FORTH PORTS

Port of Kirkcaldy Maintenance Dredge Disposal: Marine Licence Application

Best Practicable Environmental Option Report

29 June 2021

Project No: 0447789

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1. INTRODUCTION

1.1 Background

This report has been prepared by Environmental Resources Management Ltd (ERM) on behalf of Forth Ports Ltd (Forth Ports) in support of a Marine Licence application for disposal of dredged material at sea. It compares various options for the disposal of dredged material from the Port of Kirkcaldy and identifies the Best Practicable Environmental Option (BPEO) (1).

Under the *Marine (Scotland) Act, 2010, Section 21(1),* a Marine Licence issued by Marine Scotland is required for the deposit of substances or objects within waters adjacent to Scotland. Under Part 4, Section 27(2), Marine Scotland has an obligation to consider the availability of practical alternatives when considering applications involving disposal of material at sea. Applications for a Marine Licence to dispose of dredged spoil at sea require a BPEO assessment, demonstrating that alternatives to sea disposal have been investigated and that sea disposal does not pose an unacceptable risk to the marine environment and other legitimate users.

Marine Licences for these activities are valid in Scotland for up to three years (2). Forth Ports currently has a maintenance dredge disposal licence (06720/18/0) to maintain a safe navigable depth which expires on 13 November 2021. This application is therefore expected to cover dredge spoil disposal operations from late 2021 to late 2024.

1.2 The Need for Dredge Spoil Disposal

The Port of Kirkcaldy is located in the town of Kirkcaldy on the northern shores of the Firth of Forth. It has been in existence since the 16th century and underwent expansions in the mid-19th century and in the early part of the 20th century. The port has been owned by Forth Ports since 1968 and maintenance dredging has been undertaken by Forth Ports intermittently over the last 50 years, and before then by its previous owners, at least since the construction of the outer harbour in 1906. Between 1992 and 2011 the harbour was closed to commercial cargo vessels prior to the inner harbour and approach being dredged to remove the accumulation of sediment to allow the return of commercial cargo vessels.

The Port of Kirkcaldy currently has approximately 45 vessel movements into and out of the port per annum (2017 to 2020 data) (3). The port is capable of handling grains, cereals, timber, aggregate and other bulk commodities (4) and a key requirement for the port is the need accommodate vessels delivering grain to Carr's Milling Group.

The harbour entrance lies south of Pathhead Sands, a 3 km stretch of sand and shingle beach and north of Kirkcaldy Sands, a 2.5 km stretch of sand. The harbour continues to accrete sediment from the Firth of Forth and to enable vessels to continue to access the harbour Forth Ports requires to undertake maintenance dredging in the harbour and approach channel to maintain a depth of 2.7 m below Chart Datum (CD).

The sediments to be dredged are naturally occurring and have been transported into the port by tidal currents in suspension or through sediment bedload transport. The volume required to be dredged and disposed of each year is variable and depends on annual sedimentation rate which can be influenced by events such as storms.

Should Forth Ports consider the 'Do Nothing' approach, and not undertake the maintenance dredging operations, a navigable depth would not be maintained and the Port of Kirkcaldy would not be able to continue to service current vessels. Given Forth Port's statutory duty as the Harbour Authority to ensure safe navigation, there is an ongoing maintenance dredging requirement and the need for

(1) The term BPEO was derived by the Royal Commission on Environmental Pollution who described it as a procedure which 'establishes, for a given set of objectives, the option that provides the most benefit or least damage to the environment as a whole, at an acceptable cost, in the long term as well as in the short-term'.
(2) Marine (Scotland) Act 2010, Part 4 Marine Licencing. General Guidance for Applicants. Available online http://www.scotland.gov.uk/Resource/0043/00435338.pdf
(3) Forth Ports pers comm April 2021.
(4) McCabe, P (2011) Dawn of a New Era Kirkcaldy Fife Free Press pp 6–7

disposal of the dredged material, therefore the do nothing option is not considered further in this BPEO. In line with Section 13 of Scotland's National Marine Plan (Marine Planning Policy Transport 4), the planned dredging operations will continue to maintain and support the sustainable development of the Port of Kirkcaldy.

1.3 Proposed Dredge Spoil Disposal Operations

Forth Ports plans to continue the previous regime of annually dredging with the dredged material being disposed of at sea at the Kirkcaldy licenced spoil ground. *Figure 1.1* shows the planned dredging areas and the spoil ground at Kirkcaldy.

Forth Ports wishes to apply for a licence from Marine Scotland for the disposal of dredge spoil to a maximum of 15,000 m^3 of dredged material per annum (up to 21,000 wet tonnes based on density of 1.4 (1)). This is required maintain a depth to ensure compliance with safe vessel navigation and berthing and to allow for any fluctuation in sediment deposition or contingencies.

The volume of dredged material deposited at the Kirkcaldy spoil disposal ground from the Port of Kirkcaldy and approach channel from 2017 to 2021 (to date) ranged from 1,050 to 7,158 m^3 per annum (as shown in *Table 1.1*). The dredging volume each year varies with siltation levels and the application volume of up to 15,000 m^3 is to cover years when larger volumes require to be dredged and disposed of.

Table 1.1 Dredge Spoil Disposal at Kirkcaldy Disposal Ground (2017 to 2021)

Year	Quantity (m^3)
2017	1,050
2018	4,400
2019	4,297
2020	7,000
2021- to date	7,158

Data source: Forth Ports May 2021

The boundary co-ordinates of the planned dredge areas at the Port of Kirkcaldy and the approach channel are presented in *Table 1.2*.

Dredging operations are usually undertaken over several short campaigns each year (over 10 to 20 days per year), subject to requirements and plant availability. The works are normally undertaken to coincide with maintenance dredge operations at Leith, Rosyth, Methil and Newhaven, as the same plant is used.

The Kirkcaldy spoil ground (Deposit Area name and code: Kirkcaldy, FO 047) is situated approximately 1.3 nautical miles (nm) southeast of the port and has historically been used by Forth Ports for spoil disposal from Kirkcaldy prior to cessation of dredging in 1990 and after dredging recommenced in 2001. It is not used by Forth Ports for the disposal of dredged material from any other sites.

The co-ordinates of the centre of the Kirkcaldy spoil disposal ground are presented in *Table 1.3.* The water depth within the Kirkcaldy spoil disposal ground ranges from 14 m below CD at the centre of the site and increases to 17 m below CD towards the west of the site.

(1) Conversion factor used by Forth Ports for maintenance dredge sediments from the Port of Kirkcaldy. Forth Ports pers comm February 2021.

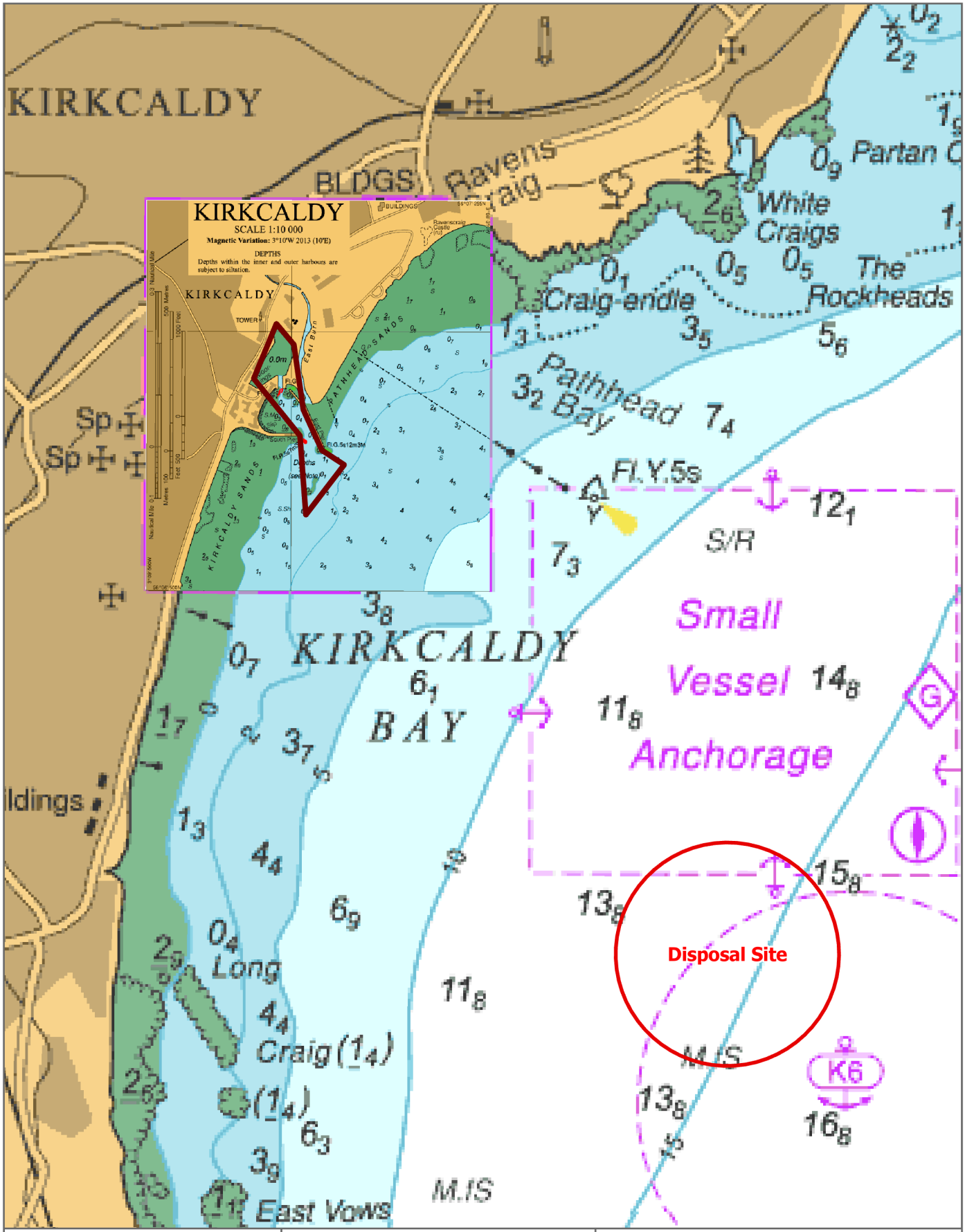

Figure 1.1
Dredge Area and Disposal Site

SCALE: See Scale Bar	VERSION: A01
SIZE: A4	DRAWN: GB
PROJECT: 0447789	CHECKED: CM
DATE: 29/06/2021	APPROVED: MI

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PROJECTION: WGS 1984 UTM Zone 30N

Path: \\UKLDCFS01\Data\Edinburgh\Projects\0447789 Forth Ports PLC Forth Ports BPEO.MI\2021 BPEO\GIS\MAPS\0447789_Sample_Locations_A01.aprx

Table 1.2 Co-ordinates of Planned Dredge Area

Node	Latitude	Longitude
A	56° 06.800' N	003° 08.970' W
F	56° 06.910' N	003° 09.130' W
B	56° 07.016' N	003° 09.052' W
C	56° 06.976' N	003° 08.992' W
D	56° 06.850' N	003° 08.958' W
E	56° 06.772' N	003° 08.894' W
G	56° 06.744' N	003° 08.817' W
H	56° 06.647' N	003° 08.949' W

Coordinates in WGS84, UTM Zone 30N, degrees decimal minutes

Table 1.3 Coordinates of Kirkcaldy Spoil Disposal Ground

Latitude	Longitude
56.105556	-3.130278

NB. The spoil site is circular with a radius of 400 m around this point. Coordinates in WGS84, UTM 30N, decimal degrees

Forth Ports had previously contracted the MV Margrethe Fighter, a 35.4 m long backhoe excavator dredger with a 2 m unloaded draught and a hopper capacity of 235 m^3 . For future dredging, Forth Ports will use similar sized vessels, depending on suitability and availability, for example the *UKD Cherry Sand* (*Figure 1.2*) or others such as the Selkie and Admiral Day.

Figure 1.2 Dredge Vessel - UKD Cherry Sand

1.4 Description of Sediment to be Dredged and Disposed

In line with Marine Scotland guidelines on pre-dredge sampling protocol (1), a survey programme was undertaken on 24 February 2021. Samples were taken at three stations using a van-Veen grab. For each of the samples the following chemical analysis was undertaken.

- Sediment water content and density.
- Total Organic Carbon (TOC).
- Sediment particle distribution (PSD).
- Metals: arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), mercury (Hg), nickel (Ni), lead (Pb), and zinc (Zn).
- Tributyl Tin (TBT).
- Polycyclic Aromatic Hydrocarbons (PAHs): US EPA 16.
- Total Hydrocarbon Content (THC).
- Poly Chlorinated Biphenyls (PCB): ICES 7.
- Presence of asbestos.

The location of the sample stations and the results of the physico-chemical analysis are presented in *Appendix A.*

The sediment to be dredged from the channel and docks comprises slightly gravelly sand and sandy mud. There are concentrations of metals, PAHs and Total Hydrocarbons above Marine Scotland Action Level 1 in some of the samples within the port. No samples has concentrations of metals or PAHs above Action Level 2. Concentrations of TBT and PCBs in the samples were all below Action Level 1. There was no asbestos in any of the samples.

(1) Guidance for the sampling and analysis of sediment and dredged material to be submitted in support of applications for sea disposal of dredged material. Available online http://www.scotland.gov.uk/Resource/0044/00443832.pdf

Samples from the Kirkcaldy spoil ground and other spoil disposal grounds in the Forth Estuary and Firth of Forth have been analysed by Marine Scotland. A summary of the historical sample analysis is also provided in *Appendix A.*

1.5 Scope of the Study

This report provides an appraisal of available disposal options and short-lists those which were considered to be practicable. Options are reviewed according to the Waste Hierarchy, as outlined in the *Waste Management Licensing (Scotland) Regulations, 2011*. The options on the short-list were then reviewed against strategic, environmental and cost considerations. The options were then compared and the BPEO identified.

The remainder of this report is structured as follows.

- Section 2 describes the BPEO assessment method.
- Section 3 provided a preliminary assessment of potential disposal options and short-lists those that are considered to be practical.
- Section 4 compares the short-listed disposal options.
- Section 5 identifies the BPEO.

Further supporting information is provided in the three Appendixes.

- *Appendix A:* Sediment Sample Chemical Analysis Results.
- *Appendix B:* Environmental Impacts of Disposal Operations.
- *Appendix C:* Summary of Consultee Responses.

2. BPEO ASSESSMENT METHOD

2.1 Introduction

The BPEO study was undertaken using the following method.

- Identification of potential disposal options.
- Preliminary appraisal and short-listing of options based on practicability.
- Assessment of the short-listed options based on:
  - strategic considerations;
  - environmental considerations *i.e.* what the environmental impacts would be; and
  - cost, in terms of capital and maintenance/operating costs.
- Comparison of the relative merits and performance of the options and identification of the BPEO.

Informal consultation by emailed letters, outlining the proposals and requesting any comments or relevant information, was undertaken with the following consultees.

- Fife Council.
- Forth District Salmon Fisheries Board (FDSFD).
- Marine Scotland.
- Maritime and Coastguard Agency (MCA).
- NatureScot (NS).
- Northern Lighthouse Board (NLB).
- Scottish Environment Protection Agency (SEPA).
- The Crown Estate.

Responses received by email are included in *Appendix C*. Formal consultations will be undertaken by Marine Scotland following receipt of the Marine Licence application from Fort Ports.

2.2 Identification of Options

The following seven potential treatment/disposal options for the dredged material were identified:

- beach nourishment;
- coastal reclamation and construction fill;
- spreading on agricultural land;
- sacrificial landfill;
- incineration;
- other disposal options and reuse; and
- sea disposal.

2.3 Preliminary Appraisal

A preliminary appraisal of the seven identified options was undertaken, based on the overall practicality of each option (*i.e.* is the option likely to be technically achievable). Following the preliminary appraisal those options that are considered to be practicable were short-listed for further consideration.

2.4 Assessment of Options

The relative performance of the short-listed options were then assessed against the following criteria.

2.4.1 Strategic Considerations

Strategic considerations included the following.

