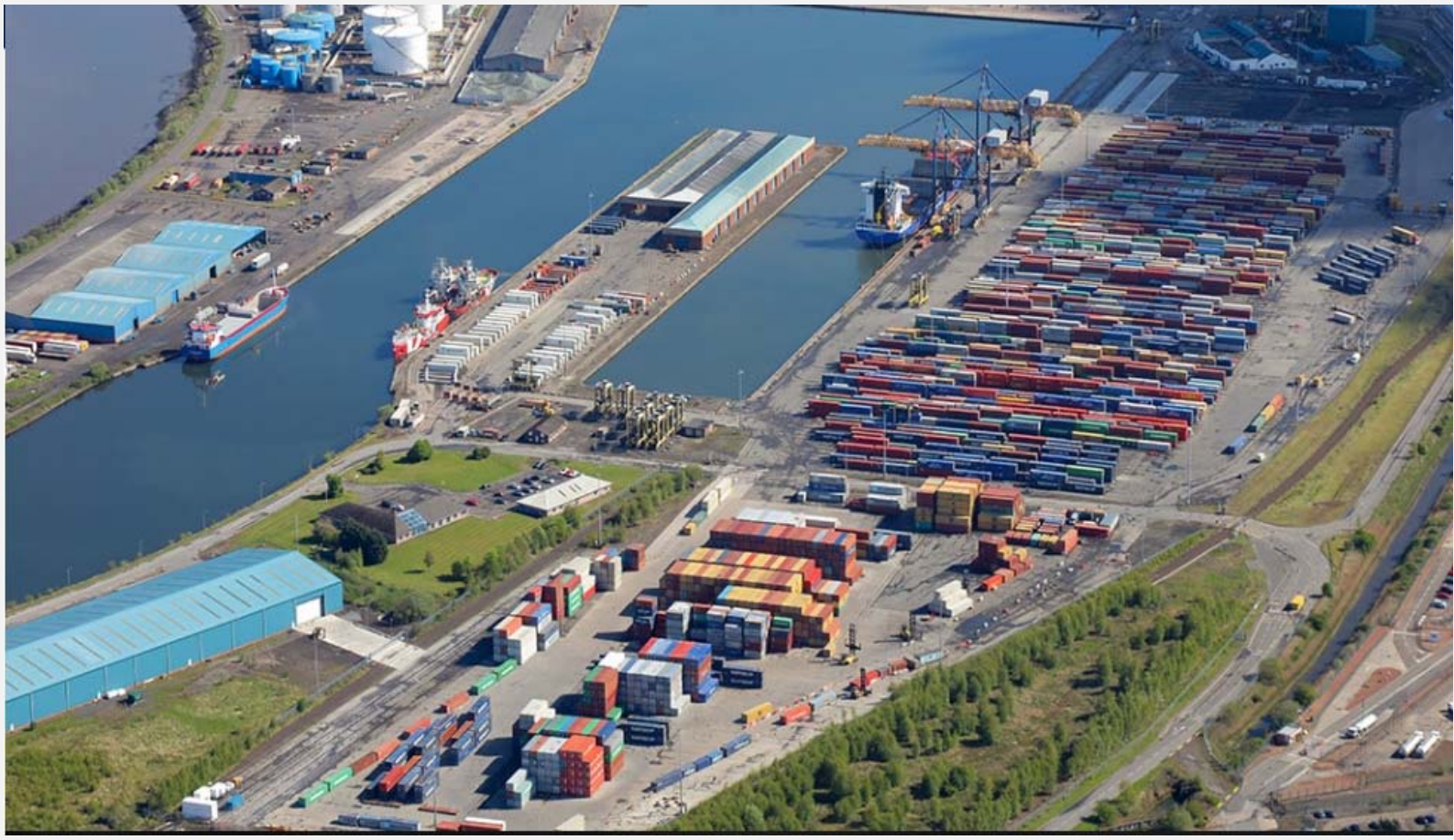

FORTH PORTS

Port of Grangemouth Maintenance Dredge Spoil Disposal License Application

Best Practicable Environmental Option Report

25 September 2019

Project No: 0352017

The business of sustainability

ERM

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Port of Grangemouth Maintenance Dredge Spoil Disposal License Application

Best Practicable Environmental Option Report

Approved for Issue by ERM
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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 dredge material from the Port of Grangemouth and identifies the Best Practicable Environmental Option (BPEO).

