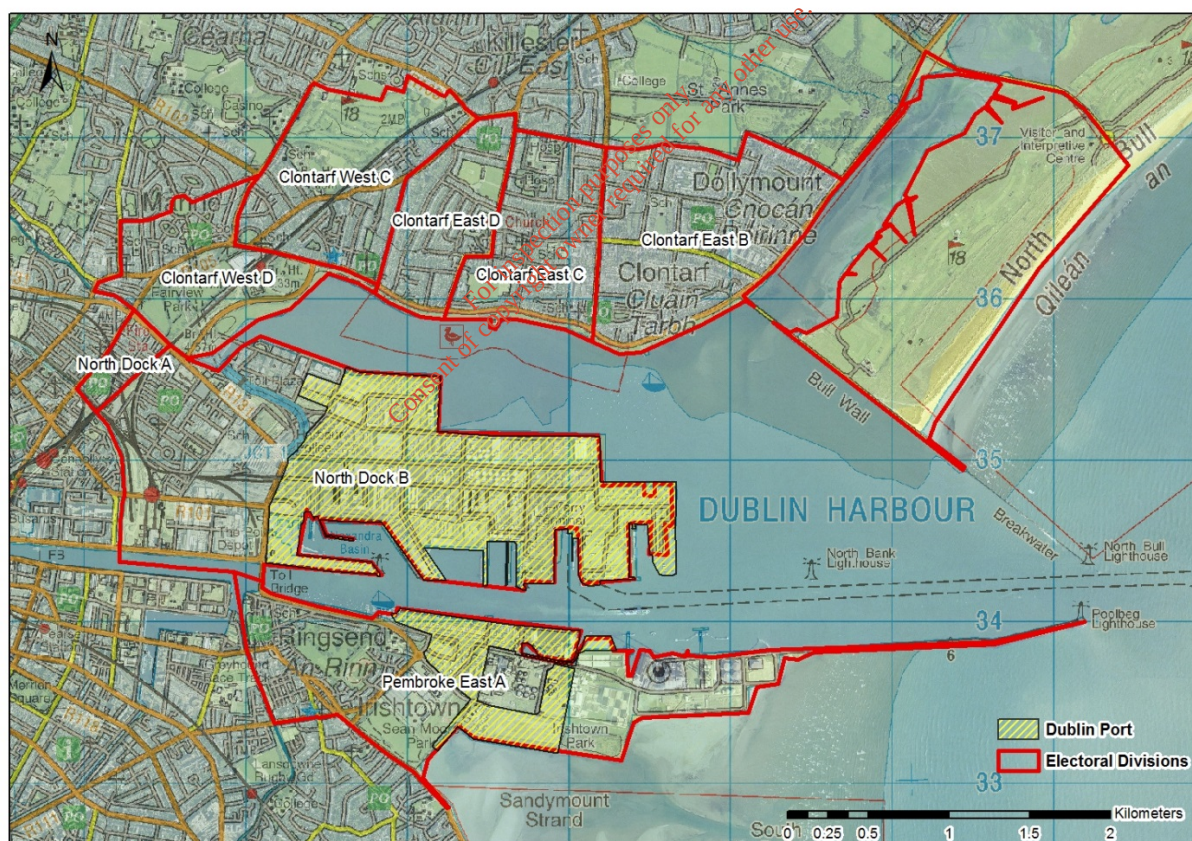


Figure 13.1 Location of District Electoral Divisions (DEDs) in close proximity to Dublin Port Estate.

Land Use

The land which constitutes the Dublin Port Estate has been reclaimed commencing in the 17th and 18th centuries and continued through the 19th and 20th centuries. The bulk of reclamation took place in the mid 20th century (Figure 13.2). Details on the history of the area can be found in Chapter 12 - Cultural Heritage.

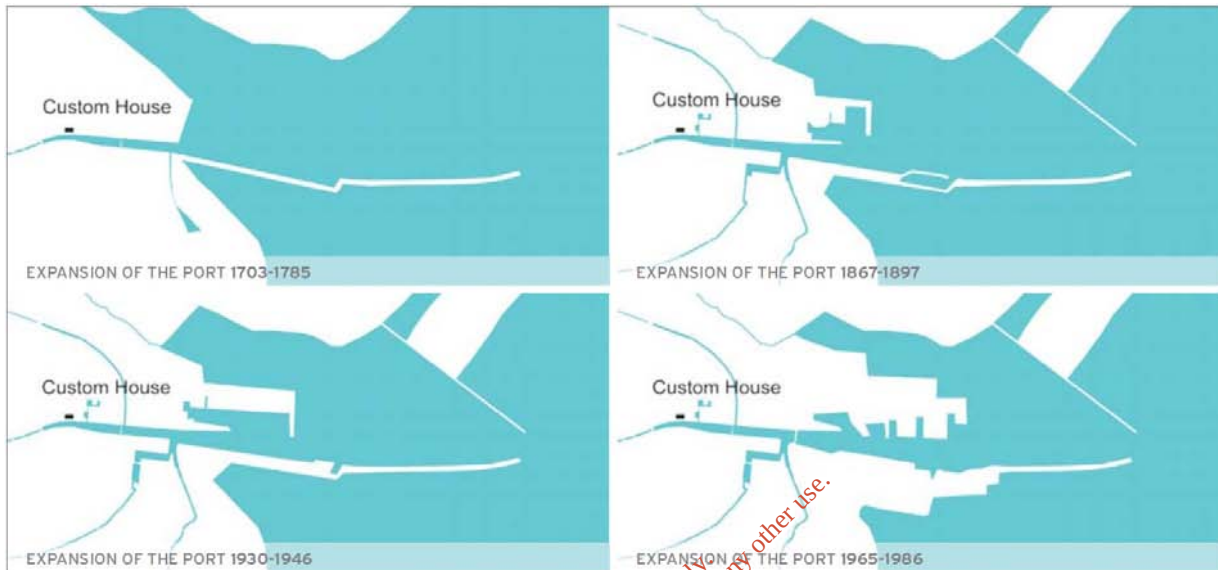


Figure 13.2 Historical expansion of Dublin Port (Dublin Docklands Authority Masterplan 2008)

Amenity and Tourist facilities

There are a number of amenity and recreation areas in the vicinity of the site including:

- Clontarf Waterfront;
- Fairview Park;
- Irishtown Nature Reserve;
- Irishtown Stadium;
- North Bull Island Nature Reserve;
- Sandymount Strand;
- Sean Moore Park; and
- South Bull Wall.

The location of these local amenities is highlighted in Figure 13.3.