- Operational feasibility - whether the option is technically practicable.
- Availability of sites/facilities - whether there are any sites or facilities which can take the dredge spoil.
- Security of option - whether Forth Ports will have control over all stages of the disposal.
- Established practice - whether technologies and techniques proposed are established and therefore whether the performance and potential difficulties of the technologies and techniques can be anticipated.
- Likely public acceptability - whether the public are likely to object to or support the proposals.
- Likely agency acceptability - whether public agencies are likely to have any major concerns when consulted on the Marine Licence application.
- Legislative implications - assessing compliance with relevant legislation and the potential management control required.

2.4.2 Health, Safety and Environmental Considerations

The factors used to assess the health, safety and environmental performance of the options are summarised below.

- Public health. Assessing whether there would be any risk of a detrimental effect on public health, based on predicted pathways and receptors.
- Safety. Considering potential sources of hazard and probability that there would be any risk to the general public or workers.

Contamination/Pollution. Evaluating whether there is potential for pollution or contamination that could result in failure to meet Water Framework Directive (WFD) [(1)] objectives and associated Environmental Quality Standards (EQSs: the amount or concentration of a substance that should not be exceeded in an environmental system). Contamination is defined as the presence of an unwanted constituent in the natural environment whilst pollution is the introduction of contaminants into the natural environment that causes adverse change.

- Ecological impact. Assessing the significance of any potential impact on important habitats or species, including designed sites.
- Interference with other legitimate users. Considering whether there are likely to be impacts on other activities, such as other users of the Firth of Forth, local ports or roads.
- Amenity/aesthetic. Assessing whether there is likely to be a visual, olfactory or noise impact resulting from the disposal or any impact on local amenity.

2.4.3 Cost Considerations

Cost of disposing of dredged material was considered in terms of the capital costs (site costs, construction and equipment hire /purchase costs) and operational/maintenance costs (transport costs, disposal costs including site operation).

(1) UKTAG 2010 Water Framework Directive An approach to the Revoked Directives - the Freshwater Fish Directive, the Shellfish Directive and the Dangerous Substances Directive Available online from http //www wfduk org/resources%20/approach-revoked-directives-%E2%80%93-freshwater-fish-directive-shellfish-directive-and-dangeroussubstances Directive

2.4.4 Comparison of Options

The performance of each option was evaluated on a scale from Low to High according to definitions presented in *Table 2.1*. Intermediate grades (Low to Medium and Medium to High) are also used where the assessment is marginal between Low, Medium or High. The results of the assessment process are presented in *Section 3* and *Section 4.*

Table 2.1 Definitions of Performance

Consideration	High	Medium	Low
Strategic Considerations			
Operational Feasibility	Practical, easy to operate and achievable as process is robust and established. Low number of stages and each stage easy to control.	Some practical difficulties. Moderate number of stages with some difficulties.	Major practical difficulties. Large number of steps with some major difficulties.
Availability of Sites/Facilities	Suitable site/facility available within 1 km of the port by road and 10 km by sea.	Suitable site/facility available within 10 km of the port by road and 20 km by sea.	No suitable sites/facilities within the vicinity (over 10 km by road and 20 km by sea).
Security of option	In complete operational control of Forth Ports.	Is mainly in control of Forth Ports with some outside involvement for which there are alternative sources of supply.	Has elements that are out of Forth Ports control for which there are no practical alternative sources of supply.
Established Practice	Technology and techniques are clearly established with no foreseeable significant problems.	Technology and techniques have been tested but not applied to dredge material.	Technologies and techniques are untested and unforeseen problems are likely.
General Public Acceptability	Likely to be generally acceptable to the public based on reaction to similar developments.	Unlikely to provoke a strong negative or positive reaction based on reaction to similar developments.	Likely to provoke a strong negative reaction based on reaction to similar operations.
Likely Agency Acceptability	Likely to be generally acceptable to statutory bodies after consultation.	Statutory bodies may have some concerns that may be overcome through further consultation.	Statutory bodies may have major concerns that may not be overcome through consultation.
Legislative Implications	Would easily comply with legislation with a low level of management and physical control.	Requires some control/intervention to achieve compliance.	Requires a high level of management control and intervention to achieve compliance.
Health, Safety and Environmental Considerations			
Safety	No significant risk to workers and the general public.	Low risk to workers and the general public which is easily controlled.	Moderate to high risk to workers and general public.
Public Health	Will not cause workers or public to be exposed to substances potentially hazardous to health.	May cause some low level intermittent exposure to substances potentially hazardous to health.	Risk of exposing workers and general public to substances potentially hazardous to health.
Pollution/Contamination	Compliant with emission standards and water quality objectives. Low risk of harm from substances released to environment.	Environmental quality standards may be approached or breached occasionally. Some risk of harm to environment.	Environmental quality standards may be breached regularly and there is a moderate or high risk of harm to environment.

Consideration	High	Medium	Low
Ecological Impact	Priority species and habitats under the UK Biodiversity Action Plan and qualifying features and species under the *Habitats Regulations, 2019* (1) will not be affected.	Priority species and habitats under the UK Biodiversity Action Plan and qualifying features and species under the *Habitats Regulations, 2019* may be slightly affected.	Priority species and habitats under the UK Biodiversity Action Plan and qualifying features and species under the *Habitats Regulations 2019*, are likely to be significantly affected.
Interference with other Legitimate Activities	Little potential for interference with other activities.	Some potential for interference with other activities.	High potential for interference with other activities.
Amenity/Aesthetic	No significant impact on local amenity or aesthetic qualities.	Potential for impacts of moderate significance on local amenity or aesthetic qualities.	Potential for impacts of high significance on local amenity or aesthetic qualities.
Cost			
Capital and operational	£1m or less.	Between £1m and £2.5m.	More than £2.5m.

(1) The *Conservation (Natural Habitats, &c) (EU Exit) (Scotland) (Amendment) Regulations, 2019* apply to European sites (formerly Special Protection Areas and Special Areas of Conservation).

3. PRELIMINARY ASSESSMENT OF AVAILABLE DISPOSAL OPTIONS

3.1 Introduction

This section describes the identified disposal options and makes a preliminary assessment of each based on overall practicality. There are a number of steps that are common to some of the land-based options and these are described in *Section 3.2* to avoid repetition. The section concludes by identifying those options that are short-listed for further consideration in the BPEO process.

The seven identified disposal options are:

- beach nourishment;
- coastal reclamation;
- spreading on agricultural land;
- sacrificial landfill;
- incineration;
- other disposal options and reuse; and
- disposal at sea.

3.2 Common Steps to Land-Based Disposal Options

The disposal options that have land-based components include:

- beach nourishment (if material transported by road);
- coastal reclamation and construction fill (if material transported by road);
- spreading on agricultural land;
- sacrificial landfill;
- incineration; and
- other disposal options and reuse (such as brick making/concrete aggregate/top soil production).

The steps that are common to the land-based disposal options are:

- landing the dredge material;
- storage of dredge material;
- dewatering the dredge material; and
- loading and transport for disposal.

These steps are described below along with a discussion of disposal and treatment issues.

3.2.1 Landing the Dredged Material

All of the land based options require transport to on-shore facilities. This could be via a pumped discharge, conveyor or grab. As Forth Ports does not have suitable landing facilities at Kirkcaldy, or elsewhere within the Firth of Forth area, a new coastal landing facility would be required to enable the materials to be off-loaded.

3.2.2 Storage of Dredged Material

Once the dredged material has been landed, it will require storage prior to onward transport for final disposal. A storage facility may therefore require to be constructed at the site, capable of retaining the dredged material and associated run-off and dust.

3.2.3 Dewatering the Dredged Material

The land disposal options require dewatering of the dredged material either to make transport more feasible or to create a material which is suitable for disposal to land or incineration *i.e.* disposal of a more solid sludge. Based on previous experience from dredging at this location the hopper contents are likely to average 20% solids (by volume) and range from 30% to 15% solids *i.e.*, solids to liquid ratio will decrease as dredging operations progress and only isolated pockets of sediments remain resulting in an increased uptake of water (1).

There are three approaches that are typically used for drying marine sediments: construction of settling lagoons, use of a mobile centrifuge unit and/or a filter press, as described below.

Settling Lagoons

Settling lagoons are likely to be large, ring-dammed structures into which the dredged material would be offloaded. These could be built within the intertidal area or on land. The material would be piled up in the lagoon and the water drained out under gravity. The lagoons would have a drainage system to collect the water and watery sludge from the dredged material for further treatment (usually by hydrocyclone, see below) or to be transported offsite for disposal. The lagoons must be of sufficient size to contain the dredged material prior to transport. They must also be accessible by road and must have facilities to load the dredged material into tankers or sealed heavy goods vehicles (HGVs) for movement to the disposal/treatment centre. To minimise the distance the wet dredge material has to be transported from the dredger they must be located near the quayside.

The majority of the intertidal area falls within the Firth of Forth Site of Special Scientific Interest (SSSI) and Outer Firth of Forth and St Andrews Bay Complex Special Protection Area (SPA). The SPA is a large estuarine/marine site consisting of the two adjacent Firths of Forth and Tay. NS has previously expressed the view on similar BPEO assessments that further loss of intertidal habitats is not considered a realistic option.

Setting up settling lagoons would require assessment to ensure that any leachate from them would not contaminate groundwater and a licence would be required from SEPA under the *Water Environment (Controlled Activities) Regulations, 2011*. Forth Ports advise that the potential to be able to find appropriate space to create settling lagoons close to the port is considered to be very low.

As some samples of the material analysed contains metals, PAHs and THC above Marine Scotland Action Level 1 (see *Appendix A*) it might be additionally necessary to construct the lagoons with special liners to retain the contaminants and consider treatment of the supernatant water draining out of the lagoons.

Centrifuge or Hydrocyclone System

The use of a centrifuge or hydrocyclone system to dewater the material to a level suitable for disposal to landfill (approximately 10% water content) may be required, depending on the final water content of the recovered material. One mobile unit system was reported as being capable of treating up to 150 $m^3\ hr^{-1}$ depending on unit size and material solids content. Other systems may be available that can process material at different rates. If material can be dried at a rate of 150 $m^3\ hr^{-1}$, to dewater a total volume of approximately 15,000 m^3 would require approximately 100 hours (over 4 days assuming working 24 hours a day, seven days a week, or approximately 13 standard working days). Other units with lower throughputs could take longer (2).

Filter Press

A filter press is a tool used to separate solids and liquids using the principle of pressure. The press is filled with the dredge spoil, building up pressure before the spoil is strained through filter cloths by force. The remaining dried spoil can then be removed from the filter press and taken away for disposal. Processing rates would be similar to that of a centrifuge.

(1) Forth Ports Ltd pers comm.
(2) Maximum throughput of 120 m^3hr^{-1} http://www.euroby.com/services/mobilecontract-dewatering-units/

3.2.4 Loading and Transport for Disposal

A loading facility would be required adjacent to the storage or dewatering area to load the material into covered HGVs for transport to disposal/treatment sites. The required infrastructure would include hard standing to allow a fleet of HGVs to be loaded by mechanical excavators. Although some areas of hard standing is available at the Port of Kirkcaldy, they are used for cargo operations there are no other sites at Kirkcaldy that could be used for storage or dewatering.

Assuming the dredged material can be dried to a water content of 10% (by volume) at or adjacent to the Port of Kirkcaldy, the estimated up to 14,025 m^3 (1) per annum of dried materials would require transportation for disposal, either to an incinerator, to agricultural land, to landfill or to a reclamation project. The length of journey required would depend on the location of the deposit/incineration sites.

A volume of 14,025 m^3 of dried (to 10% water content) material equates to approximately 19,635 tonnes (2). Assuming 20 tonne capacity HGVs/tankers are used, this would equate to 982 return trips or 1,964 vehicle movements per annum.

The access road to Kirkcaldy Harbour exits onto the trunk road network (A921) where the average daily HGV count is recorded as 309 (2019 data (3)). Assuming an up to an additional 20 HGV vehicle movements per day over 100 days this would equate to an approximate 6.5% increase in HGV movements per day on the trunk road network. This increase may be acceptable at the collection end. However, there is more likely to be an issue with regard to increase in traffic flows on rural roads if they are used to reach disposal/treatment sites.

3.2.5 Disposal/Treatment Issues

Neither method of the drying process (*e.g.* lagoons or centrifuge) is likely to reduce the concentration of metals, PAHs, THC and salt present within the dredged material. This will restrict disposal and reuse options and as the material has elevated levels of some contaminants, pre-treatment may be required prior to disposal on land.

Where an option involves disposal on land there is an issue of classification of the dredged material. Once the material has been removed from the docks for disposal on land it will be classed as waste. The waste then requires disposal at a licensed waste management facility and to be transported by a registered waste carrier. In the waste hierarchy set out in the *Waste Management Licensing (Scotland) Regulations, 2011*, dredged spoil is coded as 17 05 05 (Mirror Hazardous) or 17 05 06 (Mirror Non-hazardous), depending on the concentrations of particular contaminants. If landfill is identified as the disposal route for this waste then further analysis may be required to ensure that the material meets the Waste Acceptance Criteria for hazardous landfill.

The saline nature of the sediment also restricts its application on land, as without going through a washing process it will not be able to support any form of terrestrial flora growth.

3.3 Beach Nourishment

3.3.1 Process Description

Beach nourishment involves the disposal of the dredged material on a beach directly from the dredging vessel or, if dewatering was required, the spoil would be brought ashore and dewatered prior to transport or placement on the beach using earth moving plant.

3.3.2 Suitable Sites for Beach Nourishment

Beach nourishment requires materials of a similar composition to the existing beach materials and usually involves clean sand or gravel. Although there is a relatively high percentage of sand in some parts of the dredged areas at Kirkcaldy (approach channel), the average mud content is 45.2% (range

(1) 15,000 m^3 total spoil at 85% solids content equals 12,750 m^3 plus 1,275 m^3 (10% water content) equals 14,025 m^3.
(2) Based on a density of 1.4 tonnes per m^3 of dredge spoil (Forth Ports pers comm April 2021).
(3) UK Traffic Data, A921 Kirkcaldy 2019 traffic data Available at https //roadtraffic dft gov uk/local-authorities/32

0.8 to 83%). The mud content and associated contaminants such as metals, PAHs and THC makes this option unattractive.

Due to the risk of direct exposure to contaminated sediment, spoil containing contaminants disposed of at the public recreational sites such as beaches is considered less suitable than if it were disposed of at sea. Action Levels provided by Marine Scotland are specific to the disposal of material to sea where the sediment does not come into direct contact with the public, rather than at recreational areas. Guidance published by NS (then SNH) (1) on managing coastal erosion in beach/dune systems makes reference to use of materials that *are not contaminated in any way* but does not provide equivalent action levels for contaminants. NS has also confirmed during a previous consultations that it would only be appropriate to use material on a beach of similar substrate provided contaminant levels were not of concern.

No sites requiring beach nourishment with this grade of material have been identified. Given the conservation status of the Firth of Forth, the lack of available beaches for nourishment, the contamination of the spoil and its particle size composition, beach nourishment is not considered to be a practicable option.

3.4 Coastal Reclamation and Construction Fill

3.4.1 Process Description

This section considers the use of the dredged material in coastal reclamation projects or as fill material inland. Depending on the potential site, reclamation or fill could involve landing, storage, dewatering, transport and possibly desalination. Coastal use directly from the dredging vessel would be preferable as this would involve pumping or spraying the material directly from the dredger or barge to the site where it was needed and would avoid handling and transporting the material on land.

3.4.2 Suitable Sites for Reclamation

Forth Ports, Marine Scotland and the coastal local authorities are the most likely bodies to be responsible for or aware of reclamation projects in the Firth of Forth. No sites for coastal reclamation have been identified through the consultation process as requiring any of the dredged material. In addition, the dredged material from the docks would not be suitable for many reclamation sites due to the low compressive strength properties of muddy sediments. The spoil could be pumped into bunded lagoons at the edge of the Firth of Forth to create land that could be used for development, agricultural or similar purposes. This is unlikely to be acceptable to NS or other stakeholders due to the potential impact on designated areas in the Firth of Forth.

3.4.3 Construction Material

Use as fill in inland construction projects would not be appropriate because of low compressive strength properties of muddy sediments and the need for landing, drying and transport of the dredged material. If landing, drying and transporting the dredged material were feasible then it may be that the material could be used for quarry/landfill capping. However, the presence of metals, PAHs and THC in the dredged material and its high salt content make this option unattractive.