Under the Marine (Scotland) Act 2010, a Marine Licence issued by Marine Scotland is required for the deposit of substances or articles 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.

Forth Ports Ltd currently has a maintenance disposal licence within the port to maintain a safe navigable depth which is due for renewal at the end of January 2020.

It is proposed that the dredged material continues to be disposed of at sea at the existing licenced marine disposal site at Bo'ness. Forth Ports has been using the Bo'ness disposal site for the disposal of dredged material from the Port of Grangemouth for over 20 years.

Marine Licences for maintenance disposal activities are currently valid in Scotland for up to three years (1). This application is expected to cover the period from 1st February 2020 to 31st January 2023.

1.2 The Need for Dredge Spoil Disposal

The Port of Grangemouth is located on the south bank of the Forth Estuary; adjacent to the Grangemouth petrochemical complex where the principal cargos handled include:

- containers;
- grain and dry bulks;
- liquid bulks;
- oil and gas; and
- paper and forest products.

The entrance to the port is accessed from the Bellmouth, through lock gates and into the docks. The Bellmouth is protected by open piled lead-in jetties (see *Figure 1.1* for port and dredging areas).

The Bellmouth lies immediately west of the Kinneil mudflats and east of the Skinflats mudflats. The resuspension of sediment from a variety of sources within the Firth of Forth and Forth Estuary, the action of the waves on the mudflats and turbulence created by the movement of the tide against the west lead-in jetty contribute to the movement of suspended sediments into the Bellmouth area (2). This causes the Bellmouth area to silt up and, if the maintenance dredging did not take place, the Bellmouth would silt up at a rate of approximately two metres per month, rapidly becoming un-navigable. To maintain access to the port Forth Ports requires to dredge the Bellmouth area monthly.

Within the port, water is pumped in from the Forth Estuary to maintain a static dock level resulting in an accumulation of sediment within the port. An estimated 20,000 m^3 of silt also accumulates within

(1) Marine (Scotland) Act 2010, Part 4 Marine Licencing. General Guidance for Applicants. Available online http://www.scotland.gov.uk/Resource/0043/00435338.pdf