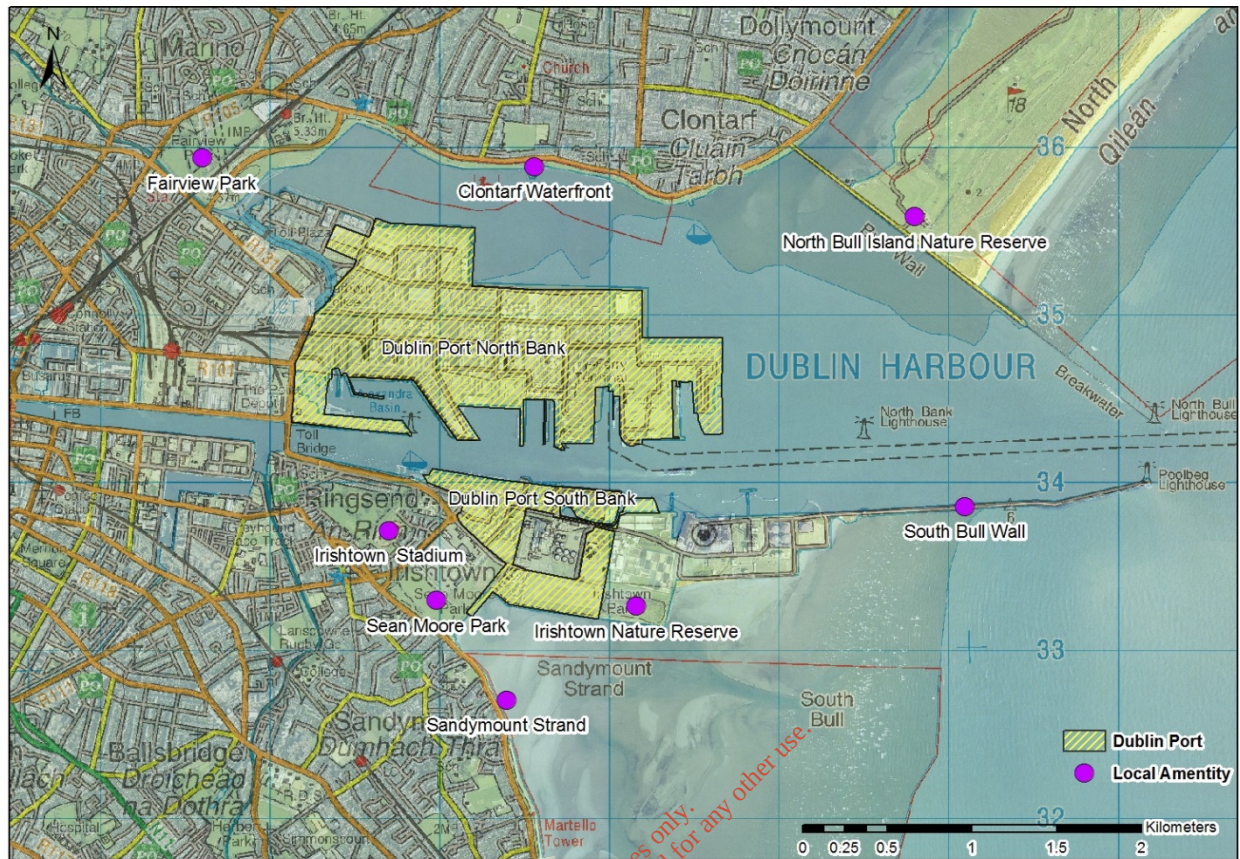


Figure 13.3 Location of amenities and recreation areas in close proximity to the Dublin Port Estate

Dublin Port and the surrounding area also benefits from the strong transport links to Dublin's main tourist attractions such as:

- The O2 (0.2 km),
- The Aviva Stadium (1.2km),
- Croke Park (1.8km),
- Dublin City Centre with its numerous bars, shops and restaurants (2km),
- National Gallery of Ireland (2km)
- Trinity College Library (2km),
- Guinness Storehouse (4km),
- Dublin Zoo (4.8km).

Population and Demographics

Population Trends

A breakdown of the population change within the relevant DEDs and the Greater Dublin Area, consisting of Dublin City, Dublin South, Dun Laoghaire Rathdown and Fingal based on Census 2002 and Census 2011 is summarised in Table 13.1.

Table 13.1 Summary of Population Change in the Dublin Area (CSO, Census of Population 2002 and 2011)

AREA	2002	2011	2002-2011 %	% MALES IN 2011
Dublin City	495,781	527,612	+6.4%	48.8%
Dublin South	238,835	265,205	+11.0%	48.8%
Dun Laoghaire Rathdown	191,792	206,261	+7.5%	47.8%
Fingal	196,413	273,991	+39.5%	49.1%
Greater Dublin Area	1,122,821	1,273,069	+13.4%	48.7%
Clontarf West D	2,140	2,066	-1.0%	47.5%
Clontarf West C	3,372	3,366	-0.2%	48.0%
Clontarf East D	2,772	2,673	-3.6%	47.3%
Clontarf East C	3,029	3,113	+2.8%	46.9%
Clontarf East B	6,458	6,759	+1.8%	47.1%
North Dock B	3,628	6,895	+90.0%	51.5%
North Dock A	1,287	1,303	+1.2%	51.8%
Pembroke East A	4,304	4,929	+14.5%	48.0%
Port Environs	26,990	31,104	+15.2%	48.6%
State	3,917,203	4,588,252	+17.1%	49.5%

Between 2002 and 2011:

- The population of Ireland increased by 17.1%;
- The population of the Greater Dublin Area increased by 13.4%;
- The population of Dublin City increased by 6.4%;
- The population of the DEDs adjacent to Dublin Port increased by 15.2%.

Three of the DEDs, Clontarf West D, Clontarf West C and Clontarf East D actually experienced a decline in population. The largest increase in population was in North Dock B, which increased by 90%.

Age Profile

The age profile of the population in the Greater Dublin Area is summarised in Table 13.2.

Table 13.2 Age Profile in the Greater Dublin Area (CSO Census 2011)

AREA	POP < 15 YEARS	% POP < 15 YEARS	POP >65 YEARS	% POP >65 YEARS
Dublin City	85,075	16.1%	66,490	12.6%
Dublin South	64,583	24.4%	23,053	8.7%
Dun Laoghaire Rathdown	40,012	19.4%	29,872	14.5%
Fingal	69,557	25.4%	19,861	7.2%
Greater Dublin Area	259,227	20.4%	139,276	10.9%
Clontarf West D	270	13.1%	272	13.2%
Clontarf West C	500	14.9%	381	11.3%
Clontarf East D	472	17.7%	533	19.9%
Clontarf East C	605	19.4%	580	18.6%
Clontarf East B	1,291	19.1%	1,048	15.5%
North Dock B	887	12.9%	469	6.8%
North Dock A	155	11.9%	165	12.7%
Pembroke East A	782	15.9%	485	9.8%
Port Environs	4,962	15.9%	3,933	12.6%
State	979,590	21.3%	535,392	11.7%

In the Greater Dublin Area 20.4% of the population was under the age of 15 years at the time of the 2011 Census. This is just lower than the State average of 21.3%. Within the environs of Dublin Port, just 15.9% of the population is under the age of 15 years. The percentage of the population over 65 years of age at 12.6% in the environs of Dublin Port is higher than the national average and the Greater Dublin Area. The population of the Dublin Port area is ageing faster than the national average.

Socio-Economic Groups

The breakdown of the socio economic groups of over 15s within each of the relevant electoral divisions for 2011 is tabulated in Table 13.3.

The socio economic distributions of Clontarf East B, Clontarf East C, Clontarf East D and Clontarf West C are similar as are the distributions of Clontarf West D, North Dock A, North Dock B and Pembroke East A. The former grouping of DEDs has a much higher proportion of employers and professionals than the latter.

Table 13.3 Persons aged 15 and over by Socio-Economic Group for relevant DEDs, 2011 (CSO Census 2011)

	A	B	C	D	E	F	G	H	I	J	Z	
	Employers and managers	Higher professional	Lower professional	Non-manual	Manual skilled	Semi-skilled	Unskilled	Own account workers	Farmers	Agricultural workers	All others gainfully occupied and unknown	Total
Clontarf East B	1992	1062	1100	1070	257	228	83	359	4	3	647	6805
Clontarf East C	959	550	497	490	101	62	6	119	1	3	213	3001
Clontarf East D	764	459	416	377	70	79	33	94	4	1	269	2566
Clontarf West C	871	550	628	560	84	103	17	161	0	0	359	3333
Clontarf West D	280	215	319	476	185	126	51	62	1	4	371	2090
North Dock A	174	83	154	264	122	116	57	96	0	1	252	1319
North Dock B	914	599	812	1575	393	547	321	212	1	5	1198	6577
Pembroke East A	665	415	483	961	433	426	366	204	2	7	1033	4995
Total	6619	3933	4409	5773	1645	1687	934	1307	13	24	4342	30686
Clontarf East B	29.27%	15.61%	16.16%	15.72%	3.78%	3.35%	1.22%	5.28%	0.06%	0.04%	9.51%	100%
Clontarf East C	31.96%	18.33%	16.56%	16.33%	3.37%	2.07%	0.20%	3.97%	0.03%	0.10%	7.10%	100%
Clontarf East D	29.77%	17.89%	16.21%	14.69%	2.73%	3.08%	1.29%	3.66%	0.16%	0.04%	10.48%	100%
Clontarf West C	26.13%	16.50%	18.84%	16.80%	2.52%	3.09%	0.51%	4.83%	0.00%	0.00%	10.77%	100%
Clontarf West D	13.40%	10.29%	15.26%	22.78%	8.85%	6.03%	2.44%	2.97%	0.05%	0.19%	17.75%	100%
North Dock A	13.19%	6.29%	11.68%	20.02%	9.25%	8.79%	4.32%	7.28%	0.00%	0.08%	19.11%	100%
North Dock B	13.90%	9.11%	12.35%	23.95%	5.98%	8.32%	4.88%	3.22%	0.02%	0.08%	18.21%	100%
Pembroke East A	13.31%	8.31%	9.67%	19.24%	8.67%	8.53%	7.33%	4.08%	0.04%	0.14%	20.68%	100%
Total	21.57%	12.82%	14.37%	18.81%	5.36%	5.50%	3.04%	4.26%	0.04%	0.08%	14.15%	100%