3.5 Spreading on Agricultural Land

3.5.1 Process Description

SEPA has previously confirmed that the disposal or recycling of marine dredged material on agricultural land does not fall within the exemptions under Paragraph 7 of Schedule 1 of the *Waste Management Licensing (Scotland) Regulations, 2011*, and the activity would therefore require to be licensed. Planning permission may also be required from the local authority. In support of the

(1) Scottish Natural Heritage (2000). A Guide to Managing Coastal Erosion in Beach/dune Systems. Summary 7: Beach Nourishment.

application to dispose of the dredged material to agricultural land, evidence that the material would not cause pollution of the environment or harm to human health would need to be provided.

The disposal of marine spoil to agricultural land would involve landing, dewatering, storage, desalination and transport for disposal. Dewatering the dredged material in lagoons, centrifugal drier or filter press would remove some of the salt; however it is likely that the desalination would still be required. Desalination could be achieved by placing the spoil in lagoons, layering it with sharp sand, spraying water over the material and allowing leaching of the salt back into the Firth of Forth.

The material sampled at the Port of Kirkcaldy has contamination from some metals, PAHs and THC above Action Level 1. The data from the 2021 samples shows that the mean metal concentrations were similar to previous samples and generally within the range the range of previously collected data from Kirkcaldy and from other ports within the Forth Estuary and the Firth of Forth (*Table* 3.1) (1).

Table 3.1 Metals in Sediment at Kirkcaldy and other Firth of Forth and Forth Estuary Ports

Metal Concentration (expressed as mg kg^{-1} on air dried sediment)								
	As	**Cd**	**Cr**	**Cu**	**Hg**	**Ni**	**Pb**	**Zn**
Kirkcaldy 2021								
Mean	12.63	0.33	34.73	55.07	0.19	32.63	46.43	113.57
Range	9.9-14.8	0.12-0.5	25.8-45.4	28.4-76.9	0.05-0.3	28.7-36.6	15.3-89.1	65.7-158
Kirkcaldy 2014-2021								
Mean	13.20	0.27	82.87	54.80	0.19	43.07	35.67	105.80
Range	7.2-22.0	0.08-0.5	27.3-210	16.5-84.0	0.02-6.2	27.5-76	8.4-89.1	50.4-182
Methil 2003-2020								
Mean	11.27	0.38	32.70	40.94	0.20	23.32	33.62	142.38
Range	2.8-17.3	BDL-0.7	10.1-72.8	11.2-90.1	0.1-0.3	7.1-39.5	7.5-76.3	26.2-347
Leith 1990-2020								
Mean	13.1	1.1	61.4	71.1	1.2	39.8	134.5	261.3
Range	4.6-21.6	0.0-3.9	14.1-84.3	12.8-144	0.2-4.4	13.0-59.3	29.0-787	62.6-687
Rosyth 2000-2020								
Mean	17.04	0.23	74.3	38.8	0.95	34.0	70.0	150.1
Range	12.4-21.9	BDL-4.5	46.3-106	22.5-189.9	0.4-2.6	24.6-43.4	43.1-137.5	88.4-1,730
Grangemouth 1988-2019								
Mean	14.5	0.1	73.3	49.6	1.1	32.2	69.9	147.3
Range	0.0-43.6	0.0-1.2	10.7-211	3.0-353	0.0-3.8	7.6-80.6	9.3-209	28.9-743

Key: As = Arsenic, Cd = Cadmium, Cr = Chromium, Cu = Copper, Hg = Mercury, Ni = Nickel, Pb = Lead, Zn = Zinc.
Blue shading indicates concentrations above Marine Scotland Action Level 1. BDL: Below Detection Levels.

Approximately 200,000 tonnes of sludge are recycled to agricultural land per annum across Scotland (2). Forth Ports is seeking to dispose of approximately 14,025 m^3 of dewatered material (19,635 tonnes at 1.4 tonnes m^{-3}) of dried material equating to approximately 9.82% of the current volume of annually recycled sludge in Scotland. As the material from Kirkcaldy has a low organic carbon content (an average of approximately 5.75% from the sediment sample analysis) spreading dredged material from the Port of Kirkcaldy on agricultural land is not considered a practicable option.

(1) Data for Grangemouth, Rosyth, Methil and Leith provided by Marine Scotland, Aberdeen and NLS, Leeds.
(2) https://www.gov.scot/publica ions/review-storage-spreading-sewage-sludge-land-scotland-sludge-review-final/

3.6 Sacrificial Landfill

3.6.1 Process Description

The type of landfill site which can take the spoil is dependent upon the classification of the waste. As discussed in Section 3.2.5 above it is understood that the waste would likely be classified as hazardous or non-hazardous rather than inert and therefore a suitably licensed landfill site with sufficient capacity is required.

3.6.2 Available Landfill Sites

Subsequent to implementation of the *Landfill Allowance Scheme (Scotland) Regulations 2005* and re-evaluation of landfill licences, there are currently three sites within an hour's drive from Kirkcaldy that may be able to accept some of the dredged material. These are set out in *Table 3.2* alongside the capacity of the sites and the tonnage accepted in 2018 (1). The Avondale site is a hazardous waste site but would only consider taking dredged material upon closure of one or all of the phases within the plant.

Table 3.2 Operational Landfills within One Hour Drive of Kirkcaldy Harbour

Site	Operator and type	Capacity at end 2018 (tonnes)	Tonnage accepted in 2018	Due to close
Lochhead Landfill. Approx. 20 km from Kirkcaldy	Fife Council, Non-Hazardous	316,350	126,120	1/12/2022
Lower Melville Wood Landfill. Approx. 20 km from Kirkcaldy	Fife Council, Non-Hazardous	616,350	113,842	1/12/2020*
Avondale Landfill, Polmont. Approx. 50 km from Kirkcaldy.	Avondale Environmental Ltd, Falkirk, Hazardous	80,000	27,293	1/1/2023

*This site was due to close at the end of 2020, however, it currently appears still to be open

3.6.3 Taxes and Royalties

The material will be exempt from landfill tax under the terms of the *Landfill Tax (Scotland) Act 2014* issued by the Scottish Government that specifies that dredged material from any inland waters, including harbours and their approaches, are not subject to landfill tax. As the Crown Estate Scotland owns part of the seabed in the Firth of Forth, royalties may be due to be paid by Forth Ports or the receiving party. The requirement and value of Royalties would require to be subject of discussions between Forth Ports and the Crown Estate Scotland and are not known at this point.

3.7 Incineration

3.7.1 Process Description

Incineration would involve landing the dredged material, dewatering, possibly storing it and transporting it to either an existing incinerator or a newly constructed incinerator. The ash would then require disposal. Options for disposal of ash include landfill, reclamation and spreading on agricultural land.

The organic content of the dredged material is assumed to be approximately 5.75% (based on the 2021 samples which had an average percentage of organic carbon of 5.75% and range of 0.7 to 9.92%) and therefore there is only a small combustible component within the material. It is anticipated that incineration would result in a reduction in volume of the dried spoil only 15.75% *i.e.,* 5.75% organics plus 10% water content. Incinerator operators generally require material to have an organic

(1)Available online from https //www sepa org uk/data-visualisation/waste-sites-and-capacity-tool/

content above 20% to ensure efficient combustion and would most likely reject material with an organic content below this threshold (1).

A further consideration is that the material to be dredged contains some metals, PAHs and THCs above Action Level 1. Following incineration the leaching potential of metals would be reduced, however, the ash would still be contaminated. Pre-treatment is likely to be required for the removal of metals. Emissions to atmosphere from the incineration processes would also require to be controlled by SEPA under the *Environmental Protection Act 1990.*

3.7.2 Available Incinerator Sites

There are no appropriate waste incinerators in Scotland that could accept the dredged material. The nearest incinerator is at Ellesmere Port, Merseyside (approximately 450 km/280 miles south) and transport would be costly and is unlikely to be practicable.

3.8 Other Disposal Options and Reuse

The other disposal options are re-injection into the tidal flats via a pipeline and reuse in brick making, concrete aggregate or top soil production processes.

3.8.1 Re-injection

Re-injection would require the construction of a pipeline to take the dredged material to a high tide point on Pathhead Sands or Kirkcaldy Sands and injecting it at velocity into the beach. The advantage of this is that it effectively keeps the sediment within the sediment cell, however, this option is more suited to fine sediments such as muds into mudflats. For Kirkcaldy, the reinjection dredged material onto beaches would not be practical given the nature of the dredged sediment and the sediments at the receiving site. In addition to the high costs associated with the construction and operation of the pipeline, re-injection would be likely to have an adverse impact on the protected intertidal habitat through disturbance and erosion and may affect the ornithological interest of the area.

3.8.2 Brick Making/Concrete Aggregate/Topsoil Production

There are processes by which marine sediments can be made into bricks or can be used to form concrete aggregate. The advantage is that the materials can be beneficially used and metals are sealed into the bricks or aggregate, although there are issues with the salt content for brick making and concrete construction material. Almost no agricultural species can grow in salty soils and very few in brackish soils. The salinity of the dredged sediment would require to be reduced naturally by rainwater or by a dewatering process before consideration for use as topsoil or construction materials (see Section 3.2.3). The best topsoil is a mixture of sand, silt, clay and organic matter and must be clean for use in the production of food crops (2).

3.9 Disposal to Sea

3.9.1 Process Description

Disposal at sea involves the dredge material being transported to a licensed marine spoil ground in a dredging vessel. Disposal to sea is the normal practice for disposal of dredged spoil from Kirkcaldy and from other ports and harbours in the Forth Estuary and Firth of Forth. This approach takes place at sea and does not require the landing of any materials. It involves the dredger sailing to a licenced spoil ground and releasing the materials through bottom doors or by lowering the excavator head into the water.

(1) Baldovie Waste to Energy Plant, pers comm, January 2017
(2) Permanent International Association of Navigation Congresses. Permanent Technical Committee II. Working Group 19. 1992. Beneficial Uses of Dredged Material, Issue 19.

There are seven licenced marine spoil grounds in the Forth Estuary and Firth of Forth; Bo'ness, Oxcars, Blae Rock, Kirkcaldy, Methil and two sites designated at Narrow Deep. For the dredging operations at Kirkcaldy, Forth Ports would propose to use the Kirkcaldy spoil ground located 1.3 nm from the Port of Kirkcaldy. This site has historically been used for the disposal of dredged material from Kirkcaldy and is the closest site to the Port of Kirkcaldy, thus minimising the distance for vessel transport. The time required for one cycle (dredging - travelling - discharging - travelling) is approximately 1 hour depending on weather and tidal conditions.

A global positioning system (GPS) would be used to position the vessel in the disposal area and records of the spoil discharge locations would be retained.

The baseline environmental conditions and potential environmental impacts at the spoil ground are described in *Appendix B*.

3.10 Conclusion

The description of the available options allows options that are evidently impracticable to be ruled out, for example due to the nature of the dredged material. This is summarised in *Table 3.3.* The assessment of the short-listed options taken forward for further consideration is presented in *Section 4.*

Table 3.3 Short-listing of Options

Option	Assessment	Result
Beach Nourishment	This option does not appear to be practicable. The material is not suited to beach nourishment in the Forth Estuary or the Firth of Forth; in addition there are no beaches within the Forth Estuary or the Firth of Forth, identified by Forth Ports, consultees or in the NCCA (2017) (1) report that require nourishment with this grade of material.	Discard
Coastal Reclamation and Construction Fill	This option may be practical. The salt content, poor load bearing properties and the potential concentration of contaminants limits the available options for reuse of the dredged material.	Short-list
Spreading on Agricultural Land	This option does not appear to be practicable. The material is not desirable for disposal on agricultural land due to potentially containing concentrations of contaminants and having a low organic content (c.5.75%). Furthermore, desalination, storage, dewatering and transport of this material are impractical. Disposal on agricultural land would require a Waste Management Licence and evidence that there would be no harm to human health.	Discard
Sacrificial Landfill	This option may be practicable. There are a large number of steps involved in storage, dewatering and transport. Landfill site operators may be unwilling to accept the material due to the sediment composition and volumes.	Short-list
Incineration	This option does not appear to be practicable. The material is not suited to incineration due to low organic content (c. 5.75%) and volume of spoil involved. If incinerated, volume would only slightly reduce and there are no available incinerators in Scotland that could take this amount of material.	Discard
Other Uses	This option may be practicable in the form of brick making, concrete aggregate and top soil production.	Short-list
Disposal at Sea	This option is practicable and has been the BPEO for previous dredging campaigns at the Port of Kirkcaldy.	Short-list

(1) Fitton JM, Rennie AF and Hansom JD (2017) Dynamic Coast - National Coastal Change Assessment Cell 2- Fife Ness to Cairnbulg Point CRW1014/2

4. ASSESSMENT OF SHORT-LISTED DISPOSAL OPTIONS

4.1 INTRODUCTION

This section presents an assessment of each option against the assessment definitions of performance listed in *Table 2.1*. A classification of likely performance is provided for each of the criteria and the assessment is then summarised in *Section 5*.

4.2 COASTAL RECLAMATION AND CONSTRUCTION FILL

4.2.1 Strategic Considerations

Operational Feasibility

The reuse of the dredged material for reclamation will involve either direct pumping from the dredger into the disposal site or landing and drying the material and desalination prior to transporting the material for disposal on land. This option would be feasible if disposal sites were available adjacent to the Firth of Forth.

Classification: Low to Medium

Availability of Sites

No coastal sites within the Firth of Forth requiring this grade of material for reclamation or construction fill have been identified by Forth Ports, consultees or in the latest Dynamic Coast – National Coastal Change Assessment (2017) [(1)].

Classification: Low

Security of Option

No sites have been identified as belonging to Forth Ports, so disposal to reclamation sites is outwith their control and could present practical problems, such as scheduling in sediment delivery with proposed dredging programme.

Classification: Low

Established Practice

The use of suitable dredged materials, such as marine aggregates, in coastal reclamation and construction fill is common practice and the technologies and techniques to move such material are well established. However, the use of dredge spoil for such activities is not common.

Classification: Low to Medium

General Public Acceptability

Use of the materials for reclamation is likely to be viewed as an acceptable option by the general public. Depending on the method of transporting the dredged material to the site requiring it will affect acceptability by the general public. Transport by sea is likely to be viewed as more favourable than transport by road, which may be viewed as unacceptable by local residents and road users.

Classification: Medium

(1) Fitton, J.M., Rennie, A.F., and Hansom, J.D. (2017) Dynamic Coast - National Coastal Change Assessment: Cell 2 - Fife Ness to Cairnbulg Point, CRW2014/2

Likely Agency Acceptability

Use of the dredged material for reclamation or construction fill is likely to be acceptable to public agencies. There may be some concerns regarding the contamination levels in the dredge spoil and the volume of material to be transported by HGVs for reasons relating to air quality and proximity to residential areas.

Classification: Medium to High

Legislative Implications

The disposal of dredged material from the Port of Kirkcaldy directly from the dredger to a reclamation site requires a Marine Licence from Marine Scotland under *Section 20(1) of the Marine (Scotland) Act, 2010*.

Once the material has been removed from the Port of Kirkcaldy for disposal on land it will be classed as waste under the *Waste Management Licensing (Scotland) Regulations, 2011* and the disposal will therefore require a waste management licence and an exemption for reclamation works. As well as a Marine Licence for the construction works, consent will be required from the planning authority and a levy paid to the Crown Estate Scotland.

Classification: Medium to High

4.2.2 Health, Safety and Environmental Considerations

Public Health

Slight risks to public health are anticipated due to intermittent increase in HGV traffic.

Classification: Medium to High

Safety

Pumping the dredged material ashore has risks associated with operational activities, all of which have mitigation measures in place. Should the dredged material be transported by HGV, there may be an increase in safety risks associated with the movement of materials for disposal, particularly if tankers/sealed HGVs travel through populated areas and along minor roads.

Classification: Medium to High

Pollution / Contamination

The material may be classified as hazardous or non-hazardous (*i.e*. not inert) due to the concentration of contaminants with respect to land based disposal, however, further analysis would be required to confirm this and run-off and leaching would need to be controlled. There may be localised and temporary deterioration in air quality as a result of HGV movements.