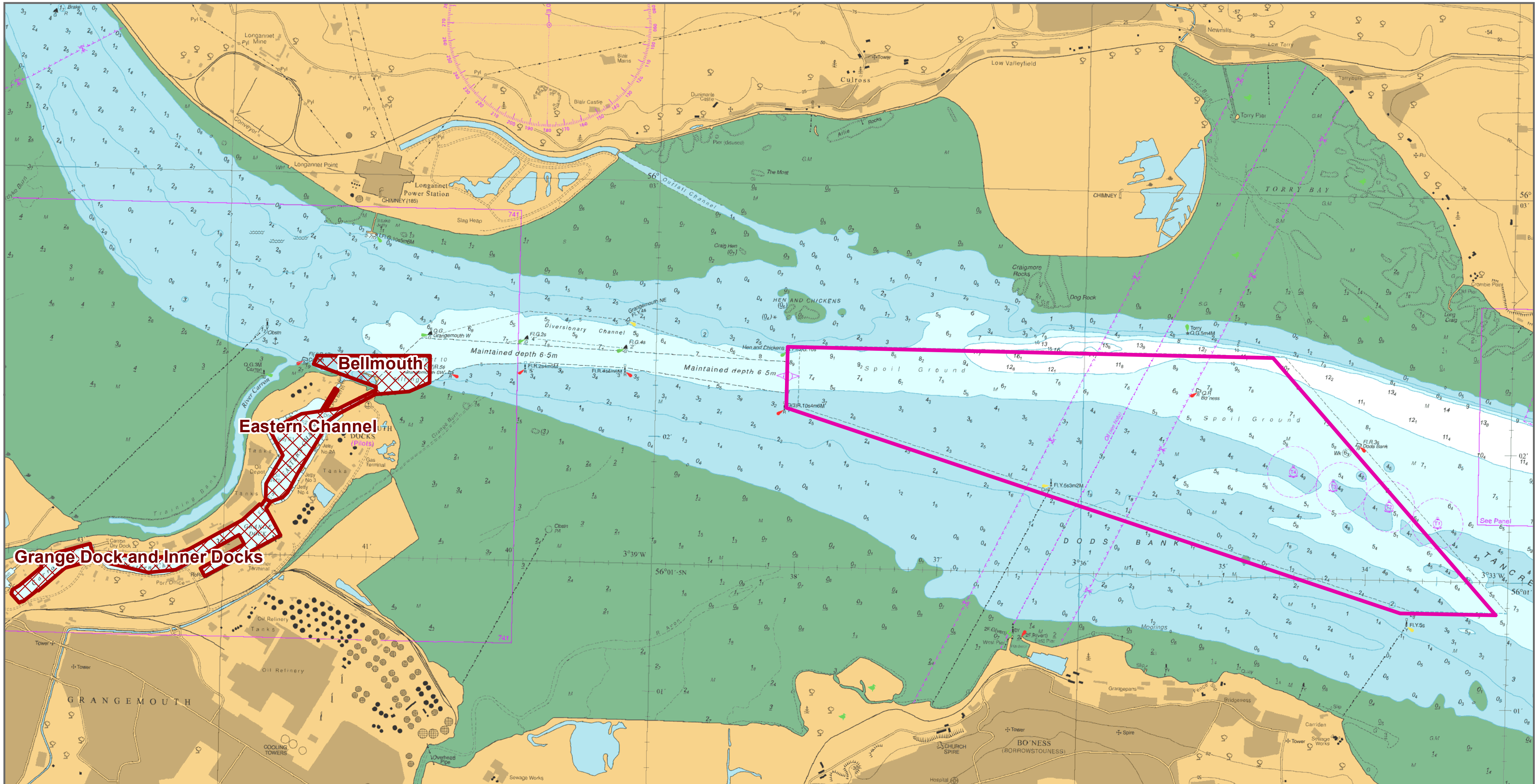
(2) HR Wallingford, Forth Ports Siltation and Dredging Study, 1998.

the locks and port annually and requires periodic dredging (in addition to the material from Bellmouth area) to maintain the passage through the Eastern Channel to Grange Dock.

In line with Section 13 of Scotland's National Marine Plan (Marine Planning Policy Transport 4) the dredging operations and disposal of the dredged material will continue to maintain and support the sustainable development of the Port of Grangemouth. The maintenance of the Port of Grangemouth is essential to enable it to continue to operate as Scotland's largest container port by allowing large vessels to safely navigate the shallower waters of the Firth of Forth, in turn supporting the national economy.

Forth Ports undertakes routine dredging at Grangemouth Dock and requires to dispose of up to 1,700,000 m^3 of material per annum. Should Forth Ports consider the "Do Nothing" approach, and not undertake any dredge disposal operations it would be unable to continue with its routine dredging operations, it is anticipated that the Port of Grangemouth would become inaccessible to most of the commercial vessel traffic within a matter of weeks. There would be serious concerns raised over navigational safety as the risk to vessels of grounding increased.

Without the ability to accommodate these vessels, the economy of the local area would decrease and there would be a wider national effect as organisations reliant on vessels accessing the Port of Grangemouth not be able to continue normal operations. Given the ongoing dredging requirements and therefore the need for disposal of the dredged material, the do nothing option is not considered further in this BPEO.



Maintenance Dredge Area

Boness Disposal Site

0 0.25 0.5 0.75 1 1.25
Kilometers

N

Figure 1.1

Grangemouth Maintenance Dredge Area and Proposed Disposal Site

SCALE: See Scale Bar	VERSION: A01
SIZE: A4	DRAWN: LST
PROJECT: 0352017	CHECKED: CM
DATE: 06/08/2019	APPROVED: MI

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CLIENT:

Forth Ports Ltd.