Employment

The employment status of persons aged 15 years and over for the Greater Dublin Area and the DEDs surrounding Dublin Port in 2011 is presented in Table 13.4.

The percentage of the population in employment in the Port Environs is significantly above the Greater Dublin Area and the national average. The number of unemployed as a percentage of the population over 15 years of age in the Port Environs is lower than the Greater Dublin Area and the national average. The student population is lower than the Greater Dublin Area and the national average. All but two of the DEDs surrounding Dublin Port have a higher percentage of retired than the state as a whole. This reflects the relatively old age profile of the population in the area.

Table 13.4 Employment Status, % of Population over 15 Years of Age (CSO, Census 2011)

Area	At work	Looking for 1st job	Unemployed	Student	Home	Retired	Disability
Dublin City	50.8%	1.1%	10.4%	12.6%	7.1%	13.1%	4.3%
Dublin South	52.2%	1.2%	11.6%	10.9%	9.4%	10.1%	4.3%
DLR	1.9%	0.6%	6.0%	14.5%	9.2%	15.2%	2.5%
Fingal	57.4%	1.1%	9.8%	10.5%	8.9%	8.8%	3.1%
GDA	52.6%	1.0%	9.8%	12.2%	8.3%	12.0%	3.8%
Clontarf West D	57.0%	1.1%	8.9%	10.4%	5.2%	13.6%	3.4%
Clontarf West C	62.7%	0.6%	6.2%	9.3%	5.9%	12.9%	2.1%
Clontarf East D	49.9%	0.4%	4.8%	13.2%	7.4%	21.8%	2.2%
Clontarf East C	51.0%	0.5%	3.0%	12.9%	8.4%	21.6%	2.2%
Clontarf East B	54.1%	0.6%	4.3%	12.6%	8.4%	17.6%	2.1%
North Dock B	65.3%	0.9%	9.2%	10.2%	4.6%	6.8%	2.8%
North Dock A	56.9%	1.3%	12.5%	8.9%	4.6%	12.6%	3.0%
Pembroke East A	57.2%	0.9%	10.8%	8.8%	6.4%	10.4%	4.9%
Port Environs	57.8%	0.8%	7.2%	10.9%	6.5%	13.7%	2.9%
State	50.1%	0.9%	10.8%	11.3%	9.4%	12.7%	4.4%

Unemployment rates expressed as a percentage of the available labour force are considered a more accurate measure of unemployment than that presented in Table 13.4. The percentage of unemployment in the labour force is shown for the Greater Dublin Area in Table 13.5.

The unemployment rate in the Port Environs at 12.2 per cent is considerably lower than the national average rate of 19 per cent and the average rate of 17.1 per cent in the Greater Dublin area.

Table 13.5 Unemployed as % of Available Labour Force (CSO, Census 2011)

AREA	UNEMPLOYMENT RATE
Dublin City	18.5%
Dublin South	19.6%
Dun Laoghaire Rathdown	11.2%
Fingal	16.0%
Greater Dublin Area	17.1%
Clontarf West D	14.9%
Clontarf West C	9.8%
Clontarf East D	9.5%
Clontarf East C	6.5%
Clontarf East B	8.3%
North Dock B	13.4%
North Dock A	19.5%
Pembroke East A	17.0%
Port Environs	12.2%
State	19.0%

Tourism

Between 2009 and 2012, 3.64 million overseas visitors spent almost €1.3 billion in Dublin and the wider Dublin region. This spending has a significant effect in terms of business profitability and employment. Many businesses and their suppliers benefit directly from the demand for goods and services created by tourism, as do the state and local authorities as a result of increased tax revenue. It is estimated that around 50,000 people in Dublin depend wholly or largely on tourism for their income.

Dublin Port offers easy access to local amenities, the capital city and its various attractions, and to other modes of transport. The strong transport links of Dublin Port are key to tourism as it widens the sphere of influence and socio-economic benefits that the Port provides.

Cruise Tourism

Fáilte Ireland identifies the tourism sectors offering the best potential for Dublin as:

- Leisure Tourism;
- Events Tourism;
- **Cruise Tourism;** and
- Business Tourism.

There has been significant expansion of the cruise liner holiday industry on a global scale in recent years and Ireland is benefiting from this. There has been very strong growth in cruise ship and passenger numbers coming through Dublin Port in recent years. The number of cruise ships visiting Dublin Port has increased from just 24 in 1992 to 100 in 2013. Over the past decade, the number of cruise passengers into Dublin has tripled, with an average annual growth rate of 12.8%. In 2013 the number of cruise visitors to Dublin passed 100,000 for the first time. Figure 13.6 shows the trends in Dublin Port's cruise business.

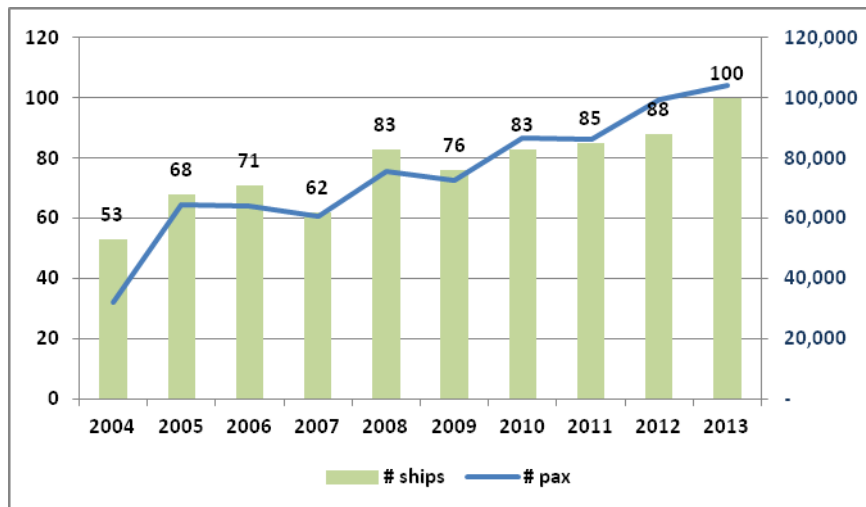


Figure 13.4 Trends in Dublin Port's cruise business 2004 to 2013

It is estimated that the average cruise visitor spends approximately € 40-100 in the local economy per day. In 2013 cruise ship crew members spent an average of €48 per day. For Dublin the current annual economic impact for direct spending based upon 2013 cruise throughput is circa €12.7 m (RPS analysis based on data sourced from Bermello, Ajamil & Partners Inc report 'Preparation of a Plan for the Development of Cruise Tourism in Dublin'). Additionally, the cruise lines spend monies on port charges, pilotage, provisions, fuel, stevedoring, etc. each time they are in port.

Developing cruise tourism therefore offers an opportunity to attract additional revenue to Dublin. This can be achieved by attracting more, and larger, cruise ships to Dublin as well as by encouraging cruise passengers to consider choosing an itinerary that includes Dublin.