Classification: Medium

Ecological Impact

There are unlikely to be any ecological risks resulting from the use of dredged materials for reclamation, assuming any contaminants are contained within the site and there would be no significant impact on national or local priority species or habitats. If the site was to be used for terrestrial habitat creation then the salt levels would limit plant growth.

Classification: Medium to High

Interference with Other Legitimate Activities

The disposal of dredged material is unlikely to interfere with other activities unless the reclamation site is in the port area, in which case the dredger may interfere with other port users, or if the area to be reclaimed was used for recreation. If HGVs are used to transport the dredged material, they may affect other road users.

Classification: Medium to High

Amenity/Aesthetic

If the dredged material is disposed of directly from the dredger there are low risks to amenities/aesthetics. If disposed of by HGV, landing, storage and transport may result in an impact to both amenities and aesthetics of the area.

Classification: Medium to High

4.2.3 Cost Considerations

If the dredged material was pumped directly ashore there would be no further capital costs. If the dredged material was landed, treated and then transported by road, the estimated costs below would apply:

- discharge berth: £3.5 m;
- pumping material to site – approximately £8.75 per m^3 (1) for 14,025 m^3: £122,718 or
- dockside centrifuge facility capable of dewatering and desalinating up to 14,025 m^3 per annum: £20 m; and
- loading and transport (sealed HGVs) – assuming the disposal site is less than one hour drive away and based on one HGV transporting 20 tonnes material at a cost of £100/hour(2): £98,175.

Total £3.72 to £23.6 m

Classification: Low

4.3 Sacrificial Landfill

4.3.1 Strategic Considerations

Operational Feasibility

Disposal to landfill would require the landing, storage and drying of the dredged materials prior to transporting to a landfill facility. Approximately 19,635 tonnes of material would require transport. This option has practical difficulties relating to drying the dredged material and transport of material to a landfill site.

Classification: Low to Medium

Availability of Sites / Facilities

The nearest non-hazardous landfill sites are two located in Fife, both approximately 20 kilometres from Kirkcaldy. The nearest hazardous waste site is at Polmont, approximately 50 kilometres from Kirkcaldy, however as discussed above, due to the dredged sediment composition and volume, these sites would be unlikely to receive any of the material. In addition, the timing of receipt of material would need to fit in with its operational requirements when closing existing landfill cells (3).

(1) Based on previous consultation with contractors.
(2) Estimated cost based on consultation with HGV operator at £50/hour and estimated cost of loading at £50/hour.
(3) Avondale pers comm, February 2016.

Under the *Landfill (Scotland) Regulations, 2003* the presence of contaminants will classify the material as *non-hazardous* rather than *inert* and consequently reduces the number of available landfill sites capable of accepting this material.

Classification: Low

Security of Option

Whilst Forth Ports have control over the dredging operations, it would have no control over the continued availability of landfill space for the material or the disposal route.

Classification: Low

Established Practice

Dredged material is sometimes disposed of to landfill for small one-off dredging operations, however it is not established practice to routinely dispose of large quantities of dredged material in this way. Landfill sites require the dredged material to be dried to 10% water content before acceptance. It is unlikely that this is a practice that would be acceptable if there are other viable alternatives.

Classification: Low to Medium

General Public Acceptability

Disposal of the material to landfill is likely to be acceptable to the general public. However, the transport of the dredged material from Kirkcaldy to potential landfill sites may be unacceptable to residents and other road users.

Classification: Medium

Likely Agency Acceptability

Scotland's Zero Waste Plan (2010) establishes the direction of the Scottish Executive's policies for sustainable waste management. One such policy is to reduce landfilling of waste to 5% of all wastes by 2025 and as such there may be objection to dredged material routinely requiring space in landfill.

Disposal to nearby landfill sites is likely to be acceptable to SEPA provided the materials are regarded as suitable for landfill, however, the acceptability would depend on the quantities to be disposed of and further assessment and classification of hazardous substances.

Classification: Medium

Legislative Implications

The material would be controlled waste material for the purposes of transport, storage and disposal. As such, Section 34(7) of *The Environmental Protection Act 1990* and Regulation 6 of the *Pollution Prevention and Control (Scotland) Regulations, 2012* would apply and compliance is likely to be possible. The disposal of the material will also require a waste management licence under *Waste Management Licensing (Scotland) Regulations, 2011*.

Classification: Medium to High

4.3.2 Health, Safety and Environmental Consideration

Public Health

Slight risks to public health are anticipated due to the intermittent increase in HGV traffic.

Classification: Medium to High

Safety

There may be an increase in safety risks associated with the movement of materials for disposal, particularly if there are 1,964 tankers/sealed HGVs movements through populated areas and along minor roads each year.

Classification: Medium to High

Pollution/Contamination

There may be a small risk of leaching of contaminants that should be contained on site.

Classification: Medium to High

Ecological Impacts

Although there is a small risk of contaminants leaching out from the dredged material, this would be at very low concentrations and is unlikely to cause significant harm to the local ecology. The salt content in the material may prevent plant growth unless covered in a top soil.

Classification: Medium to High.

Interference with Other Legitimate Activities

The increase in HGV movements may interfere with other road users. Baseline traffic data for the A921 in the vicinity of the port entrance indicates that approximately 2.74% of all road traffic are HGVs (1). As a result of the proposed disposal to landfill, the proportion of HGVs would increase by approximately 1.74% (2) averaged over a year with the daily increase during operations being approximately 6.5%, based on 20 HGV movements per working day. In addition, depending on the landing and storage arrangements there may be potential for interference with other dock users.

Classification: Medium

Amenity/Aesthetic

The movement of HGVs through the area will have an impact on local amenity through noise, vibration, visual impacts and road congestion. This risk also applies to the disposal site.

Classification: Medium

4.3.3 Cost Considerations

Capital would be required to purchase new equipment. Estimates of the cost of this equipment are:

- discharge berth: £3.5 m;
- lagoons to settle dredged material: £2.5 m; or
- dockside centrifuge facility capable of dewatering and desalinating 14,025 m^3: £20 m; and
- loading and transport (sealed HGVs) – assuming the disposal site is less than one hour drive away and based on one HGV transporting 20 tonnes material at a cost of £100/hour(3): £98,175.

Total £6.98 m to £24.5 m

Classification: Low

(1) UK Traffic Data, A921 Kirkcaldy 2019 traffic data Available at https //roadtraffic dft gov uk/local-authorities/32
(2) 2019 data present 112,785 HGVs per annum on the A921 at Kirkcaldy which would increase to 114,749 HGV movements
(3) Estimated cost based on consultation with HGV operator at £50/hour and estimated cost of loading at £50/hour

4.4 OTHER DISPOSAL OPTIONS AND REUSE

4.4.1 Strategic Considerations

Operational Feasibility

Reuse for brick making, concrete aggregate or top soil production would require the landing, storage and drying of the dredged materials prior to transporting to a landfill facility. Approximately 19,635 tonnes of dried material would require transport.

There are practical difficulties relating to handling the dredged material at the Port of Kirkcaldy. The availability of suitable factories/facilities to process the dredged material and markets for the final products are also considerations. Previous consultations between Forth Ports and a brick making factory confirmed that the mineralogy of the material would not be appropriate for brick making and the contamination by salt would be unacceptable for any construction material.

Classification: Low to Medium

Availability of Sites/Facilities

There are no known sites or facilities to receive the dredged material for other uses such as top soil production, brick making or other construction materials.

Classification: Low

Security of Option

Although Forth Ports would have control over the dredging and landing, they would not have control over the continued acceptance of the materials for making bricks or aggregate.

Classification: Low to Medium

Established Practice

Use of excavated materials for brick making or concrete aggregate is common practice but use of marine dredged spoil is not and it is generally not feasible due to the level of salinity and the composition of the material. Whilst top soil has been made from dredged material in the past it is not common practice.

Classification: Low to Medium

General Public Acceptability

Making bricks, concrete or top soil is likely to be publicly acceptable depending on the end use. However, the transport of the material over a large distance may not be acceptable to residents and other road users.

Classification: Medium to High

Likely Agency Acceptability

It is likely that brick making, concrete production and top soil production would be acceptable to agencies and considered a positive activity. However, the contaminant levels in the samples would make using the material for top soil unattractive.

Classification: Medium to High

Legislative Implications

SEPA would control emissions from brick making factories under the provisions of the *Environmental Protection Act 1990*. A waste management licence would also be required for their transport and storage under the *Waste Management Licensing (Scotland) Regulations, 2011*.

Classification: Medium

4.4.2 Health, Safety and Environmental Considerations

Public Health

Slight risks to public health are anticipated due to the intermittent increase in HGV traffic.

Classification: Medium to High

Safety

There are unlikely to be any significant safety risks associated with making bricks, concrete or top soil with the exception that there may be an increase in safety risks associated use of plant and manual handling of materials as well as the movement of materials, particularly if HGVs travel through settlements and along minor roads.

Classification: Medium

Pollution / Contamination

The contaminant levels in the dredged material would make using the material for top soil unattractive. Pollution from plant emissions is not likely to be an issue provided emissions are controlled in accordance with licences.

Classification: Medium to High

Ecological Impact

Making bricks or concrete should have no adverse ecological effects, provided the materials were decontaminated and desalinated before use.

Classification: High

Interference with Other Legitimate Activities

There is a slight risk that movement of the material would impact other road users.

Classification: Medium to High

Amenity/Aesthetic

The only impacts on amenity are likely to stem from the impact of HGVs from transporting the material (up to 1,964 HGV movements per annum).

Classification: Medium to High

4.4.3 Cost Considerations

An estimate of costs is provided below.

Capital would be required to purchase new equipment. Estimates of the cost of this equipment are:

- a discharge berth for the dredger with a storage facility: £3.5 m;
- lagoons to settle dredged material and possibly desalinate: £2.5 m; or
- dockside centrifuge facility capable of dewatering and desalinating 14,025 m^3 per annum: £20 m; and
- loading and transport (sealed HGVs) – assuming the disposal site is less than one hour drive away and based on one HGV transporting 20 tonnes material at a cost of £100/hour(1): £98,175.

Total - £6.98 m to £24.5 m

Classification: Low

(1) Estimated cost based on consultation with HGV operator at £50/hour and estimated cost of loading at £50/hour.

4.5 SEA DISPOSAL

4.5.1 Strategic Considerations

Operational Feasibility

Operationally disposal at the Kirkcaldy disposal site is comparatively simple as it does not require the landing, storage and drying of the spoil and all the necessary procedures are understood. As this is the present discharge route for the ongoing maintenance dredge operations at the Port of Kirkcaldy, it has been proven as practicable and all the necessary procedures are understood and logistical arrangements in place.

Classification: High

Availability of Sites / Facilities

The sites/facilities which are required for the sea disposal option are those which are already used. No other disposal sites have been indicated by Forth Ports as available at this time for the dredged material from the Port of Kirkcaldy.

Classification: High

Security of Option

Forth Ports will have full control over all stages in the dredging and disposal process assuming they receive a disposal licence.

Classification: Medium to High

Established Practice

Disposal at the Kirkcaldy licenced spoil ground is the current practice for the disposal of the dredged spoil from the Port of Kirkcaldy is, therefore, established and proven as effective.

Classification: High

General Public Acceptability

Forth Ports has confirmed that similar disposal operations from other ports and harbours in the Firth of Forth and Forth Estuary have not attracted any appreciable public comment. Dredging operations are unlikely to affect members of the general public, with the possible exception of some recreational users in the Firth of Forth when the vessel is transiting to and from the disposal site.

Classification: High

Likely Agency Acceptability

Consultations with the regulatory bodies for previous Marine Licences indicate that there is no objection to sea disposal at Kirkcaldy. The Forth District Salmon Fishery Board (FDSFB) has previously highlighted concerns surrounding time of year of disposal coinciding with seaward migration of salmon smolts and requested that disposal in the Firth of Forth is avoided during June and July. Due to the operational requirements at Kirkcaldy to maintain the navigation channel at all times of the year and the small magnitude of potential effects of disposal operations to migrating salmonids, Forth Ports does not consider that this request is justified. This issue is addressed in *Appendix B*.

Classification: Medium to High

Legislative Implications

A Marine Licence will be required from Marine Scotland and provided that the BPEO is satisfactory, and the statutory consultees do not object, it is established practice that a Marine Licence will be issued. Compliance should not therefore demand significant management control. Permission will be

required from the Crown Estate Scotland for disposal of spoil to the Crown Estate Scotland owned sea bed.

Classification: Medium to High

4.5.2 Health, Safety and Environmental Considerations

Safety

The operations are undertaken at sea, therefore members of the public are not likely to be exposed to risk from the disposal activities. Forth Ports will have oversight of the dredging contractor's operations.

Classification: Medium to High

Public Health

The risk of members of the general public being exposed to contamination from the dredged material deposited at the Kirkcaldy spoil ground is considered to be low. Commercial species of demersal fish are not taken from the disposal area so no direct food chain links between the disposal site, fish and human consumers leading to impacts on public health are considered likely.

Classification: Medium to High

Pollution/Contamination

The effects on water quality of the disposal operations and the potential for impacts on sediment contamination may cause the occasional exceedance of Environmental Quality Standards, although based on current evidence this would be localised and short-term. The identification and assessment of environmental impacts of dredged material are presented in *Appendix B* and follow the guidance provided in Best (2106) (1).

Classification: Medium

Ecological Impacts

The disposal operations may affect the benthic fauna in proximity to the disposal site due to sediment drifting from the disposal area itself. It is anticipated that there will not be any significant impact on the Forth marine ecosystem as a whole given the scale and duration of effects of continued disposal at this site which has been ongoing for at least 50 years. There may be some localised and short-term effects such as displacement on migrating fish due to increased suspended sediments caused by the discharge of dredged material into the water column but these impacts are not predicted to prevent migration, cause mortalities or affect the viability of fish populations. Under the proposed disposal proposals, cumulative impacts with other operations are not predicted to create a significant impact to the Firth of Forth SSSI, SPAs or SACs farther afield or marine ecosystems.

The ecological impacts of disposal of dredged material to sea is addressed in *Appendix B.*

Classification: Medium to High.

Interference with Other Legitimate Activities

The transport and disposal activities may cause some disruption to other users of the Firth of Forth, however as the operations will only be occurring for a limited period of time and are controlled directly by Forth Ports it is not anticipated that there will be any significant interference. In addition, historic operations at Kirkcaldy have not resulted in any reported disruption to other Firth of Forth users.

Classification: High

(1) Best, M (2016) Clearing the Waters for All WFD guidance for developers and regulators in estuarine and coastal waters Environment Agency

Amenity/Aesthetic

The disposal activities may cause some short-term disruption to other users of the Firth of Forth but the proposals will contribute to the normal functioning of the Port of Kirkcaldy.

Classification: Medium to High

4.5.3 Cost Considerations

There would be no capital required to purchase new equipment. Operational costs for the operation of the dredger are approximately £55,000 to 200,000, depending on dredging volume requirements.

Classification: High

5. SUMMARY OF THE BPEO

5.1 INTRODUCTION

This section summarises the assessment of options against the criteria described in *Chapter 2*: *Table 2.1* and identifies the BPEO.

5.2 COMPARISON OF OPTIONS

Seven options were initially considered for the disposal of the dredged spoil from the Port of Kirkcaldy. These were reduced to a short-list of four options, based on operational and technical feasibility. A summary of the key considerations with regard to each of the four short-listed options is provided below and illustrated in *Table 5.1.*

5.2.1 Coastal Reclamation and Construction Fill

Operationally, coastal reclamation and construction fill would be possible. The process would be expensive and would involve a number of contractors to undertake the transition from vessel to bunded lagoons and drying and fixing of the material in the lagoons. The sediment is primarily sandy mud with low compressive strength properties, making it unsuitable for most types of construction. In the approach channel the material is slightly gravelly sand. In addition, the presence of some metals, PAHs and THC restricts its suitability for application on land.

Currently there are no significant areas of coastal reclamation planned in the Firth of Forth or Forth Estuary. If the dredged material (where owned by the Crown Estate Scotland) is beneficially used for fill or construction purposes this will attract a royalty rate per cubic metre. The specific royalty rates for material beneficially used are dependent on the quality and specific end use, and this is set during commercial negotiations between the developer and the Crown Estate Scotland.