PROJECTION: British National Grid

SOURCE:

Path: P:\Projects\0352017 Forth Ports Grangemouth2016.MI\00 GIS\MAPS\0352017_Grangemouth_A02.mxd

1.2.1 Previous Disposal Activities

The Port of Grangemouth has been dredged since the 1910s on a continual basis with Forth Ports taking over the port in the late 1960s. To maintain access to the Port of Grangemouth, Forth Ports previously dredged the Bellmouth area from Monday to Friday, early morning to late evening for 48 weeks of the year. Between 1967 and 2000 this was mainly undertaken using the trailing suction dredger *Abbotsgrange* or a chartered suction trailer dredger if the *Abbotsgrange* was not available.

Since January 2001, Forth Ports have contracted United Kingdom Dredging (UKD) for the majority of operations within the Forth Estuary. The *UKD Marlin* (*Figure 1.2*) is a trailing suction dredger, with a hopper capacity of 3,000 m^3, which is double that of the *Abbotsgrange.*

Figure 1.2 Dredge Vessel - UKD Marlin

1.3 Proposed Disposal Operations

The intended dredging and dredged material disposal operations to maintain the Bellmouth, Eastern Channel and inner docks areas are estimated to require four 24 hour days per month with the *UKD Marlin* trailing suction dredger. The time required for one cycle (dredging - travelling - discharging - travelling) is approximately 1 hour and 30 minutes. There are time restrictions getting in and out of the lock and delays due to other shipping movements meaning that longer periods are required for some dredging loads.

The boundary co-ordinates of the proposed dredge areas are presented in *Table 1.1* and illustrated in *Figure 1.1.*

Table 1.1 Coordinates of Proposed Dredge Sites at Grangemouth

Node	Co-ordinates	
Bellmouth Area		
1	56° 02.139"N	3° 40.958"W
2	56° 02.169"N	3° 40.958"W
3	56° 02.253"N	3° 41.397"W
4	56° 02.286"N	3° 41.374"W
5	56° 02.297"N	3° 40.585"W
6	56° 02.190"N	3° 40.582"W
7	56° 02.153"N	3° 40.723"W
Eastern Channel		
1	56° 02.148"N	3° 40.968"W
2	56° 02.076"N	3° 41.214"W
3	56° 02.070"N	3° 41.304"W
4	56° 02.148"N	3° 41.220"W
5	56° 02.154"N	3° 41.244"W
6	56° 02.064"N	3° 41.334"W
7	56° 02.052"N	3° 41.472"W
8	56° 01.986"N	3° 41.694"W
9	56° 01.890"N	3° 41.592"W
10	56° 01.776"N	3° 41.706"W
11	56° 01.716"N	3° 41.712"W
12	56° 01.704"N	3° 41.670"W
13	56° 01.728"N	3° 41.592"W
14	56° 01.746"N	3° 41.556"W
15	56° 01.770"N	3° 41.532"W
16	56° 01.824"N	3° 41.484"W
17	56° 01.986"N	3° 41.316"W
18	56° 02.028"N	3° 41.280"W
19	56° 02.064"N	3° 41.202"W
20	56° 02.136"N	3° 40.956"W
Inner Docks and Grange Dock		
1	56° 01.708"N	3° 41.675"W
2	56° 01.682"N	3° 41.705"W
3	56° 01.579"N	3° 41.600"W
4	56° 01.409"N	3° 42.124"W
5	56° 01.440"N	3° 42.156"W
6	56° 01.539"N	3° 41.853"W
7	56° 01.575"N	3° 41.890"W
8	56° 01.477"N	3° 42.193"W
9	56° 01.432"N	3° 42.328"W
10	56° 01.420"N	3° 42.520"W
11	56° 01.442"N	3° 42.729"W
12	56° 01.454"N	3° 42.819"W
13	56° 01.467"N	3° 42.844"W
14	56° 01.470"N	3° 42.899"W
15	56° 01.462"N	3° 42.901"W
16	56° 01.429"N	3° 43.100"W
17	56° 01.423"N	3° 43.114"W
18	56° 01.336"N	3° 43.285"W
19	56° 01.339"N	3° 43.292"W