Consultation

In March 2011 Dublin Port Company (DPC) commenced a year-long consultation process for the Masterplan 2012 to 2040. The process was aimed at soliciting views from a wide circle of stakeholders whose perspectives on the operations and future of the port were regarded as important.

Building on the extensive consultation carried out during the process to develop the Masterplan, DPC and their consultants RPS have carried out further extensive consultation on the ABR Project in the course of developing the current proposal.

A comprehensive programme of public consultation concerning the ABR Project was undertaken between September and November 2013 to seek the views of the wider public on the proposed ABR Project and the proposed community gain initiative to be advanced as part of the project.

Further details on the consultation carried out are available in Chapter 2 - Consultation Process.

13.2 POTENTIAL IMPACT OF THE PROPOSED PROJECT

Construction Phase

The ABR Project will comprise major construction and refurbishment works which inherently have the potential to produce some negative environmental impacts on human beings as a result of increased construction traffic, noise and dust during the construction period. These potential impacts have been addressed in detail within this EIS and mitigation measures have been developed to minimize disruption to the local community.

The construction phase will however also offer benefits to the local economy through:

- Employment opportunities in the construction and related industries; and
- Increased revenue for the services sector as a result of spending by construction workers.

The ABR Project can be broken down into 5 stages:

- Stage 1: Preconstruction Stage and Advance Works;
- Stage 2: Alexandra Basin West Construction Works;
- Stage 3: Berth 52 Construction Works, Further Works at Alexandra Basin West, Re-location of Operations;
- Stage 4: North Quay Wall Extension & Marina Wall Construction Works; and
- Stage 5: Dredging Works.

In order to highlight the socio-economic benefits of the construction works, employment levels, wage payment and tax contributions are estimated for each stage in Tables 13.6 – 13.10.

In addition the newly generated net income will increase spending in the area, which becomes an increase of income to the local service industries. The multiplier effect refers to the estimated increase in economic benefit to the area arising from the ABR Project's construction phase.

Table 13.6 Socio Economic benefits of Stage 1 - Preconstruction Stage and Advance Works

Activity	No.	Duration	Annual Wage	Total Wage	Tax	Net Wage
Design Staff	15	1.9 Years	€40,674	€1,159,209	€289,802	€869,407
Site Operatives	5	0.5 Years	€37,600	€94,000	€23,500	€70,500
Total				€1,253,209	€313,302	€939,907
Multiplier Effect						€1,879,818

Table 13.7 Socio Economic benefits of Stage 2 - Alexandra Basin West Construction Works

Activity	No.	Duration	Annual Wage	Total Wage	Tax	Net Wage
Site Staff	32	1.75 Years	€37,600	€2,105,600	€526,400	€1,579,200
Site Operatives	80	1.75 Years	€37,600	€5,264,000	€1,316,000	€3,948,000
Design Staff	24	1.75 Years	€40,674	€1,708,308	€427,077	€1,281,231
Total				€9,077,908	€2,269,477	€6,808,431
Multiplier Effect						€13,616,862

Table 13.8 Socio Economic benefits of Stage 3 – Berth 52 Construction Works, Further Works at Alexandra Basin West, Re-location of Operations

Activity	No.	Duration	Annual Wage	Total Wage	Tax	Net Wage
Site Staff	16	1.6 Years	€37,600	€962,560	€240,640	€721,920
Site Operatives	40	1.6 Years	€37,600	€2,406,400	€601,600	€1,804,800
Design Staff	12	1.6 Years	€40,674	€780,940	€195,235	€585,705
Total				€4,149,900	€1,037,475	€3,112,425
Multiplier Effect						€6,224,850

Table 13.9 Socio Economic benefits of Stage 4 - North Quay Wall Extension & Marina Wall Construction Works

Activity	No.	Duration	Annual Wage	Total Wage	Tax	Net Wage
Site Staff – North Q	16	1.25 Years	€37,600	€752,000	€188,000	€564,000
Site Operatives – North Q	40	1.25 Years	€37,600	€1,880,000	€470,000	€1,410,000
Design Staff – North Quay	12	1.25 Years	€40,674	€610,110	€152,527	€457,583
Site Staff – Marina Wall	4	0.5 Years	€37,600	€75,200	€18,800	€56,400
Site Operatives – Marina Wall	10	0.5 Years	€37,600	€188,000	€47,000	€141,000
Design Staff – Marina Wall	3	0.5 Years	€40,674	€61,011	€15,252	€45,759
Total				€3,566,321	€891,579	€2,674,742
Multiplier Effect						€5,349,484

Table 13.10 Socio Economic benefits of Stage 5 - Dredging Works

Activity	No.	Duration	Annual Wage	Total Wage	Tax	Net Wage
Channel Dredging	15	3 Years	€37,600	€1,692,000	€423,000	€1,269,000
Site Staff – Bull Wall	4	1.6 Years	€37,600	€240,640	€60,160	€180,480
Site Operatives – Bull Wall	10	1.6 Years	€37,600	€601,600	€150,400	€451,200
Design Staff – Bull Wall	3	1.6 Years	€40,674	€195,235	€48,808	€146,427
Dredging Alexandra Basin	10	1.6 Years	€37,600	€601,600	€150,400	€451,200
Treatment & Placement Site Staff	2	1.6 Years	€37,600	€120,320	€30,080	€90,240
Treatment & Placement Site Operatives	20	1.6 Years	€37,600	€1,203,200	€300,800	€902,400
Treatment & Placement Design Staff	2	1.6 Years	€40,674	€130,156	€32,539	€97,617
Total				€4,784,751	€1,196,187	€3,588,564
Multiplier Effect						€7,177,128

Tables 13.6 to 13.10 estimate 375 workers will be employed on the site for varying lengths of time on different aspects of the project. Due to these employment levels it is estimated that over the construction period the following financial flows will occur:

- Gross wages paid out €22.8 million;
- Labour tax payments to the Exchequer €5.7 million;
- Net wages paid out €17.1 million; and
- Assuming a conservative income multiplier effect of 2, this net wage could result in an injection of €34.2 million into the broader economy.

Further details on the construction activities associated with the redevelopment are available in Chapter 4 - Project Description.

Operational Phase

The ABR project will play a key role in Dublin Port's plans to meet the demands of a predicted 60 million tonnes cargo throughput by 2040. The Irish economic model is heavily based on exports. In 2012, merchandise exports accounted for 52.4% of GDP and merchandise imports accounted for 30.2% of GDP. Irish seaports handle around 84% of Ireland's trade in volume and 62% in value terms based on data from Irish Exporters Association (2012). Dublin Port dominates Ireland's merchandise trade movements. It handles more than two thirds of containerised trade to and from Ireland and half of Ireland's imports and exports.

Dublin Port Company employs more than 140 people directly, but a further 4,000 people are employed in what is Ireland's largest industrial estate. The ABR Project will help to secure existing employment at the Dublin Port Estate and provide opportunities for further employment associated with the continued growth in trade.

Cruise Tourism

Dublin Port also handles 1.6 million passengers through the ferry companies that operate out of the Port and the cruise vessels that call to the Port. The ABR Project will also play a key role in supporting cruise tourism as outlined below:

"This is an area of tourism that has increased substantially in recent years, and there is real potential to grow both the number of cruise ships that visit Dublin and the value that cruise tourists bring to the city and region." Fáilte Ireland

A recent study by Bermello, Ajamil & Partners for Dublin Port estimates that cruise traffic can continue to grow at a rate exceeding 8% a year, reaching 200,000 passengers by 2020 and circa 350,000 by 2032 (Further details are presented in Chapter 1 - Introduction).

The cruise industry provides a wide variety of direct and indirect socio-economic benefits to the communities they visit based upon passenger and crew spending; provisions required by the vessels including food & beverage, fuel and other supplies; tourism venues, guides, coaches; taxis; port and operational charges; air and hotel for homeport operations; and numerous secondary impacts based upon trickle down spending.