5.2.2 Sacrificial Landfill

Operationally, disposal to landfill will be possible. The dredged materials would require landing and drying in specially constructed facilities and would then require transport in sealed HGVs to an appropriate landfill site. There are limited sites available to take the material, and a full analysis of the contaminants in the material would be required by the operators before final acceptance.

Whilst small amounts of dredged material are sometimes disposed of to landfill, it is not common practice and Forth Ports would not have the security of controlling the disposal route. The public and agencies are likely to find this disposal acceptable, but there may be concerns relating to transport and Scotland's Zero Waste Plan (2010) which favours a reduction in the volume of material disposed by landfill (to 5% of all wastes by 2025).

The requirement for transport will result in some safety and public health risks and interference with legitimate activities and there is low risk of ecological disturbance. There would be an increase in traffic volume due to HGV movements. The costs of this option would be high due to the requirement for construction of a landing and storage facility, a drying facility and transport costs.

5.2.3 Other Disposal Options and Reuse

Operationally the option to supply the dredged material for other purposes such as brick making would be possible but there would be difficulties associated with the requirement to land, store, dry and transport the material leading to high capital and operational costs. Forth Ports would have limited control over the option and it is not common practice to use marine dredged material for these purposes. It is likely to be viewed as an attractive option by the public and agencies and no legislative issues are anticipated. Environmental and public health and safety concerns associated with this option are linked to transport of the materials, and are anticipated to be minimal. There will be no significant impact on amenity and little interference with other legitimate users other than road users.

The mineralogical composition and salinity of the material limit its suitability for use for brick making, as concrete aggregate or in top soil production as it would require treatment to desalinate and decontaminate the material.

5.2.4 Sea Disposal

Operationally few problems are anticipated with disposal at Kirkcaldy and this site is has been historically used for disposal of dredged materials from the Port of Kirkcaldy. It is anticipated that this option will be generally acceptable to both public and agencies, based on previous applications. The FDSFD has previously sought a seasonal restriction to disposal operations in the Firth of Forth and Forth Estuary during June and July. The assessment presented in Appendix B concludes that there will be no significant impacts on fish and fish passage based on the levels of suspended sediment generated during disposal operations and the intermittent, localised and temporary nature of the effects of dredge spoil disposal, and therefore no seasonal restrictions are justified. Forth Ports would have full control over the dredging process through the appointment of contractors and risks to safety and public health are anticipated to be low.

There will be some intermittent, short-term and localised effects on water quality during disposal, such as raised turbidity and suspended sediment levels, which may, in turn, have short-term and localised ecological effects but these are considered to be not significant given the scale and frequency of these impacts. There is unlikely to be interference with other legitimate activities and there is not anticipated to be any impact on local amenity.

5.3 IDENTIFICATION OF THE BPEO

The assessment of options highlights the major operational difficulties associated with the landfill and other use options that primarily relate to lack of available sites and facilities and the nature of the material. There are also major costs associated with the need to construct landing, storage and drying facilities at the Port of Kirkcaldy, or elsewhere in the vicinity of Kirkcaldy.

The proposed disposal of dredged material at sea supports the objectives set out in Scotland's National Marine Plan and will support the planned dredging operations to safeguard the access to the Port of Kirkcaldy and its navigational safety.

Disposal at sea will keep the dredged material within the ecosystem, maintaining the sediment budget for the area. In line with guidance from Marine Scotland, the Best Practicable Environmental Option is identified as the disposal at a licensed marine spoil ground. The preferred site for this is the existing Kirkcady licenced spoil ground.

Table 5.1 Summary of Assessment of Options

	Coastal Reclamation and Construction Fill	Sacrificial Landfill	Other Uses	Sea Disposal
Operational feasibility				
Availability of sites/facilities				
Security of option				
Established practice				
General public acceptability				
Likely Agency acceptability				
Legislative implications				
Public health				
Safety				
Pollution/contamination				
Ecological impact				
Interference with other users				
Amenity/aesthetic				
Cost considerations				

Key: Performance of Options	
Low	
Low to Medium	
Medium	
Medium to High	
High	

APPENDIX A SEDIMENT SAMPLE CHEMICAL ANALYSIS

A1 PORT OF KIRKCADY SEDIMENT SAMPLE DATA

A1.1 Introduction

Samples of the seabed sediments to be dredged were collected from the Port of Kirkcaldy by Forth Ports on 24 February 2021 and were analysed by SOCOTEC. The survey plan followed the Marine Scotland guidance and was submitted to Marine Scotland for review and approved on 21 December 2020. Based on the maximum dredge volumes and dredging depths applied for, grab samples from three stations were required. Sample station locations are presented in *Table A1.1* and shown in *Figure A1.1*.

Table A1.1 Positions of the Kirkcaldy 2021 Sample Stations

Sample Station	Latitude	Longitude
K1-2021	56° 06.759’	003° 08.912’
K2-2021	56° 06.843’	003° 08.979’
K3-2021	56° 06.951’	003° 09.015’

Coordinates in WGS84, UTM Zone 30N, degrees decimal minutes

The grab samples retrieved from each survey station were subsampled on deck and stored in pre-cleaned sample containers provided by SOCOTEC. Each sample was labelled with a unique sample ID and a field log was kept to record the sample location, date and time sample was taken. Samples were kept chilled and sent by overnight courier in coolboxes to the analytical laboratory.

For each of the samples the following chemical analysis was undertaken.

- Metals (As, Cd, Cr, Cu, Hg, Ni, PB, Zn).
- TBT.
- PAHs (EPA 16).
- Total Hydrocarbon Content.
- PCBs (ICES 7).
- Sediment moisture content and sediment particle density.
- Total Organic Carbon (TOC).
- Sediment particle distribution (PSD).
- Presence of asbestos.

Marine Scotland Action Levels are discussed in Section A1.2 and the sediment sample data are presented in Section A1.3 to Section A1.8.

Figure A1.1
Surface Sediment Sample Stations

SCALE: See Scale Bar	VERSION: A01
SIZE: A4	DRAWN: GB
PROJECT: 0447789	CHECKED: MI
DATE: 29/03/2021	APPROVED: MI

ERM

Forth Ports Ltd

PROJECTION: WGS 1984 UTM Zone 30N

Path: \\UKLDCFS01\Data\Edinburgh\Projects\0447789 Forth Ports PLC Forth Ports BPEO.MI\2021 BPEO\GIS\MAPS\0447789_Sample_Locations_A01.aprx

A1.2 Marine Scotland Action Levels

Table A1.2 and *Table A1.3* set out the Action Levels for metals, PCBs, TBT, PAHs and THC used by Marine Scotland to assess the suitability for disposal of sediments at sea.

Based on the Marine Scotland guidance contaminant levels in dredged material below Action Level 1 are generally of low concern and are unlikely to influence the licensing decision. Exceeding Action Level 1 does not automatically preclude disposal at sea but usually requires further consideration before a decision can be made. Dredged material with contaminant levels above Action Level 2 is generally considered unsuitable for normal sea disposal, but may be suitable for other management options, such as treatment or seabed burial/capping, unless a compelling case can be made for normal sea disposal.

Table A1.2 Marine Scotland Action Levels: Metals

Metal	AL1 (mg kg^{-1} dry weight)	AL2 (mg kg^{-1} dry weight)
Arsenic (As)	20	70
Cadmium (Cd)	0.4	4
Chromium (Cr)	50	370
Copper (Cu)	30	300
Mercury (Hg)	0.25	1.5
Nickel (Ni)	30	150
Lead (Pb)	50	400
Zinc (Zn)	130	600

Table A1.3 Marine Scotland Action Levels: PCBs, TBT PAHs and THC

Determinand	AL1 (mg kg^{-1} dry weight)	AL2 (mg kg^{-1} dry weight)
ICES 7 PCBs	0.02	0.18
TBT	0.10	0.50
PAHs		
Acenaphthene	0.10	
Acenaphthylene	0.10	
Anthracene	0.10	
Benz[a]anthracene	0.10	
Benzo[a]pyrene	0.10	
Benzofluoranthenes	0.10	
Benzoperylene	0.10	
Chrysene/Triphenylene	0.10	
Dibenz[a,h]anthracene	0.01	
Fluoranthene	0.10	
Fluorene	0.10	
Indenopyrene	0.10	
Naphthalene	0.10	
Phenanthrene	0.10	
Pyrene	0.10	
Total Hydrocarbons	100	

A1.3 Metal Results

Concentrations of metals from the three samples, along with the average and range of concentrations are presented in *Table A1.4*. Levels above Marine Scotland Action Level 1 are highlighted in blue. No concentrations above Action Level 2 were recorded (see *Table A1.1* for Action Levels for metals).

Table A1.4 Analysis of Metal Contaminants from the Port of Kirkcaldy in 2021 (mg kg^{-1} Dry Weight)

Station	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
K1-2021	9.9	0.12	25.8	28.4	0.05	28.7	15.3	65.7
K2-2021	13.2	0.38	33	59.9	0.21	32.6	34.9	117
K3-2021	14.8	0.5	45.4	76.9	0.30	36.6	89.1	158
Mean	12.63	0.33	34.73	55.07	0.19	32.63	46.43	113.57
Range	9.9-14.8	0.12-0.5	25.8-45.4	28.4-76.9	0.05-0.30	28.7-36.6	15.3-89.1	65.7-158

As = Arsenic, Cd = Cadmium, Cr = Chromium, Cu = Copper, Hg = Mercury, Ni = Nickel, Pb = Lead and Zn = Zinc.

Table A1.5 provides a comparison of metal data from samples analysed from 2014 to 2021. The concentrations of metals over the period for which there is available sample data are variable however, in the majority of cases most metal concentrations are below Action Level 1. The exceptions are copper and nickel where mean concentrations have been above Action Level 1 in all the three survey years. The 2021 samples had higher levels of Cd and Pb but lower levels of the other metals,

Table A1.5 Metal Concentrations from Kirkcaldy 2014 to 2021 (mg kg^{-1} Dry Weight)

Year		As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
2014	Mean	16.17	0.27	166.67	74.33	0.26	62.67	33.67	99.33
	Range	8.50-22.0	0.20-0.30	110.0-210.0	61.0-84.0	0.05-0.39	45.0-76.0	11.0-59.0	56.0-150.0
2018	Mean	10.8	0.2	47.2	35.0	0.13	33.9	26.9	104.5
	Range	7.2-13.7	0.08-0.45	27.3-67	16.5-52.7	0.02-6.22	27.5-41.6	8.4-50.8	50.4-182
2021	Mean	12.63	0.33	34.73	55.07	0.19	32.63	46.43	113.57
	Range	9.9-14.8	0.12-0.5	25.8-45.4	28.4-76.9	0.05-0.3	28.7-36.6	15.3-89.1	65.7-158
2014-2021	Mean	13.20	0.27	82.87	54.80	0.19	43.07	35.67	105.80
	Range	7.2-22.0	0.08-0.5	27.3-210	16.5-84.0	0.02-6.2	27.5-76	8.4-89.1	50.4-182

BDL: Below Detection Levels. N/A: Not Applicable. ND = Not Detected as reported by Marine Scotland laboratory. *Detection limit not known, mean taken from concentrations recorded

A1.4 Tributyltin

Tributyltin (TBT) is a highly toxic compound historically used as an anti-biofouling agent in paint used to coat the hulls of vessels. It is also toxic to non-target organisms and is linked to immune-suppression and imposex (1) in snails and bivalves. TBT was also used in various industrial processes as a biocide and can enter the marine environmental through effluent discharges. In some cases, TBT can also be persistent in the marine environment.

(1) The development of male characteristics in females

Mean dry weight concentrations of TBT from the samples collected are presented in *Table A1.6.* No samples were observed to have TBT concentrations above Marine Scotland Action Level 1 (0.1 mg kg^{-1}).

Table A1.6 Analysis of TBT from the Port of Kirkcaldy in 2021 (mg kg^{-1} Dry Weight)

Station	TBT Concentration
K1-2021	<0.005
K2-2021	0.0095
K3-2021	<0.005
Mean	**<0.0063**
Range	**<0.005-0.0095**

Note: DBT was analysed for along with TBT. The DBT results are not reported here as there is no Action Level for DBT but have been provided in the Marine Scotland Pre-Disposal Sampling Results Form.

A comparison of TBT concentrations from samples collected between 2014 and 2021 (1) are presented in *Table A1.7*, which shows that TBT concentrations are below Action Level 1 in all years.

Table A1.7 TBT from the Port of Kirkcadly in 2014-2021 (mg kg^{-1} Dry Weight)

Year		TBT Concentration
2014	Mean	<0.01
	Range	<0.01
2018	Mean	<0.007
	Range	0.001-0.019
2021		0.0063
		<0.005-0.0095
2014-2021	**Mean**	**<0.0078**
	Range	**0.001-0.019**

ND= no data (i.e. from a single sample). BDL=below detection level

A1.5 Polychlorinated Biphenyls Results

Polychlorinated biphenyls (PCBs) are organic compounds comprising a biphenyl group (composed of two benzene rings) with between one and ten bonded chlorine atoms. PCBs are highly toxic, persistent pollutants and are readily bioaccumulated in animals.

Although production in the UK ceased in the 1970s, PCBs still enter the marine ecosystem through the disposal of industrial plant, emissions from old electrical equipment and from landfill sites (2).

Dry weight concentrations of ICES 7 PCBs from samples collected in 2021 are presented in *Table A1.8*. All samples were below Action Level 1. *Table A1.9* presents a comparison of mean dry weight concentrations of ICES 7 PCBs from samples collected between 2014 and 2021.

(1) TBT analysis in 2003 was from a single sample
(2) Forth Replacement Crossing: Environmental Statement 2009. Available online from http://www.transportscotland.gov.uk/strategy-and-research/publications-and-consultations/j11223-081.htm

Table A1.8 Analysis of PCBs from the Port of Kirkcaldy in 2021 (mg kg^{-1} Dry Weight)

Station	Sum of ICES 7 PCB Concentrations
K1-2021	0.00056
K2-2021	0.0111
K3-2021	0.00939
Mean	**0.00702**
Range	**0.00056-0.0111**

ICES 7 PCB congeners (with IUPAC numbers): 28 - 2,4,4' - Trichlorobiphenyl, 52 - 2,2',5,5' - Tetrachlorobiphenyl, 101 - 2, 2', 4, 5, 5' - Pentachlorobiphenyl, 118 - 2, 3', 4, 4', 5 - Pentachlorobiphenyl, 138 - 2, 2', 3, 4, 4', 5' - Hexachlorobiphenyl, 153 - 2, 2', 4, 4', 5, 5' - Hexachlorobiphenyl, 180 - 2, 2', 3, 4, 4', 5, 5' - Heptachlorobiphenyl.

Table A1.9 Analysis of PCBs from the Port of Kirkcaldy 2014–2021 (mg kg^{-1} Dry Weight)

Year		Mean Sum of ICES 7 PCB Concentrations (rounded to four decimal places
2014	Mean	<0.0005
	Range	<0.0005
2018	Mean	0.0056
	Range	<0.0007-0.0131
2021	Mean	0.0070
	Range	0.00056-0.0111
2014-2021	**Mean**	**0.0044**
	Range	**<0.0005-0.0131**

ICES 7 PCB congeners (with IUPAC numbers): 28 - 2,4,4' - Trichlorobiphenyl, 52 - 2,2',5,5' - Tetrachlorobiphenyl, 101 - 2, 2', 4, 5, 5' - Pentachlorobiphenyl, 118 - 2, 3', 4, 4', 5 - Pentachlorobiphenyl, 138 - 2, 2', 3, 4, 4', 5' - Hexachlorobiphenyl, 153 - 2, 2', 4, 4', 5, 5' - Hexachlorobiphenyl, 180 - 2, 2', 3, 4, 4', 5, 5' - Heptachlorobiphenyl.

A1.6 Polycyclic Aromatic Hydrocarbons

Levels of the US EPA 16 PAHs are presented in *Table A1.10*. The US EPA 16 PAHs are generally considered to be of environmental concern because of their potential toxicity in humans and other organisms and their prevalence and persistence in the environment.

Levels above Marine Scotland Action Level 1 for individual PAHs are highlighted in blue. There are no Marine Scotland Action Level 2 standards for PAHs. The only sample with concentrations of PAH above Action Level 1 was K3-2021 from the inner harbour with the highest mud content (83%).