Node	Co-ordinates	
20	56° 01.293"N	3° 43.392"W
21	56° 01.294"N	3° 43.402"W
22	56° 01.287"N	3° 43.417"W
23	56° 01.321"N	3° 43.474"W
24	56° 01.339"N	3° 43.469"W
25	56° 01.354"N	3° 43.421"W
26	56° 01.430"N	3° 43.267"W
27	56° 01.437"N	3° 43.271"W
28	56° 01.486"N	3° 43.165"W
29	56° 01.490"N	3° 43.144"W
30	56° 01.526"N	3° 42.933"W
31	56° 01.481"N	3° 42.908"W
32	56° 01.477"N	3° 42.845"W
33	56° 01.491"N	3° 42.804"W
34	56° 01.486"N	3° 42.715"W
35	56° 01.472"N	3° 42.522"W
36	56° 01.491"N	3° 42.331"W
37	56° 01.516"N	3° 42.233"W
38	56° 01.634"N	3° 41.869"W
39	56° 01.698"N	3° 41.751"W
40	56° 01.694"N	3° 41.738"W
41	56° 01.719"N	3° 41.712"W
42	56° 01.708"N	3° 41.675"W

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

The Bo'ness spoil ground is situated approximately 1.5 nautical miles east of the Port of Grangemouth and has been used by Forth Ports for dredge spoil disposal from Grangemouth for over 20 years. The water depth within the spoil disposal ground ranges from 0.1 m below Chart Datum (CD) along the southern edge and increases to 17 m below CD along the northern edge. The boundary co-ordinates of the spoil ground are presented in *Table 1.2* and illustrated in *Figure 1.1.*

Table 1.2 Coordinates of Bo'ness Spoil Disposal Ground

Node	Coordinates	
1	56°01.380'N	3°33.000'W
2	56°01.380'N	3°33.670'W
3	56°02.130'N	3°38.000'W
4	56°02.370'N	3°38.000'W
5	56°02.370'N	3°34.600'W

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

The volume of dredged material deposited at the Bo'ness spoil ground from the Port of Grangemouth from 1997 to 2018 ranged from 781,967 to 1,253,600 m^3 per annum as presented in *Table 1.3.* Larger volumes may be required in some years due to variation in sediment deposition rates, hence a higher volume applied for than the previous maximum disposal volume.

Table 1.3 Volume of Dredge Spoil Disposal at Bo'ness Spoil Ground from Grangemouth (1997 to 2018)

Year	Quantity (m^3)
1997	911,509
1998	921,670
1999	931,062
2000	967,801
2001	823,624
2002	781,967
2003	821,019
2004	834,131
2005	991,276
2006	801,209
2007	920,639
2008	979,537
2009	876,955
2010	808,744
2011	999,538
2012	1,084,760
2013	1,253,600
2014	1,029,611
2015	1,188,021
2016	1,231,497
2017	1,038,961
2018	987,594

Data source: Forth Ports Ltd

1.4 Description of Sediment to be Dredged

In line with Marine Scotland guidelines on pre-dredge sampling protocol (1), a survey programme was undertaken on 10th July 2019 to sample the sediments within Grangemouth Harbour and the Bellmouth. This survey programme was reviewed and agreed with Marine Scotland.

A hand held van-Veen grab was used to take a surface sample from 16 stations within the harbour and 13 in the Bellmouth. Sediments were analysed by SOCOTEC for:

- total organic carbon
- particle size analysis
- sediment density
- a suite of metals (arsenic, cadmium, chromium, copper, mercury, nickel, lead, zinc);
- Tributyl Tin and Dibutyl Tin (TBT and DBT);
- Poly Chlorinated Biphenyls (PCB); and
- Polycyclic Aromatic Hydrocarbons (PAH).

The physico-chemical analysis is presented in *Appendix A.*

In addition 6 samples were analysed for specific gravity for Forth Ports use for calculating tonnages from volumes dredged.