In terms of potential employment, Fáilte Ireland suggests that 1000 additional tourists support 15 jobs in the tourism and associated industries. A projection of the overall economic impacts to Dublin from the cruise line industry from 2013 to 2043, prepared by Bermello, Ajamil & Partners, is shown in Figure 13.5.

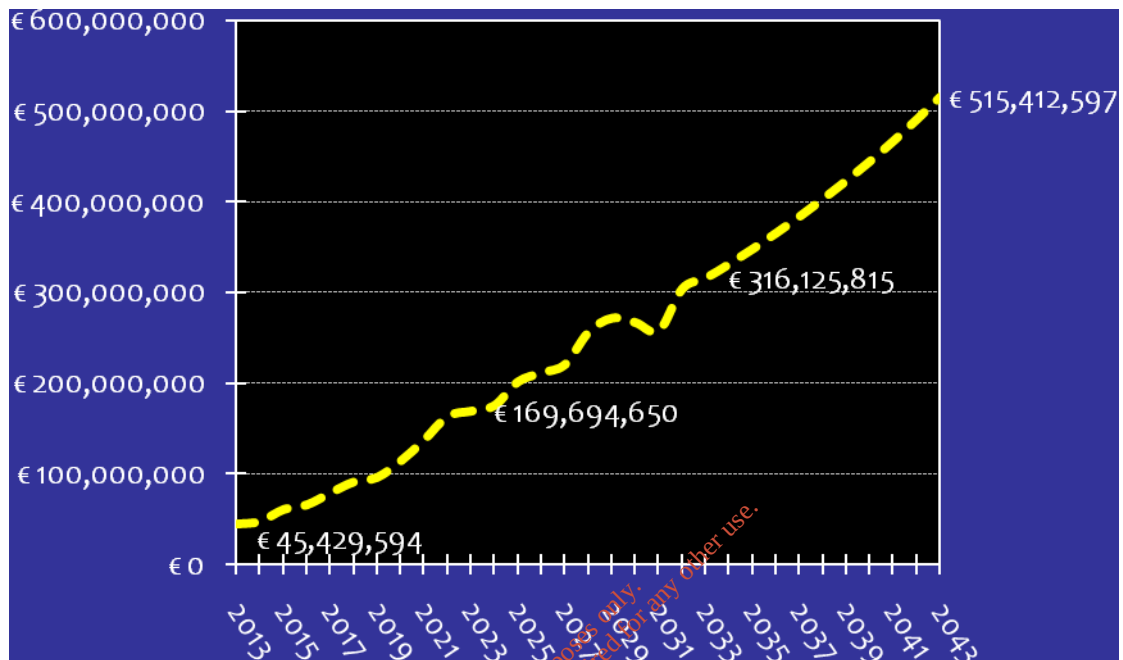


Figure 13.5 Dublin total economic impacts from cruise tourism, 2013 - 2043 (Bermello, Ajamil & Partners)

The total contribution to Dublin from cruise tourism has the potential to increase from €45 million in 2013 to more than €515 million in 2043.

These projections assume that it is most likely that Dublin will remain port-of-call dominant. Longer term efforts made to persuade cruise planners to consider using Dublin as a turn-around port and inter-porting hub, in order to establish a more significant and longer-term role for Dublin City and Region within the European cruise scene, will enhance the economic benefits from cruise tourism in Dublin further still.

Do Nothing Impact

In the absence of the proposed project, the socio-economic benefits from cruise tourism are likely to plateau and eventually subside because of limitations associated with the size of ships which can be accommodated at the port. The maximum size of ship which can be accommodated in Dublin Port is currently circa 300m. However the trend is for larger ships as shown in Figure 13.6.

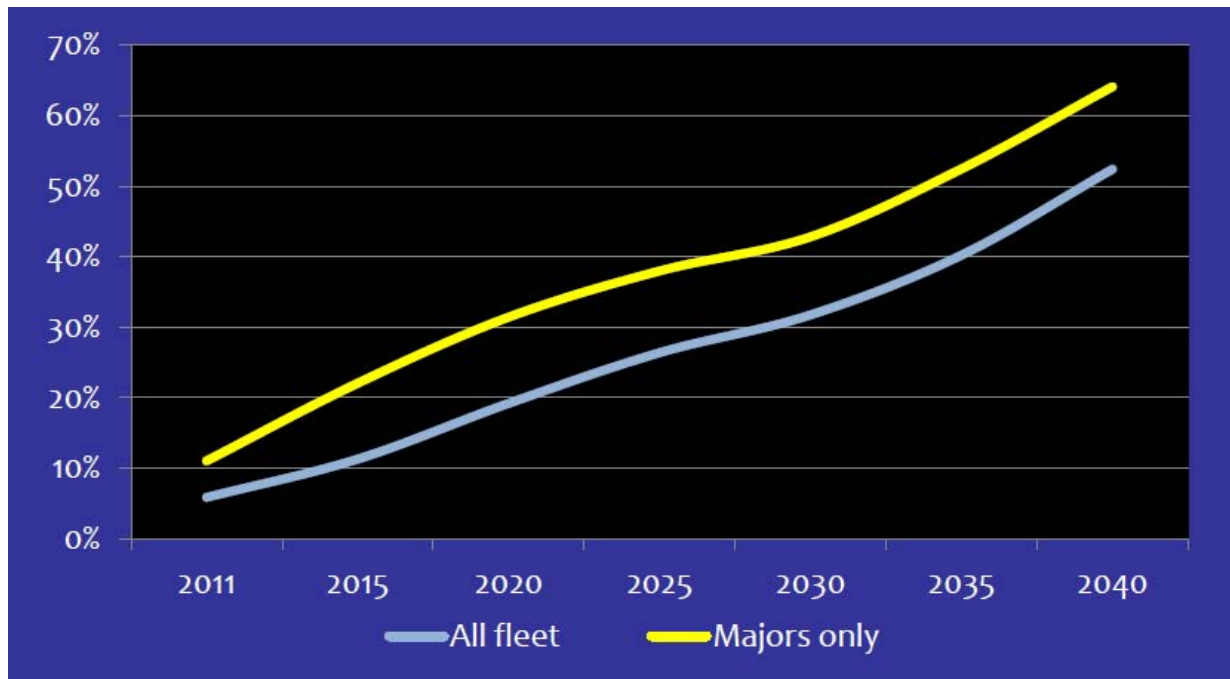


Figure 13.6 Projected percentage of cruise ships over 300 metres worldwide, 2012 - 2040 (Bermello, Ajamil & Partners)

13.3 MITIGATION MEASURES

Construction Phase

A Construction Environmental Management Plan (CEMP) will be developed which will collate all mitigation measures contained within this EIS together with all conditions applied by An Bord Pleánala.

The development of the CEMP will include continued consultation with statutory bodies, interested parties and the local communities.

The CEMP will form part of the Specification for the Construction Works, thereby contractually binding Contractors to adhere to the mitigation measures as well as providing Contractors with the opportunity to price for the inclusion of the mitigation measures.

Dublin Port Company will encourage Contractors to utilise local construction workers where it is practical to do so.

Safe working practices, in accordance with current legislation, will be enforced during the construction period to protect construction workers, port operators and visitors to the construction sites. The construction sites will be suitably fenced and access to the sites shall be limited to authorised personnel.

Operational Phase

The ABR Project will play a key role in providing the necessary infrastructure required for continued growth within the port. It will therefore provide an overall beneficial socio-economic impact.

The new berth configuration proposed in Alexandra Basin West involves the extension of Berth 29 on Alexandra Quay West westwards in front of the entrance to Graving Dock #2. As a result, the port will lose the utility of this graving dock.

The operation of graving docks was always financially challenging and the pressure on DPC to make best use of the Port's existing estate allied to the poor commercial returns from the Port's Graving Dock combine to make the provision of additional berthing space at the entrance to Graving Dock #2 a more suitable use of the scarce land resource.