A comparison of mean dry weight concentrations of PAHs from samples collected in 2018 and 2021 are presented in *Table A1.11* that shows that the mean PAH concentrations of the majority of individual PAHs were higher in 2018 compared to 2021 with the means in 2021 being mostly below Action Level 1. There was no comparable data from previous surveys.

In addition, the total hydrocarbon (THC) concentrations were also analysed for and these are presented in *Table A1.10*. Marine Scotland Action Level 1 for total hydrocarbons is 100 mg kg^{-1}. (0.01%). There are no Marine Scotland Action Level 2 concentrations for THCs. The dry weight concertation of THCs in the 2021 samples ranged between 0.00178 to 0.0628% which have corresponding wet weights of 0.0013 to 0.025%

These wet weight concentrations are below the toxic (1%) and harmful (0.1%) classifications for ecotoxicology based on the UK country agency guidance (1). It is noted that the guidance is related to Total Petroleum Hydrocarbons (TPH) and not Total Hydrocarbons (THC). THC were not analysed for in the previous surveys.

Table A1.10 Analysis of PAHs and THC from the Port of Kirkcaldy 2021

PAH	Sample Station			
	K1-2021	K2-2021	K3-2021	Mean
LMW (µg kg^{-1} Dry Weight)				
Acenaphthene	3.17	<1	8.31	4.2
Acenaphthylene	14.3	<1	13.8	9.7
Anthracene	11.4	2.35	37.6	17.1
Fluorene	5.84	1.27	13.7	6.9
Naphthalene	9.6	4.11	43.7	19.1
Phenanthrene	22.1	4.91	85.4	37.5
HMW (µg kg^{-1} Dry Weight)				
Benzo(a)anthracene	23.5	2.31	68.1	31.3
Benzo(a)pyrene	34.1	5.18	150	63.1
Benzo(b)fluoranthene	33.2	6.05	130	56.4
Benzo(k)fluoranthene	25.0	6.49	106	45.8
Benzo(ghi)perylene	29.3	5.07	137	57.1
Chrysene	29.6	2.49	127	53.0
Dibenzo(ah)anthracene	5.69	<1	24.0	10.2
Fluoranthene	39.4	6.15	147	64.2
Indeno(1,2,3-c,d)pyrene	25.9	4.71	134	54.9
Pyrene	45.1	7.91	148	67.0
Sum US EPA 16 PAHs	57.2	59.0	1,373.6	596.6
Total Hydrocarbons THC (mg kg^{-1} Dry Weight)	18.8	628	536	393.93

LMW = Low Molecular Weight. HML = High Molecular Weight. Action Level 1 for Total PAH is 100 mg kg^{-1}

(1) NRW, SEPA, NIA, EA. 2015. Guidance on the Classification and Assessment of Waste. Technical guidance WM3. LIT 10121.

Table A1.11 Comparison of Mean PAHs from the Port of Kirkcaldy 2018 and 2021

Year	2018	2021
PAH	Mean (N=3)	Mean (N=3)
LMW (µg kg^{-1} Dry Weight)		
Acenaphthene	72.6	4.2
Acenaphthylene	15.8	9.7
Anthracene	136.4	17.1
Fluorene	123.4	6.9
Naphthalene	512.9	19.1
Phenanthrene	490.6	37.5
HMW (µg kg^{-1} Dry Weight)		
Benzo(a)anthracene	190.7	31.3
Benzo(a)pyrene	163.9	63.1
Benzo(b)fluoranthene	167.4	56.4
Benzo(k)fluoranthene	76.8	45.8
Benzo(ghi)perylene	244.2	57.1
Chrysene	146.4	53.0
Dibenzo(ah)anthracene	32.3	10.2
Fluoranthene	339.9	64.2
Indeno(1,2,3-c,d)pyrene	112.8	54.9
Pyrene	343.7	67.0

LMW = Low Molecular Weight. HML = High Molecular Weight. There was no THC sample analysis in 2018.

A1.7 Asbestos

No asbestos was reported from any of the samples.

A1.8 Sediment Physical Properties

The physical properties of the dredge sediment was analysed on the 3 sediment samples taken from the Port of Kirkcaldy in 2021. Sediments comprised slightly gravelly sand (station K1-2021) and sandy mud (stations K2-2021 and K3-2021)

- Gravel is defined as >2 mm,
- Sand is defined as >63 µm<2 mm, and
- Mud (silts and clays) is defined as <63 µm.

Table A1.12 and Figure A1.3 present the 2021 data. Sediment contamination is typically higher in sediments less than 63 µm diameter *e.g.* silts and clays due to the increased surface area providing more adhesion sites for contaminants than the same volume of sand or gravel.

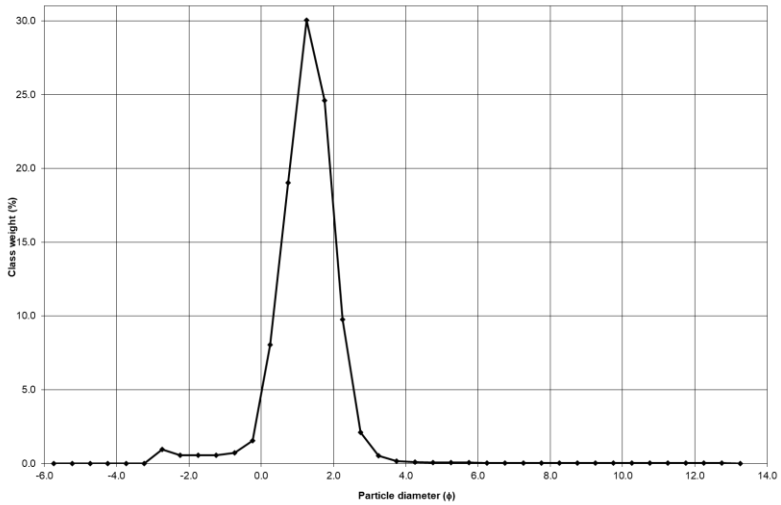
Table A1.12 Port of Kirkcaldy 2021 Sediment Data Summary

Parameter	Sample Station		
	K1-2021	**K2-2021**	**K3-2021**
Textural Group Classification	Slightly Gravelly Sand	Sandy Mud	Sandy Mud
Folk and Ward Description	Medium Sand	Very Coarse Silt	Coarse Silt
Folk and Ward Sorting	Moderately Sorted	Very Poorly Sorted	Very Poorly Sorted
Mean µm	413.31	50.7	17.73
Mean phi	1.275	4.303	5.818
Sorting Coefficient	0.709	2.454	2.212
Skewness	-0.061	0.154	0.105
Kurtosis	1.048	1.094	1.114
Gravel (%)	2.7%	0.0%	0.0%
Sand (%)	96.6%	48.2%	17.0%
Mud (silts and clays) (%)	0.8%	51.8%	83.0%
Total Organic Carbon (%)	0.7	9.92	6.64
Solids (%) @120^{o}C	74.5	63.9	46.8
Density (mg m^{-3})	2.50	2.19	2.42

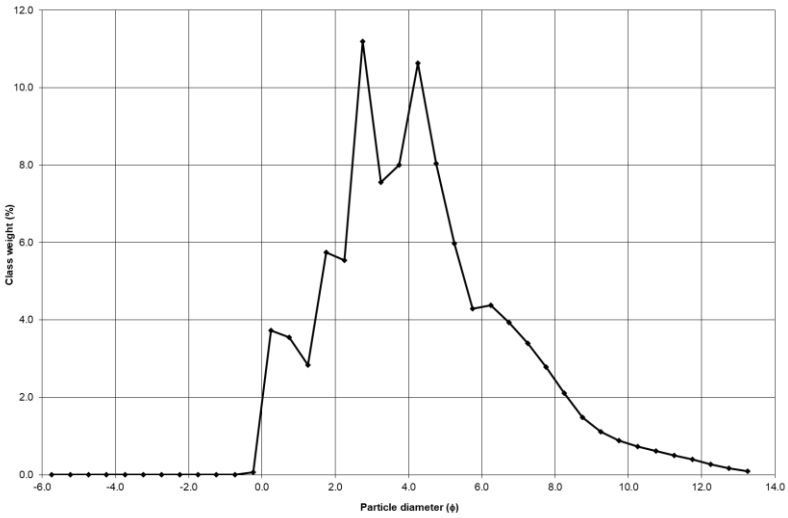
Phi: $-\log_2$ of sediment particle diameter in mm

Figure A1.1 Port of Kirkcaldy 2021 Sediment PSA

Station K1-2021



Station K2-2021



Station K3-2021

Figure A1.3 Port of Kirkcaldy 2021 Sample Photographs

		
K1-2021	**K2-2021**	**K3-2021**

A2 SPOIL GROUND SEDIMENT SAMPLE DATA

Table A1.14 presents metal and PCB concentration data from sediment sampled from spoil ground sites within the Firth of Forth and Forth Estuary. Levels above Marine Scotland Action Level 1 for metals and PCBs are highlighted in blue. Monitoring of spoil grounds is not mandatory therefore, the data presented in *Table A1.13* are the most recent data available.

Concentrations of metals and PCBs in the samples from the Kirkcaldy site are generally lower than in the samples form the material to be dredged from Kirkcaldy (refer to *Table A1.4 and Table A1.7*), which would be expected from a dispersive spoil ground such as Kirkcaldy.

Table A1.13 Concentration of Metals and PCBs from Forth Spoil Grounds (mg kg^{-1} Dry Weight)

Site Name/Date	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn	Sum ICES 7 PCBs
Kirkcaldy 2011	6.24	0.1	21.9	16.2	0.14	16.4	21.7	45.9	-
N=3									
Kirkcaldy 2015	8.9	0.1	43.1	17.0	0.2	22.0	30.6	62.9	0.0025 (n=3)
(n=3)									
Methil 1993	8.2	0.2	9.8	10.7	0.1	19.2	10.5	51.0	
(n=1)									
Methil 2011	6.9	0.07	13.7	7.14	0.07	8.97	20.2	39.8	0.0004 (n=3)
(n=3)									
Methil 2015	8.7	0.1	18.0	9.6	BDL	11.2	14.5	72.8	0.003 (n=1)
(n=1)									
Narrow Deep 2011	9.5	0.2	42.9	21.6	0.49	22.9	53.4	109.4	0.008 (n=3)
(n=6)									
Narrow Deep 2015	11.7	0.2	63.8	24.6	0.6	30.0	58.4	105.9	0.03 (n=3)
(n=4)									
Oxcars 2011	11.2	0.1	42.5	22.2	0.6	22.3	153.5	92.2	0.007 (2007, n=6)
(n=6)									
Oxcars 2015	15.7	0.3	79.6	41.6	1.0	35.8	78.1	141.7	0.008
(n=3)									
Blae Rock 2007	13.4	BDL	59.7	32.4	0.8	28.2	63.9	108.6	0.008 (n=5)
n=3)									
Blae Rock 2011	17.2	0.1	39.6	21.9	0.5	21.4	52.1	80.3	0.01 (n=2)
(n=6)									
Bo'ness 2011	14.5	0.1	50.8	23.3	0.8	23.6	56.9	95.7	0.005 (n=3)
(n=7)									
Bo'ness 2015	18.6	0.1	59.6	26.5	0.7	27.5	54.2	114.0	0.004 (n=3)
(n=5)									

* Data provided by Marine Scotland (2019)

Key: n = the number of samples analysed (where known)

APPENDIX B ENVIRONMENTAL IMPACTS OF DISPOSAL OPERATIONS

B1 INTRODUCTION

This Appendix addresses the environmental impacts of the disposal of dredged material from the planned maintenance dredging work at the Port of Kirkcaldy at the Kirkcaldy licenced spoil ground within the Firth of Forth. Impacts on water quality, sediment quality, and habitats and species are considered. *Table B2.1* presents the impact summary.

Typically, dredging and disposal takes place over a period of approximately ten to twenty days per annum with the scheduling of the dredging and disposal operations depending on operational requirements, weather and tides. The cycle time from dredging to disposal and back to the dredging site is approximately 1 hour. Potential impacts on general vessel movements and fishing due to the disposal operations are not considered to be significant as commercial traffic in the main channel is controlled by Forth Ports' standard operating procedures.

As the Marine Licence application is for disposal of the dredged material, impacts of the dredging activities are not addressed, other than in the context of Bathing Waters and cumulative impacts from existing and proposed dredging and disposal activities, and other activities and developments.

B2 DISPOSAL IMPACTS

The identification and assessment of environmental impacts of the disposal of dredged material in this Appendix follows the Clearing the Waters for All guidance (1).

As described in *Section 1.4*, it is proposed that up to 15,000 m^3 (approximately 19,635 wet tonnes) of material from the Port of Kirkcaldy is disposed of at the Kirkcaldy spoil ground per annum. The material consists primarily of sandy silt with gravelly sand in the approach channel. The concentrations of contaminants are presented in *Appendix A*. Samples were taken at 3 stations (K01-2021 to K03-2021) and the results are summarised here.

- The concentrations of metals, except for arsenic and chromium were above Action Level 1 in at least one sample, but all below Action Level 2. The average metal concentrations were above Action Level 1 for copper and nickel.
- The concentration of TBT and ICES 7 PCBs in each sample was below Action Level 1.
- The EPA 16 PAHs were below Action Level 1 for stations K1-2021 and K2-2021 and above Action Level 1 for Station K3-2021 in the inner harbour. The mean concentrations of all but one PAH were below Action Level 1.
- The THC concentrations were above Action Level 1 for stations K2-2021 and K3-2021.
- No asbestos was recorded.

Available metal and PCB concentration data from sediments sampled in the Kirkcaldy spoil ground are presented in *Appendix A*. This shows the concentration of mercury in the sediment was above Action Level 1 but below Action Level 2 in 2011. Concentrations of metals are generally similar or lower than those from samples at other spoil disposal sites within the Firth of Forth and Forth Estuary.

B2.1 Impacts on Water and Sediment Quality

Coastal water quality in the Firth of Forth is currently Good in the outer Firth, with the exception of the area around Portobello and Musselburgh, which is classified as Poor. It is classified as Good in the lower estuary to Muirhouses and Moderate upstream in the estuary to Kincardine bridge (2).

The salinity in the Firth of Forth averages 33‰, decreasing into the Forth Estuary under the influence of freshwater inputs. Suspended solids levels in the inner Firth of Forth are usually low compared to

(1)Best, M (2016). Clearing the Waters for All: WFD guidance for developers and regulators in estuarine and coastal waters. Environment Agency.
(2)Water Framework Directive (WFD) Waterbody Classification 2007-2017 (SEPA) https://marinescotland.atkinsgeospatial.com/nmpi/default.aspx?layers=1110. Consulted 8 February 2020.

levels in the upper estuary (1). In the Firth of Forth, dissolved oxygen concentrations show little variation with depth and are approximately 90-95%, but may be lower during periods of high summer water temperatures (2).

The material disposed at the Kirkcaldy spoil ground will fall to the sea bed by gravity and consists of cohesive lumps of dredged material. Fine sediment will be liberated as it sloughs off the descending material and when the clumps reach the seabed. Field measurements of suspended solids in surface waters following similar disposal operations indicate that less than 5% of the discharged material escapes the descending density jet (3).

There are no data available that indicate the concentration or dispersion of suspended solids from the disposal operations at Kirkcaldy. Data available from Middle Bank in the Firth of Forth during dredging operations in 2008 (4) recorded the baseline mean suspended solids concentrations between 8.87 mg l^{-1} and 10.3 mg l^{-1} (mean 9.1 mg l^{-1}). Comparison of these mean baseline suspended solids concentrations with those recorded during dredging activities at Middle Bank indicated peak increases were approximately two and half times above background levels (1). These increases were short-lived and dissipated with the outgoing tide. Significant increases in suspended sediments associated with the disposal operations are therefore likely to be confined to the immediate area of the spoil ground and for a short period.

Similar studies were undertaken for the Forth Replacement Crossing which showed that increases in suspended sediment concentrations from dredging works were short-lived and localised (5).

The levels of suspended sediments in the Firth of Forth vary with seasonal weather conditions. The natural sedimentation in the Firth of Forth aids the removal of contaminants from the water column and incorporates them in the seabed sediments.

Any increased nutrient levels from suspended sediments from disposal operations may stimulate local algal production, although the effects are predicted to be short-term and confined to the immediate area of the disposal operations. Nitrogen is generally regarded to be the limiting nutrient in estuarine and marine systems and in its reduced form (ammoniacal nitrogen) is also toxic to fish. As a consequence of the reduced (oxygen demanding) nature of the seabed sediments, nitrogenous nutrients are likely to be in this form.

The oxidation of anoxic sediments released into the water column has been shown to reduce oxygen concentrations by up to 58% (6). Based on the background levels, this may reduce the oxygen saturation to between 40 and 50% (equating to approximately 4 to 5 mg l^{-1}). Therefore, if the disposal operations occurred during a period of 'naturally' low dissolved oxygen it is possible that the water quality standards of oxygen concentration greater than 6 mg l^{-1} would not be met (7). It is predicted that this would be short-lived, due to the limited period over which disposal is intended to occur, and localised based on previous dredge plume studies. The impacts are not considered to be significant given the generally high dissolved oxygen levels anticipated at the spoil ground, the relatively low levels of organic carbon in the dredged sediments (c 5.75%) and the extent of the area potentially affected.

Although there may be some release of contaminants such as metals, PAHs and THCs into the water column during disposal operations the majority of the dredged material will descend to the seabed rapidly. Sediment bound contaminants liberated during the disposal operations will quickly become complexed with particulate matter in the water column and be re-deposited on the sea bed. Previous

(1) SEPA monitoring buoy data from Gunnet Ledge, Firth of Forth, available online from http://www.sepa.org.uk/environment/environmental-data/monitoring-buoys-network/gunnet-ledge/
(2) SEPA (1998). Winter Nutrient Distribution in the Firth of Forth, 1987 - 1997. Report TW 01/98, January 1998.
(3) Kennish M.J. 1992. Ecology of Estuaries Anthropogenic Effects Dredging and Dredged Spoil Disposal p357-397
(4) ERM, 2008. Middle Bank Aggregate Production Licence: Monitoring Report. A report for Westminster Gravels Ltd.
(5) Transport Scotland, 2009. Forth Replacement Crossing: Environmental Statement.
(6) Brown C. 1968. Observations on Dredging and Dissolved Oxygen in a Tidal Waterway. Water Resources Research Vol 4, No 6, p1381.
(7) UKTAG 2010. Water Framework Directive: An approach to the Revoked Directives:- the Freshwater Fish Directive, the Shellfish Directive and the Dangerous Substances Directive. Available online from: http://www.wfduk.org/resources%20/approach-revoked-directives-%E2%80%93-freshwater-fish-directive-shellfish-directive-and-dangeroussubstances Directive

studies have shown that metal concentrations in the water column remained consistent following sediment disposal [(1)].

The PAHs in the sediment samples comprised both low molecular weight (LMW) (two and three benzene rings) and high molecular weight (HMW) (more than 3 benzene rings) compounds. The individual PAHs that were in concentrations above Action Level 1 in station K3-2021 were all HMW PAHs. PAHs tend not to be volatile and are poorly soluble and therefore readily absorb onto particulate matter in the water column and are incorporated into marine sediments. The HMW PAHs are generally the less water soluble, less acutely toxic and slower to biodegrade (*i.e.* more persistent) than the LMW PAHs.

The ratios of individual PAHs have been used to determine the likely anthropogenic source of PAHs in the environment: *e.g.* from petroleum hydrocarbons (petrogenic) or combustion sources (pyrolytic). Petrogenic PAHs are often characterised by phenanthrene to anthracene (Ph/An) ratios more than 10, whereas pyrolytic PAH from combustion processes are characterised by Ph/An ratios less than 10. Ratios of fluoranthene to pyrene (Fl/Py) of less than 1 generally indicates petrogenic sources while ratios more than 1 generally come from pyrolytic sources [(1)].

For the sediment samples analysed from the Port of Methil in 2020 the Ph/An ratios were between 3.63 and 5.56 and the Fl/Py ratios were between 0.84 and 1.04. This suggests that these contaminants are from both combustion and petroleum hydrocarbon sources. This pattern has been identified in other ports in the Firth of Forth and Forth Estuary indicating that these sources of PAHs are in the sediments from the wider Forth Estuary and Firth of Forth sediment circulation system.

There was a large reduction in point source discharges of metals and hydrocarbons within the Forth Estuary and the Firth of Forth between the mid-1980s and 1990s [(2)]. Reduction and improved regulation of point source discharges has improved many aspects of the Forth system: inputs of organic material have declined and there has been an associated rise in dissolved oxygen during summer in the upper Forth Estuary. The rise in dissolved oxygen has led to increasing numbers of smelt caught in the upper estuary and to increasing inputs of nitrate generated by nitrification in the suspended sediment maxima of the estuary during summer. In winter, conservative mixing of nutrients is seen and there has been little change in winter nutrient concentrations in the Forth Estuary and Firth of Forth. Metal and trace organic inputs have been reduced so that aqueous concentrations have fallen rapidly [(3)]. With efforts focussed on improving the water quality of the Firth of Forth in more recent years, point source discharges have continued to decrease and the water quality of the Firth of Forth has continued to improve as a result [(4)].

It is not anticipated that the disposal operation at the Kirkcaldy spoil ground will introduce significant amounts of contamination into the water column. Disposal of the dredged material may result in a localised and short-term increase in the levels of some contaminants; however, the deposited sediment will disperse over time. Considering the short-term, localised and intermittent increase in the levels of some contaminants in the water column will not affect the overall water body quality statuses of the Firth of Forth.

The Kirkcaldy (Seafield) Bathing Water is an approximately 600 m long sandy beach to the south of Kirkcaldy. It was designated in 2008 is located approximately 2.5 km from the closest part of the dredging area and Kirkcaldy spoil ground. It is currently classified as Good (2020) [(5)].During the bathing season (usually 1 June to 15 September) the site is monitored for faecal indicators which are identified as the main risk to water quality at this location[(6)].

(1)Y.W. Qiu, G. Zhang, G.Q. Liu, L.L. Guo, X.D. Li, O. Wai. Polycyclic aromatic hydrocarbons (PAHs) in the water column and sediment core of Deep Bay, South China. Estuar. Coast. Shelf Sci., 83 (1) (2009), pp. 60-66.
(2) SEPA, 1998. Trace Metals in the Forth 1986 - 1996. Available online from
http://www.sepa.org.uk/science_and_research/data_and_reports/water/forth_estuary_trace_metals.aspx
(3) Dobson, J., Edwards, A., Hill, A. et al. *Senckenbergiana maritima* (2001) 31: 187. https://doi.org/10.1007/BF03043028
(4) SEPA, 2014. Scottish bathing waters 2013-2014. Available online http://www.sepa.org.uk/media/39125/scottish-bathing-waters-report-2013-2014 pdf
(5)https://www2.sepa.org.uk/bathingwaters/Classifications.aspx
(6) https://www2.sepa.org.uk/BathingWaters/ViewResults.aspx?id=9337

SEPA's standing guidance on dredging and sea disposal operations within or adjacent to (i.e. within 2 km) of a designated bathing waters states that ideally these operations should not be undertaken during the bathing season, unless a strong case can be made as to why a particular operation would not present a risk to Bathing Waters (1). The Kirkcaldy Bathing Water site is not within 2 km of the dredge or disposal site therefore no impacts are expected.

B2.2 Impacts on Benthic Ecology

The benthic macrofaunal communities present in proximity to Kirkcaldy spoil ground are expected to be typical for Firth of Forth conditions and not considered to be of high conservation significance due to the wide distribution, low diversity and lack of any rare or notable species (2).

It is anticipated that the deposition of dredged material at the Kirkcaldy spoil ground will result in the loss (burial) of the benthos within and in the immediate vicinity of the 'deposition zone' within the spoil ground. Localised impoverishment of the fauna (in terms of abundance and diversity) may occur along the axis of tidal flow as a result of secondary impacts comprising sediment deposition subsequent to the disposal activities. Kirkcaldy is an existing licenced spoil ground therefore the benthic communities in this area will have been impacted by the ongoing spoil deposition activities that have occurred there intermittently for at least the last 50 years.

Given the relatively homogenous nature of benthic communities in this part of the Firth of Forth and the availability of similar habitat within the Firth of Forth, the spatial extent of predicted sediment related impacts to benthos (and resultant impact on prey availability for foraging seabirds) are not considered to be significant.

B2.3 Impacts on Seabirds

The Firth of Forth Special Protection Area (SPA), Forth Islands SPA and the Outer Firth of Forth and St Andrews Bay Complex SPA are designated (3) for rare, vulnerable and regularly occurring migratory bird species.

There are three potential effects of the disposal of dredge material at sea on seabirds; increased suspended solids, release of contaminated particulates and physical disturbance of birds by the dredging vessel. These effects could potentially have a significant effect on the qualifying interests of the SPAs by reducing prey availability and disturbing bird behaviour and breeding patterns.

The vessel used for disposal of the material will be travelling to and from the Port of Kirkcaldy and the spoil ground for ten to twenty days per annum, a round trip of approximately 2.6 nm.

The SPAs support breeding seabirds which forage over a wide area. The disposal of the dredged material will result in localised increases in suspended sediment which may reduce the ability of fish eating birds to forage around the spoil ground due to impaired visibility. However the area affected is a small percentage of the total available foraging habitat, with alternative sources of prey available close by.

Kirkcaldy is an established and long term spoil ground with disposal activities from the Port of Kirkcaldy being ongoing prior to the time that the SPAs were designated. Given that disposal was an existing activity and ongoing disposal is at a similar scale to previous disposal activities, it is considered that the proposals will not have significant effects on the qualifying interest of the SPAs.

B2.4 Impacts on Fish and Marine Mammals

The River Teith Special Conservation Area (SAC), the Isle of May SAC and the Moray Firth SAC are designated for their habitats and fish and mammals species of European importance (4).

(1) http://www.sepa.org.uk/media/143312/lups-gu13-sepa-standing-advice-for-marine-scotland-on-small-scale-marine-licence-consultations.pdf
(2) Elliot M & Kingston P F (1987). The Sublittoral Benthic Fauna of the Estuary and Firth of Forth, Scotland. Proceedings of the Royal Society of Edinburgh, 93B, pp 449-465
(3) The *Conservation (Natural Habitats, &c) (EU Exit) (Scotland) (Amendment) Regulations, 2019*.
(4) The *Conservation (Natural Habitats, &c) (EU Exit) (Scotland) (Amendment) Regulations, 2019.*

Atlantic salmon, river lamprey and sea lamprey inhabit and migrate up and down the Firth of Forth and Forth Estuary to reach spawning grounds in the River Teith SAC and may therefore pass the Kirkcaldy spoil ground. The Forth District Salmon Fishery Board has previously advised that smolts are likely to be passing through the lower Forth Estuary and Firth of Forth during June and July. The river lamprey grows to maturity in estuarine environments and between October and December moves into fresh water to spawn in clean rivers and streams. The sea lamprey spends most of its life at sea, only returning to freshwater to spawn around April and May.

A potential effect of disposal at sea is for increased levels of suspended solids to disturb fish migration routes and areas they occupy. The proposals are not likely to have a significant effect on fish for the following reasons.

- The concentration of suspended sediment at which the passage of salmonid fish is affected has been observed to be approximately 500 mg l^{-1} (1). Studies in the US, looking at a variety of salmonid species, illustrates that fatalities to smolts (50%) can occur at high suspended sediment concentrations over extended periods (*e.g.* exposure of between 488 to 19,364 mg l^{-1} for 96 hrs) (2). The natural suspended sediment maxima in the Forth Estuary is in the upper estuary with mean concentrations over ten times higher than in the Firth of Forth (130 mg l^{-1} at Kincardine (3) and approximately 10 mg l^{-1} ambient levels recorded during the Middle Bank dredging and disposal operations in the Firth of Forth) (4).
- The disposal activities will take place within the Firth of Forth which represents a small area where sea lamprey and salmon smolts may be present or may pass through. The width of the Firth of Forth at the Kirkcaldy spoil ground is approximately 18.5 km (10 nm) wide. The fish species will be able to avoid the area during the short periods of raised suspended sediment during disposal and migrate using an alternative route through the Firth of Forth and therefore short-term and intermittent disposal operations are not considered to present a significant barrier to migration.

A localised, short-term and non-continuous increase in suspended sediment concentration affecting a small proportion of the width of the Firth of Forth is not anticipated to affect the migration of adult salmon, smolts or other fish species, based on the evidence of studies on the effects of suspended sediments on salmonids and the predicted suspended sediments concentrations resulting from the disposal operations. It has been reported that Atlantic salmon numbers have been decreasing in Scotland and farther afield over the last ten years (5). Forth Ports' dredge spoil disposal operations have been ongoing at Kirkcaldy intermittently for at least the last 50 years, covering the periods of much higher salmon numbers indicating that there is no causal link between the ongoing spoil disposal activities and a broad scale decline in salmon numbers. Seasonal restrictions to operational requirements to dispose of dredged material at the Kirkcaldy spoil ground are therefore not considered to be justified.

The Isle of May SAC, in the outer Firth of Forth, is designated for its populations of grey seal. Grey seals forage widely and may forage at the Kirkcaldy spoil ground. Potential effects on grey seals resulting from the disposal activities are disturbance and noise due to vessel movements and disposal activities and displacement of prey species as a result of increased levels of suspended sediment at the spoil ground.

The proposals are not likely to have a significant effect on grey seals for the following reasons.

(1) Redding M.J. and Schreck C.B. 1987, Physiological effects on coho salmon and steelhead of exposure to suspended solids, Transactions of the American Fisheries Society, Vol 116 pp737-747
(2) Bash J, Berman, C and Bolton S. 2001. Effects of Turbidity and Suspended Solids On Salmonids. Prepared for Washington State Transportation Commission, Department of Transporta ion and U.S. Department of Transportation, Federal Highway Administration
(3) Transport Scotland, 2009. Forth Replacement Crossing: Environmental Statement.
(4) ERM, 1998 Aggregate Production Licence Application, Middle Bank, Firth of Forth Environmental Statement Report to Westminster Gravels Ltd
(5) https //www britishecologicalsociety org/understanding-decline-atlantic-salmon-catches-scotland/# ~ text=The%20Scottish%20Government%20has%20collected,the%20previous%205%2Dyear%20average

- The small potential foraging area affected by disposal activities at the Kirkcaldy spoil ground in relation to the available foraging area in the Firth of Forth.
- The intermittent and short duration of disposal activities (ten to twenty days a year).
- The small number of vessel movements associated with the disposal activities in relation to total vessel movements within the Firth of Forth.
- The long term existing disposal operations in the area which pre-date the site designation.

Bottlenose dolphins are a Habitats Directive Annex II species and are resident in the Moray Firth SAC. They are infrequent summer visitors to the Firth of Forth, mainly between June and September (1).

Vessel movements and noise have the potential to disturb or displace marine mammals and disposal activities have the potential to displace prey species within and in the vicinity of the spoil ground. The proposals are not likely to have a significant effect on bottlenose dolphins for the following reasons.

- The distance between the spoil ground and the SAC is large and the proportion of the bottlenose dolphin population anticipated to pass through the small area affected by disposal activities is anticipated to be low.
- The intermittent and short duration of disposal activities (ten to twenty days a year).
- The small number of vessel movements associated with the disposal activities in relation to total vessel movements within the Firth of Forth.
- The relatively low speed and direct line of travel of dredge vessel movements to and from the spoil ground (*i.e.* no fast moving and erratic vessel movements).
- The long term existing disposal operations in the area which pre-date the site designation.

(1) Evans P. G. H. Chapter 5.15 Whales, Dolphins and Porpoises. In Coasts and Areas of the United Kingdom. Region 4 South- east Scotland: Montrose to Eyemouth, ed by J H Barne, C F Robson, S S Kaznowska, J P Doody, N C Davidson and A L Buck, pp 129-132. JNCC (Coastal Directories Series).

B2.5 Summary of Impacts

Table B1.1 presents a summary of the impacts and an assessment of significance of the impacts in relation to the sensitivity/importance of the receiving site.