The poor financial return from Graving Dock #2 represents an underutilisation of port assets and is sufficient reason alone for DPC now to reconfigure the graving dock and its 1.4 hectare curtilage. Commercially, DPC earns about one sixth of what would be earned by an equivalent land area elsewhere in the Port close to working berths.

13.4 RESIDUAL IMPACTS

The ABR Project will provide an overall positive socio-economic benefit through direct and indirect employment opportunities associated with the predicted growth in trade and in tourism associated with cruise ships.

There will however be an unavoidable loss associated with ship repairs as a result of the closure of Graving Dock #2 within the Alexandra Basin West.

14. INTERACTIONS AND IN-COMBINATION EFFECTS

Chapters 5 to 13 of this EIS assess the likely significant impacts arising from the ABR Project and present mitigation measures to reduce the residual impact to acceptable levels. This chapter describes the interactions between the various aspects of the Environmental Impact Assessments and in-combination effects with other plans or programmes.

14.1 INTERACTIONS

The main interactions between the various aspects of the Environmental Impact Assessments are presented in Table 14.1. A brief description of the interactions is presented overleaf.

Table 14.1 Interactions

	Flora & Fauna	Landscape & Visual	Air & Climate	Material Assets	Coastal Processes	Water	Geology & Soils	Cultural Heritage	Human Beings
Flora & Fauna									
Landscape & Visual	(A)								
Air & Climate	(B)	(F)							
Material Assets	None	None	(I)						
Coastal Processes	(C)	None	None	None					
Water	(D)	None	(J)	None	(N)				
Geology & Soils	(E)	None	(K)	None	(O)	(R)			
Cultural Heritage	None	(G)	None	None	(P)	None	None		
Human Beings	None	(H)	(L)	(M)	(Q)	None	None	(S)	

Description of interactions between the Environmental Impact Assessment topics**A Interaction between Flora & Fauna and Landscape & Visual**

The ABR Project has the potential to alter terrestrial habitats, notably the demolition of buildings which may be used by bats.

B Interaction between Flora & Fauna and Air & Climate

Construction noise, particularly from piling activities associated with the quay walls creates underwater noise which can be harmful to cetaceans, seals and fish. Construction noise also has the potential to temporarily disturb birds.

C Interaction between Flora & Fauna and Coastal Processes

The dispersal, fate and deposition of sediments arising from dredging and disposal operations has the potential to impact on birds, marine mammals, benthic ecology and fisheries.

D Interaction between Flora & Fauna and Water

The potential risk of pollution incidents to water during the construction and operational phases of the ABR Project can be harmful to birds, marine mammals benthic ecology and fisheries.

E Interaction between Flora & Fauna and Geology and Soils

There is a potential risk associated with the dredging and treatment of contaminated sediments from Alexandra Basin West resulting in losses to the receiving waters which can be harmful to birds, marine mammals benthic ecology and fisheries.

F Interaction between Landscape & Visual and Air & Climate

The potential requirement for noise mitigation measures can have a visual impact.

G Interaction between Landscape & Visual and Cultural Heritage

The ABR Project has the potential to impact on built heritage aspects of the existing port including the North Quay Wall Extension and Lighthouse thereby giving rise to a visual impact.

H Interaction between Landscape & Visual and Human Beings

The proposed works at Alexandra Basin West has the potential to alter the landscape character and visual impact, including lighting, from nearby viewpoints.

I Interaction between Air & Climate and Material Assets

Construction traffic and increased operational traffic has the potential to impact on air quality.

J Interaction between Air & Climate and Water

Construction noise, particularly from piling activities associated with the quay walls creates underwater noise which can be harmful to cetaceans, seals and fish.

K Interaction between Air & Climate and Geology & Soils

The temporary storage of dredge material prior to treatment has the potential to cause a dust nuisance. General construction works associated with demolition and the movement of materials can also give rise to a dust nuisance.

L Interaction between Air & Climate and Human Beings

During the construction phase, the generation for noise, dust, odour, gaseous emissions and vibration has the potential to temporarily disturb people, therefore mitigation measures have been proposed. During the operational phase, there is a potential risk of noise and emissions to air from increased port activity.

M Interaction between Material Assets and Human Beings

The ABR Project has the potential to increase the traffic on roads adjacent to the Dublin Port Estate.

N Interaction between Coastal Processes and Water

The dispersal, fate and deposition of sediments arising from dredging and disposal operations has the potential to impact on water quality which in turn can impact on birds, marine mammals, benthic ecology and fisheries.

O Interaction between Coastal Processes and Geology and Soils

The capital dredging scheme has the potential to impact on the sediment transport regime in Dublin Bay.

P Interaction between Coastal Processes and Cultural Heritage

The capital dredging scheme has the potential to disturb known or unknown marine archaeology

Q Interaction between Coastal Processes and Human Beings

The construction of the ABR Project has the potential to temporarily impact on other users of Dublin Bay and the River Liffey Channel including commercial and recreational fishermen

and yachtsmen.

R Interaction between Water and Geology & Soils

The dredging and treatment of contaminated sediments from Alexander Basin West has the potential to release contaminants to the receiving waters and groundwater.

S Interaction between Cultural Heritage and Human Beings

The ABR Project has the potential to impact on built heritage aspects of the existing port including the North Quay Wall Extension and Lighthouse which are of historic interest.

Interaction between the environmental experts who have undertaken the environmental impact assessments has taken place on a continual basis throughout the preparation of the EIS. This has enabled the environmental assessment of each topic to take into consideration the issues associated with all other topics and to develop appropriate mitigation measures to eliminate the risk of potential impact or to reduce the potential risk to an acceptable level.

Interaction has also taken place between the environmental experts and the engineering design team on a continual basis in order to integrate the environmental mitigation measures with the engineering design of the project.

During the preparation of the EIS, fortnightly meetings were held among the Environmental team, Engineering team and Dublin Port Company. Two formal workshops were also held specifically to address interactions among the teams.

14.2 IN-COMBINATION EFFECTS

An assessment was made of other projects, plans or programmes in the general vicinity of the ABR Project during the preparation of the EIS in order to assess in-combination effects with other projects, plans and programmes.

This assessment was also undertaken within the scope of the Habitats Directive Assessment – Natura Impact Statement (under separate cover).

The in-combination assessment commenced during the preparation of the Dublin Port Masterplan (February 2012) which was supported by a non-statutory Strategic Environmental assessment (SEA) and Strategic Natura Impact Statement.

Relevant projects, plans and programmes were assessed for their potential to have in combination effects with the Dublin Port Masterplan. Preliminary screening assessment indicated that ten projects had possible significant impacts, whilst eight projects had no impact.

The majority of the projects were subject to Environmental Impact Assessment and Appropriate Assessment. These assessments either identified no impacts on Natura 2000 sites or proposed mitigation to ensure that no impacts would take place.

The key projects with the potential for in-combination effects, particularly with respect to Natura 2000 sites, were:

- S2S Sutton to Sandycove Project;
- Dollymount Promenade and Flood Protection Project; and
- Dublin Eastern Bypass.

S2S Sutton to Sandycove Project and Dollymount Promenade and Flood Protection Projects

The assessment of in-combination effects identified the S2S project to have a number of potential impacts to the North Bull Island SPA and the South Dublin Bay & River Tolka Estuary SPA. The Appropriate Assessment report for the S2S Project proposed a number of mitigation measures in relation to the proposed scheme and concluded on the basis of these that there will be no impact on the integrity of the Natura 2000 sites.

Since the publication of the Masterplan a Part 8 planning application has been made by Dublin City Council in relation to the S2S Cycleway and Footway, interim works between Bull Road (Wooden Bridge) and Causeway Road. This is an interim scheme comprising elements of two projects, the Dollymount Promenade & Flood Protection Project (DPFPP) and the North City Arterial Watermain (NCAM) both of which received planning approval from An Bord Pleanála in May 2013. Both projects were separately assessed as having no adverse effect on the integrity of any Natura 2000 site. Consequently, no in-combination effects with the ABR Project are envisaged.

The Eastern By-Pass

The Dublin City Development Plan 2011-2017, Policy S19 states that “It is the policy of Dublin City Council To support the provision of a link between north Dublin Port and the Southern Cross/South Eastern Motorway via an eastern by-bass of the city, in conjunction with and co-operation with other transport bodies, the National Road Authority and local authorities. The preferred method is by means of a bored tunnel and the preferred route is under Sandymount Strand and Booterstown Marsh. However the route and detailed design of the link road will be subject to an environmental impact Assessment and all statutory requirements, including a public consultation process, by the relevant authorities. An appropriate assessment of the proposed project for the entire route is also required in accordance with the Habitats Directive.”

The Eastern By-pass is not likely to proceed until after 2030, at the earliest. It would therefore be too premature to assess in-combination impacts with the ABR Project.

14.3 THE NEXT STEP

A Construction Environmental Management Plan (CEMP) will be developed in the next stage of the process, should planning permission be granted by An Bord Pleanála. The objective of the CEMP is to capture all mitigation measures within the Environmental Impact Statement together with any conditions imposed by An Bord Pleanála and to provide additional detail in order to develop a practical programme of measures for the Contractor. The CEMP will form part of the specification of the Contract Documents for the construction stage.

The CEMP will include:

- Traffic Management Plan
- Waste Management Plan
- Noise Management Plan
- Dust Management Plan
- Contamination Strategy
- Marine Mammal Observation Plan
- Marine Archaeology Management Plan
- Industrial Heritage Conservation Plan
- Water Quality Management Plan
- Establishment of lines of communication, reporting and actions

The preparation of the CEMP will require continual engagement with a range of interested parties/stakeholders including Dublin City Council, EPA, National Parks & Wildlife Service, Department of Arts, Heritage & Gaeltacht, National Roads Authority, Inland Fisheries Ireland, Commissioners of Irish Lights, Dublin Port tenants and local community groups.

A Construction Environmental Monitoring Programme will also be developed. The objective of the Construction Environmental Monitoring Programme is to provide additional safeguards to the receiving environment during the construction phase of the works. The monitoring programme will form part of the specification of the Contract Documents for the construction stage.

The design of the Construction Environmental Monitoring Programme will include the following elements:

- An assessment using 3-D hydrodynamic computational modelling and water quality modelling to design the placement of a number of water quality monitoring buoys and telemetry based warning systems.
- The establishment of water quality trigger levels and corresponding actions
- The design of noise and dust monitoring programmes
- Scheduling of Marine Mammal Observers and Marine Archaeological Observers

The preparation of the Construction Environmental Monitoring Programme will require continual engagement with a range of interested parties/stakeholders including Dublin City Council, EPA, National Parks & Wildlife Service, Department of Arts, Heritage & Gaeltacht, power station operators, Dublin Port tenants and local community groups.

Monitoring programmes already established, particularly in relation to birds, will continue prior to construction, during construction and post construction. This will provide additional information on seasonal and annual variations particularly with respect of the qualifying interest species within the adjacent SPA and for the tern colonies within the harbour estate.

14.4 TECHNICAL DIFFICULTIES

This EIS was prepared over a one year period during which time extensive baseline surveys were undertaken.

The EIS benefited from earlier work undertaken for the Port's Masterplan and associated Strategic Environmental assessment.

As a result, there were no technical difficulties encountered during the preparation of this EIS.

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GLOSSARY OF TERMS

TERM	DESCRIPTION
AA	Appropriate Assessment
AADT	Annual Average Daily Traffic
AAGR	Average Annual Growth Rate
ABC	Construction noise assessment method
ABR	Alexandra Basin Redevelopment
ADCO	Archaeological Diving Company Ltd
ADCP	Acoustic Doppler Current Profilers
AEP	Annual Expedience Probability
AERMOD	Atmospheric dispersion modeling system
AG4	Air dispersion modelling from industrial installations guidance notes
BAT	Best Available Technique
BCI	Bat Conservation Ireland
BCT	Bat Conservation Trust
bgl	below ground level
Break bulk	Loose cargoes such as reels of paper, bales of timber. Also includes project cargoes such as power transformers, wind turbine components.
Bulk Liquid	Primarily comprises petroleum products (such as petrol, diesel, aviation fuel) but also includes products such as molasses.
Bulk solid	Products such as animal feed, grains, cereals, peat moss, scrap steel loaded / discharged using quay side cranes with grab attachments.
CD	Chart Datum, depths in the Port vary with tidal conditions and all depths (and heights) are referenced to an appropriate datum point called "chart datum".
CDL	Coal Distributors Limited, also refers to a mooring structure on the south side of the River Liffey, near the Poolbeg power station owned by Coal Distributors Limited
CDM	CDM Smith, consulting engineers
CEMP	Construction Environmental Management Plan
CFRAM	Catchment Flood Risk and Management
CIEEM	Chartered Institute of Ecology & Environmental Management
CIRIA	Construction Industry Research and Information Association
CISS	cast-in-steel-shell, concrete piers fabricated within a steel shell.
CL	Conservation Limit, the number of adult fish of a particular species that are needed to return to a system each year to spawn in order to maintain a healthy sustainable population in the system.
CO	Carbon Monoxide
CO ₂	Carbon Dioxide
CO _{2eq}	Total estimated greenhouse gas emissions
COSHH	Control of Substances Hazardous to Health
CPT	Carriage Paid To
CRTN	Calculation of Road Traffic Noise

cSAC	Candidate Special Area of Conservation
CSO	Central Statistics Office
DAHG	Department of Arts, Heritage and the Gaeltacht
dB(A)	Decibel, expression of sound level. The (A) denotes that levels are "A"- weighted.
DBT	Dibutyltin
DDDA	Dublin Docklands Development Authority
DEds	District Electoral Divisions
DCC	Dublin City Council
DCIHR	Dublin City Industrial Heritage Record
DEHLG	Department of the Environment Heritage and Local Government
DGPS	Differential Global Positioning System
DHI	Danish Hydraulic Institute
DIN	Dissolved Inorganic Nitrogen
DMRB	Design Manual for Roads and Bridges
DO	Dissolved Oxygen
DPC	Dublin Port Company
Dry Bulk	Cargoes of free flowing dry solids such as grain or sand
EA	Environment Agency
EAL	Environmental Assessment Level
EC	European Community
EEA	European Environment Agency
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EMEP	European Monitoring and Evaluation Programme, European policy to identify and measure air pollutants
EMS	Environmental Management System
EPA	Environmental Protection Agency
EQS	Environmental Quality Standard
ERBD	Eastern River Basin District
ES	Estuarine Species, fish species dependent on estuaries.
ESB	Electricity Supply Board, also refers to a mooring structure on the south side of the River Liffey, near the Poolbeg power station owned by the Electricity Supply Board
EU	European Union
EUNIS	European Nature Information System
FRA	Flood Risk Assessment
FRAM	Flood Risk Assessment Management
GDA	Greater Dublin Area
GDP	Gross Domestic Product
GES	Good Environmental Status
GGBS	Ground Granulated Blast Furnace Slag
GLVIA	Guidelines for Landscape and Visual Impact Assessment
GPS	Global Positioning System
GSI	Geological Survey of Ireland
GHG	Green House Gas
Gross tonnes	Dublin Port measures cargo tonnage in gross tonne. The CSO , on the other hand, uses net tonnes. In the case of bulk liquid, bulk solid and break bulk, gross tonnes and net tonnes are the