Table B1.14 Summary of Significance of Impacts

Receptor	Impact Significance Justification	Impact Significance
Water quality at spoil ground	Disposal will be periodic and sediment will descend to the seabed rapidly. Any impacts will be localised and short-lived.	Not Significant
Sediment quality at spoil ground	Increase in the levels of some contaminants will be localised and short-term and the deposited sediment will disperse within the open water system over time.	Not Significant
Benthic ecology at spoil ground	Kirkcaldy is designated as a spoil ground and disposal operations have taken place there for at least the last 50 years. Disposal will occur over a relatively short period of time and similar habitat is available in close proximity to the site.	Not Significant
Seabirds	Proposed disposal operations are over a short period of time (up to ten days per annum) and the area affected is a small percentage of the total available foraging habitat, with alternative sources of prey available close by. The volume of dredger vessel traffic will not be significant in relation to the existing traffic in the Firth of Forth. The SPAs were designated after the Kirkcaldy spoil site was designated, and have not been impacted by historic and ongoing disposal operations for at least the last 50 years.	Not Significant
Marine mammals and fish	Proposed disposal operations are over a short period of time and the area affected is a small percentage of the total available foraging habitat, with alternative sources of prey available close by. The volume of dredger vessel traffic will not be significant in relation to the existing traffic in the Firth of Forth. The SACs were designated after the Kirkcaldy spoil site was designated, and have not been impacted by historic and ongoing disposal operations.	Not Significant

B3 Cumulative Effects within the Firth of Forth

B3.1 Introduction

The potential impacts of the sea disposal option have been assessed within *Section B2* in isolation from other activities within the Firth of Forth. The impacts associated with the sea disposal option are not predicted to result in adverse effects on the integrity of the SPAs and SACs, however, it is possible that cumulative impacts with other projects could result in significant impacts.

For the purposes of this report, a working definition of cumulative impacts as ‘impacts that result from incremental changes caused by other past, present or reasonably foreseeable actions, together with the project [(1)] has been adopted. The assessment of potential cumulative impacts has been restricted

(1) European Union. Guidelines for the Assessment of Indirect and Cumulative Impacts, as well as Impact Interactions, DG XI Brussels Downloaded from http://ec.europa.eu/environment/eia/eia-support.htm

to activities and proposed activities with the potential to directly impact the water and / or sediment quality or cause disturbance to the qualifying interests of the SPAs and SACs. The other activities considered therefore include those that are at some distance from the activities at the Kirkcaldy spoil ground but are within the foraging range of species that may utilise both areas.

B3.2 Past and Current Activities within the Firth of Forth and Forth Estuary

B3.2.1 Introduction

The Firth of Forth and Forth Estuary has previously experienced pollution from a number of industrial sources and sewage discharges, such as the petro-chemical operations at Grangemouth and the sewage works at Seafield. The Imperial Chemical Industries (ICI) chemical plant previously based in Grangemouth is also known to have been a source of mercury into the Forth Estuary. Over the past 35 years, however, most of these pollution sources have been controlled or eliminated altogether.

Additional improvements to sewage works and other effluent treatment plants upstream have improved the condition of the water coming down the estuary into the Firth of Forth.

In addition, there are unknown and diffuse sources of discharges into the Forth Estuary, Firth of Forth and riverine inputs to these areas, for example from agricultural run-off and unrecorded drainage outfalls.

Petro-Chemicals and Power Generation

The INEOS refinery and wider petro-chemical complex at Grangemouth are historically a dominant source of oil related PAHs in the Forth Estuary and the Firth of Forth.

Methil power station was a small base load coal slurry-fired power station, located on the south side of the mouth of the River Leven, where the river enters the Firth of Forth at Methil. The power station started operations in 1965 and was decommissioned in 2000, finally being demolished in 2011. Water from the Firth of Forth was abstracted and used as cooling water by the power station before being discharged back into the Firth of Forth.

The Longannet coal-fired power station on the north bank of the estuary closed in March 2016. The historic release of combustion related PAHs from this source will have contributed to the PAH loading within the Forth Estuary and Firth of Forth [(1)]. Water was abstracted from the Firth of Forth in the same way it was for Methil.

Cockenzie power station was a coal-fired power station located on the southern shore of the Firth of Forth near to Cockenzie and Port Seaton. It generated electricity between 1967 and 2013, with demolition of the station completed in 2015. Water was abstracted from the Firth of Forth in the same way it was for Methil and Longannet.

B3.2.2 Commercial Fishing Activity

The sandeel fishery on the Wee Bankie, at the mouth of the Firth of Forth, has been closed since 2000 on seabird conservation grounds. The initial five year period was reviewed and extended following the reduction in numbers of some seabird species observed during a 2004 count (reduced sandeel numbers may be linked) within the Firth of Forth [(2)].

Improved water quality in the Firth of Forth has led to a resumption of cockle fishing, particularly on the Fife coast. Uncontrolled cockling could impact upon wintering bird populations by causing loss of prey species, directly (removal of cockles) and indirectly (damage to non-target species). A Special Nature Conservation Order (SNCO) was implemented under the *Conservation (Natural Habitats)*

(1) Richardson D.M., Davies I.M., Moffat C.F., Pollard P. and Stagg R.M. 2001. Biliary PAH metabolites and EROD activity in flounder (*Platichthys flesus)* from a contaminated estuarine environment. J. Environ. Monit., **3**, 610-615.
(2) Marine Scotland (2012). The Distribution of Zooplankton Prey of Forage Fish in the Firth of Forth Area, East Coast of Sco land. Available online http://www.scotland.gov.uk/Publications/2012/08/2345/1 .

Regulations, 1994 to the outer Firth of Forth. This Order, implemented in March 2003, was revoked and reissued in 2006, and still stands (1).

B3.2.3 Other Dredging Disposal Activities

In addition to the intended maintenance dredging activities at the Port of Kirkcaldy with disposal at the Kirkcaldy spoil ground, Forth Ports manages five other dredging operations within the Forth Estuary and Firth of Forth. The operations comprise the following.

- Trailer suction dredging in Grangemouth: maximum capacity for maintenance dredging is 1,700,000 m^3 per annum, undertaken over four days every month.
- Grab/backhoe dredging at Newhaven with disposal at Oxcars spoil ground: maximum capacity for maintenance dredging is 15,000 m^3 per annum, undertaken over four weeks per annum.
- Trailer suction dredging in Rosyth: maximum capacity for maintenance dredging is 400,000 m^3 per annum, undertaken over three days per month, every other month with disposal at Oxcars spoil ground.
- Trailer suction dredging in Leith with disposal at Narrow Deep spoil ground: maximum capacity for maintenance dredging is 100,000 m^3 per annum, undertaken over one to two days per month.
- Trailer suction or grab dredger Methil approach channel with disposal at Methil spoil ground: maximum quantity of disposed material is 12,500 m^3. This is undertaken annually.

The actual timing of dredging and volumes required to be dredged during each campaign depend on operational requirements and sedimentation rates (for example due to storm events, which can happen at any time of year).

Other recent, ongoing or planned licenced dredging activities in the Firth of Forth include the following (note these are based on planned or licenced activities so actual volumes dredged may be lower and dates may have been delayed due to Covid-19).

- Babcock Marine at Rosyth had a Marine Licence for maintenance dredging of up to 100,000 tonnes between March 2019 and March 2020 with disposal at Oxcars B.
- Maintenance dredge of 3,300 tonnes per year using a plough dredger at Port Edgar within the confines of the marina between 2018 and 2021 with disposal to an area immediately adjacent to the marina breakwater on the north east boundary of the marina.
- Trailer suction and backhoe dredging with self-propelled barge at Defence Munitions Crombie, maximum quantity of disposed material is 22,000 m^3 per annum for maintenance (2) with disposal at Bo'ness spoil ground.
- Capital dredge of 86,980 m^3 at Granton Harbour with disposal at Bo'ness or Narrow Deep spoil ground between August 2019 and July 2022.
- Maintenance dredging at Pittenweem Harbour, with disposal of 27,334 tonnes at Anstruther spoil ground between August 2019 and August 2020.
- Maintenance dredging of 3,600 tonnes over three years at Dysart Harbour, Fife, with disposal on the adjacent foreshore where it is dispersed on the incoming tide (July 2020 to July 2021).

The above maintenance dredging spoil disposal operations require licence renewals every three years by Marine Scotland. Potential impacts are therefore assessed and reviewed every three years prior to granting a Marine Licence. The historical disposal route for spoil from all listed dredging operations has been deposition at sea, and to date, no environmental impacts, other than direct impacts within the spoil ground, have been reported.

(1)http://gateway.snh.gov.uk/sitelink/siteinfo.jsp?pa_code=8499
(2) Rosyth International Container Terminal. Operational In-combination Assessment of Maintenance Dredging and Implications for the River Teith SAC. Jacobs, 2011.

Work began on the Forth Replacement Crossing at the end of 2011, and capital dredging works for the bridge support foundations started at the beginning of 2012. The purpose of the dredging was to create access for the construction of the foundations for the structures which supports the new bridge. In total 180,000 m^3 silt and sand was dredged from the seabed to form access channels for bridge foundation works between 2011 and 2016. This spoil was disposed of at Oxcars (1).

B3.2.4 Foreseeable Future Activities within and Close to the Firth of Forth

Levenmouth Demonstration Turbine

The Offshore Renewable Energy (ORE) Catapult's seven megawatt wind turbine was completed in 2013 and is located 50 m from the coast connected to the land by a ramp. The tower stands at 110 m and is 195 m to the top of the blade. Samsung had previously owned the wind turbine demonstrator, before selling to ORE Catapult in December 2015. In 2018 the licence to permit the turbine was extended to 2029.

Inch Cape Offshore Wind Farm

Consent was granted for the proposed Inch Cape Offshore Wind Farm in October 2014. Consent was delayed following an objection lodged by the Royal Society for the Protection of Birds and final approval was given in 2017. A revised scope of design was granted by Scottish Ministers in June 2019. This scope reduced the number of wind turbine generators from 110 to 72. The turbines will occupy an area of 150 km^2. Construction is expected to begin in 2021. Once fully operational the wind farm will have an export capacity of approximately 1,000 megawatts. An application to vary the maximum generating capacity, within the overall footprint of the wind farm, was submitted to Marine Scotland in January 2021.

Seagreen Offshore Wind Farm

Scottish and Southern Electric (SSE) and Fluor joint venture partnership Seagreen Wind Energy was awarded the exclusive development rights for the Firth of Forth Zone by the Crown Estate Scotland. The zone covers an area of 2,852 km^2 in the outer Firth of Forth. Seagreen was awarded consent by the Scottish Government in October 2014 to develop the northern part of the Firth of Forth Zone to generate up to 1,050 megawatts of power from up to 150 turbines. The design was updated and approved in 2018 to comprise fewer, larger wind turbines. Currently the plan is for 1075 MW from 114 turbines. Onshore cable installation commenced in September 2020. Montrose port is the preferred location for the operations and maintenance base.

Neart na Gaoithe Offshore Wind Farm

NnG Offshore Wind was granted consent by the Scottish Government in 2018 to build a 450 megawatt offshore wind farm in the outer Firth of Forth comprising up to 54 wind turbines up to 208 m high occupying an area of approximately 105 km^2. Construction commenced in 2020 with seabed preparations being undertaken prior to piling works. An onshore operations and maintenance base at Eyemouth received planning permission in September 2020. The wind farm is expected to be operational in 2023.

B3.3 Conclusions

Potential cumulative impacts associated with the above activities can be broadly categorised as comprising suspension of sediments during dredge spoil disposal operations and construction activities resulting in loss or smothering of benthos, the discharge of contaminants with the potential to impact both water and sediment quality, and the disturbance to seabirds and mammals from piling operations and vessel movements. These other activities are at some distance from the Kirkcaldy spoil site and no cumulative impacts from suspended sediments and other vessel movements are considered likely.

(1) Hochtief (UK) Construction (2016). Forth Road Bridge Replacement - Queensferry Crossing. Available online http://www.hochtief-construction.co.uk/bridges_Forth_Road.shtml

The dredge spoil disposal operations at the Kirkcaldy spoil ground pre-date the SPA and SAC designations and there is no evidence to suggest that the past and current disposal operations at Kirkcaldy managed by Forth Ports have impacted the integrity of designated sites, supported species or resulted in other significant environmental impacts either alone or cumulatively with other activities in the area. Any significant future developments within the Firth of Forth are likely to be subject to assessment of significant environmental effects through the appropriate consenting processes.

APPENDIX C CONSULTEE RESPONSES (EXTRACTS FROM LETTERS/EMAILS RECEIVED)

1 Fife Council

I can confirm that as Coast Protection Authority we have no objections to the proposals, and I can also confirm that at this time we have no plans for any beach nourishment / reclamation projects along the adjacent coastline for beneficial re-use of the material.

Nicholas Williamson, Consultant Engineer, Flooding, Shoreline & Harbours, Fife Council, Assets, Transportation and Environment

2 Maritime and Coastal Agency

Thank you for your letter to our Glasgow Marine Office, inviting our comments regarding Forth Ports Ltd's planned Marine Licence application. We understand that the licence that you will seek is for maintenance dredging, and you have specifically asked our advice regarding options for sea disposal. Your query has been forwarded to my team at Technical Services Navigation branch who co-ordinate Marine Licence consultation responses centrally on behalf of the MCA.

Typically, we reserve comments for the formal marine licence consultation once your application is submitted to Marine Scotland. However, based on the information you have supplied, we would suggest that you consult local marine users, especially the local fishing industry, as they are likely to have some of the best local knowledge of this area and an idea of what might pose a navigation hazard or impede existing activities. Ideally your application, once submitted, should include evidence that you have consulted with local stakeholders and give consideration to potential navigation hazards.

If approved, MCA would then seek to advise standard conditions and advisories to Marine Scotland to be included on the Marine Licence. Typically this will include a requirement to notify local mariners, HM Coastguard and the UK Hydrographic Office. The UKHO may have additional requirements regarding survey data so that nautical charts and hydrography programmes can be kept updated.

Thomas Bulpit, Marine Licensing Lead, Marine Licensing and Consenting, UK Technical Services Navigation, Maritime & Coastguard Agency, Southampton

3 NatureScot

Thank you for consulting us on beneficial uses for the Port of Kirkcaldy spoil.

At this time we are not aware of any beneficial uses in the region, and suggest that disposal at sea remains the best option.

Malcolm Fraser, Area Officer – Forth

4 Northern Lighthouse Board

Northern Lighthouse Board would have no objection to the proposed dredging activity at Port of Kirkcaldy, and will respond as such to any ML consultation.

We have no additional comment to make at this pre-application stage.

Adam Lewis, Coastal Inspector

5 SEPA

Environmental Protection Act 1990 (as amended). The waste management licensing (Scotland) regulations 2011. Dredge spoil disposal from Kirkcaldy harbour waste management options

In response to your letter dated 08 April 2021 concerning the above site, the waste hierarchy as set out within the European Waste Framework Directive (2008/98/EC) should be used as a framework for any re-use or disposal options relating to the dredged material. However, before any re-use or disposal to land options are identified, the dredged material must be suitably characterised and the composition assessed. Provided the dredged spoil materials are categorised in accordance with

European Waste Classification code 17 05 06 (dredging spoil) and do not contain any dangerous substances, it may be possible to use the materials on land in accordance with exemptions from waste management licensing. The most relevant exemptions being paragraphs 7 and 9 as detailed in Schedule 1 of the above regulations.

Prior to applying for an exemption, detailed analysis, and testing of the dredged spoil and potentially the receiving land would need to be carried out. There are also limitations on the quantities that can be used in accordance with each exemption. Please find below the link to Technical Guidance on the classification and assessment of waste, further information and technical guidance documents can be found on the waste regulation pages of SEPA's website. If landfilling is identified as a disposal option, the spoil would need to be suitably analysed to determine which landfill sites(s) can accept it. Again, further details can be found on the waste classification technical document and on SEPA's website. For guidance on offshore disposal please contact Marine Scotland.

Richard O'Reilly, Environment Protection Officer, Fife, Angus and Dundee Team.

6 Crown Estate

In response to your query, we are not aware of any potential beneficial uses in the area and will generally follow Marine Scotland's licenced disposal site as per their licence. Occasionally there may be site specific reasons for objecting to this but this can only be considered on a case by case basis at the time of application.

Peter Galloway, Bidwells, on behalf of the Crown Estate

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