	same. For unitised freight (Ro-Ro or Lo-Lo), gross tonnes includes the weight of the shipping container or trailer; net tonnes includes the weight of the goods themselves plus immediate packaging. For port operations, gross tonnes is a more useful measure as ship carrying capacity, crane handling capacities and road / rail capacities are determined by gross tonnage.
HCB	Hexachlorobenzene
HD	Hydro Dynamic
H_{mo}	Significant wave height
H₂S	Hydrogen sulphide
HAT	Highest Astronomical Tide
Hectare	Land areas in Dublin Port are referred to in hectares (where one hectare is equivalent to 2.47 acres and is equal to 10,000m ²).
HGV	Heavy Goods Vehicle
HS	Hydrographic Surveys Ltd., environmental and hydrographic survey company
HSA	Health and Safety Authority
Hz	Hertz, SI unit of frequency. It is defined as the number of cycles per second of a periodic phenomenon.
ICAN	noise and vibration consultancy
ICOMOS	International Council on Monuments and Sites
ICPSS	Irish Coastal Protection Strategy Study
IFI	Inland Fisheries Ireland
IGSL	Ground investigation and geotechnical company
IMO	International Maritime Organization
INFOMAR	Integrated Mapping for the Sustainable Development of Ireland's Marine Resources.
INSS	Irish National Seabed Survey
IPPC	Integrated Pollution Prevention Control
ISO	International Standards Organisation
ISPS	International Ship and Port Security code, originally introduced by the IMO (International Maritime Organisation) and later incorporated into EU legislation.
IQI	Infaunal Quality Index, assessment of the ecological status based on the soft sediment infaunal communities of transitional and coastal waters.
ITAP	Institut für technische und angewandte Physik GmbH, a measuring body for noise emission
ITM	Irish Transverse Mercator, geographic coordinate system for Ireland
IUCN	International Union for Nature Conservation
IWeBS	Irish Wetland Bird Survey
IWDG	Irish Whale and Dolphin Group
MS	Marine Stragglers, fish species which are fully marine and are only occasionally found in the lower reaches of estuaries.
JNCC	Joint Nature Conservation Committee
L_{Aeq}	The continuous equivalent A-weighted sound pressure level. This is an "average" of the sound pressure level.
L_{Amax}	This is the maximum A-weighted sound level measured during a sample period.

L_{Amin}	This is the minimum A-weighted sound level measured during a sample period.
L_{night,outside}	Threshold of night noise exposure for the purposes of assessing overall annoyance.
LAT	Lowest Astronomical Tide
Lo-Lo	Lift-on Lift-off , cargo mode which involves shipping containers lifted on and off ships with quayside cranes
LOI	Loss on Ignition, method of calculating organic matter content of soil samples
LVIA	Landscape and Visual Impact Assessment
MARPOL	International Convention for the Prevention of Pollution From Ships
MDS	Multidimensional Scaling
MEPC	Marine Environment Protection Committee
MHWM	Mean High Water Mark
MIKE	Coastal process modelling software
MM	Marine Migrant, marine fish species that use estuaries primarily as nursery grounds but usually spawn and spend much of their adult life at sea, while often returning seasonally to estuaries when adult.
MMO	Marine Mammal Observer, a qualified marine mammal observer is a visual observer who has undergone formal marine mammal observation training.
MOLA	Murray Ó Laoire Architects, architecture company
MRP	Molybdate Reactive Phosphorus
MSFD	Marine Strategy Framework Directive
MSL	Mean Sea Level
MTL	Marine Terminals Ltd., shipping & forwarding agents
NBDC	National Biodiversity Data Centre
NCEHD	National Civil Engineering Heritage Database
NCT	National Car Test
NHA	Natural Heritage Area
NIEA	Northern Ireland Environment Agency
NIR	Natura Impact Report
NMI	National Museum of Ireland
NNG	Night Noise Guideline
NO₂	Nitrogen Dioxide
NO_x	Oxides of nitrogen
NPWS	National Parks and Wildlife Service
NQE	North Quay Extension
NRA	National Roads Authority
NSS	National Spatial Strategy
NTS	Non-Technical Summary
NTS	Not To Scale (drawings)
OD	Ordnance Datum
ODOM	Single frequency portable hydrographic echo sounder
OEE	Office of Environmental Enforcement
OMP	Odour Management Plan
OPW	Office of Public Works
OSPAR	Convention of fifteen Governments of the western coasts and catchments of Europe, together with the European Union,

	aiming to protect the marine environment of the North-East Atlantic.
P&O	Ferry operators
Pa	Pascal, SI derived unit of pressure. It is a measure of force per unit area, defined as one Newton per square meter.
PAH	Poly Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
PPV	Peak Particle Velocity
pNHA	Proposed Natural Heritage Area
PM_{2.5}	Particles measuring 2.5µm or less
PM₁₀	Particles measuring 10µm or less
PSA	Particle Size Assessment
PSD	Particle Size Distribution
pSPA	proposed Special Protected Area
PTS	Permanent Threshold Shift, a permanent elevation of the hearing threshold due to noise exposure
Ramsar	Convention on Wetlands of International Importance, an intergovernmental treaty that provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources.
RMP	Record of Monuments and Places
RNLI	Royal National Lifeboat Institution
RPII	Radiological Protection Institute of Ireland
RPS	Rural Planning Service, consulting engineers
RPS	Record of Protected Structures
Ro-Ro	Roll-on Roll-off cargo mode which includes freight trailers, tourist vehicles and trade car imports all of which are driven on or off ferries, specialised ships.
SAC	Special Area of Conservation
SECA	Sulphur Emission Control Area
SEA	Strategic Environmental Assessment
SEPA	Scottish Environmental Protection Agency
SEL	Sound Exposure Level, the constant sound level in one second, which has the same amount of acoustic energy as the original time-varying sound i.e., the total energy of a sound pulse
SFPA	Sea Fisheries Protection Authority
SMRU	Sea Mammal Research Unit
SNIFFER	Scotland and Northern Ireland Forum for Environmental Research
SO₂	Sulphur Dioxide
SPA	Special Protection Area
SPL	Sound Pressure Level, a logarithmic measure of the effective sound pressure of a sound relative to a reference value.
S/S	Solidification/Stabilisation, remediation technology that relies on the reaction between a reagent and soil to reduce the mobility of contaminants
SSC	Suspended Sediment Concentration
SW	Spectral Wave, simplification of surface conditions giving the distribution of wave energy among different wave frequencies of wave-lengths on the sea surface.
TEN-T	Trans-European Transport Networks, a set of integrated

	international road, rail, air and water transport networks in Europe.
TEU	Twenty Foot Equivalent Unit. Shipping containers come in many lengths including 20", 30", 40" and 45". TEU is used as an industry standard measurement for containers where a 20" is 1.0 TEU , a 40" 2.0 TEU and so forth. The TEU measurement particularly is useful when specifying container ship or container terminal capacities.
TICCIH	The International Committee for the Conservation of the Industrial Heritage
T_m	Mean wave period
TSAS	Trophic Status Assessment Scheme
TBT	Tributyltin
TBM	Temporary Benchmark
TSP	Total Suspended Particulate
TTS	Temporary Threshold Shift, a temporal elevation of the hearing threshold due to noise exposure
UN	United Nations
UNESCO	United Nations Educational, Scientific and Cultural Organisation
Units Unitised	Freight can be in the form of shipping containers or trailers. The sizes of shipping containers vary and are measured in terms of TEU . Trailers vary to a lesser extent and are generally 13.6m long. Trailers are shipped either accompanied (by a road tractor unit and driver) or unaccompanied. In general each unit of unitised freight moved by road will generate at least one HGV movement into the Port and a second one out of the Port.
URPACTII	Programme funded by the European Regional Development Fund to develop a strategy for the development of cruise traffic and the urban regeneration of city ports.
USEPA	United States Environmental Protection Agency
UTC	Coordinated Universal Time
UWWT	Urban Waste Water Treatment
VDV	Vibration Dose Value
VMU	Vertical Mixed Use
VOC	Volatile Organic Compound
W	Historic shipwreck inventory
WFD	Water Framework Directive
WHO	World Health Organisation
γ-HCH	Lindane
ZVI	Zone of Visual Influence

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