The sediment to be dredged from the channel and dock areas is composed of soft, estuarine sandy silt with small fractions of gravel in some samples in the Bellmouth. The mean concentration of most metals and PAHs were above the Marine Scotland Action Level 1 but below Action Level 2, with the exception of copper, mercury and TBT which returned some samples above Action Level 2. Concentrations of some PCBs from the innermost docks were above Action Level 1. These results are similar to previous samples collected from the dock since 1988 and are comparable with other samples collected in harbours and docks with the Forth Estuary and Firth of Forth (see *Appendix A* for further details).

As required in the previous licence (Condition 4), Forth Ports will develop a dredging plan that ensures that dredged material from the areas where sediment samples had elevated concentrations of contaminants above Action Level 2 will be mixed with material dredged from areas at least 10 m away from such sample locations (based on a maximum of 50% dredged material per load from the areas with elevated concentrations). In addition, three samples will be collected and analysed from dredged loads from within 10 m of these sample locations, as required under the previous licence (Condition 5). Analysis will be same as undertaken to inform this BPEO as described above.

Sediment analysis data from Bo'ness disposal site from 2015 is presented in *Appendix A,* along with data from other spoil disposal sites. Concentrations of metals and PCBs are found to be similar to those from the other spoil disposal sites in the Firth of Forth.

1.5 Scope of the Study

This report provides an appraisal of available disposal options and short-lists those that are considered to be practicable. Options are reviewed according to the Waste Hierarchy, as outlined in the European Waste Framework Directive (2008/98/EC) (2). The options on the short-list are then reviewed against strategic, environmental and cost considerations. The options are then compared and the BPEO identified.

(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

(2) Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives. Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32008L0098

The remainder of this report is structured as follows.

- *Section 2* describes the BPEO assessment method.
- *Section 3* describes each of the available disposal options and summarises their respective advantages and disadvantages.
- *Section 4* compares the 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:* 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 *ie* 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.

Information was obtained through literature review and consultation with the following consultees.

- Forth Ports Ltd;
- Marine Scotland;
- The Crown Estate;
- Scottish Environment Protection Agency (SEPA);
- Northern Lighthouse Board (NLB);
- Forth District Salmon Fishery Board;
- Scottish Natural Heritage (SNH);
- Falkirk Council; and
- Maritime and Coastguard Agency (MCA).

2.2 Identification of Options

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

1. beach nourishment;
2. coastal reclamation and construction fill;
3. spreading on agricultural land;
4. sacrificial landfill;
5. incineration;
6. other disposal options and reuse; and
7. sea disposal.

2.3 Preliminary Appraisal

A preliminary appraisal of each of the options identified above was undertaken, including an assessment of the practicability of each option with regard to availability of disposal sites. Following the preliminary appraisal those options that are considered to be practicable were short-listed for further consideration.

2.4 Assessment of Options

The short-listed options were then subject to detailed assessment. The parameters which were used to assess the short-listed options are described below.

2.4.1 Strategic Considerations

Strategic considerations included the following.

- Operational practicability - focusing on whether the option is technically and operationally practicable.
- Availability of sites/facilities - considering whether there are any sites or facilities which can take the dredge spoil.
- Security of option - examining whether Forth Ports will have control over all stages of the disposal.
- Established practice - considering whether technologies and techniques proposed are established and therefore whether the performance and potential difficulties of the technologies and techniques can be anticipated.
- General public acceptability - gauging whether the public are likely to object to or support the proposals.
- Likely Agency acceptability - gauging 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.

- Safety. Considering potential sources of hazard and probability that there would be any risk to the general public or workers.
- Public health. Assessing whether there would be any risk of a detrimental effect on public health, based on predicted pathways and receptors.
- Contamination/pollution. Evaluating whether there is potential for pollution or contamination that could result in failure to meet Water Framework Directive (WFD) 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 users of the estuary, docks 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 following.

- Capital cost (site costs, construction and equipment hire /purchase costs).

- Maintenance/operational cost (transport costs, disposal costs including site operation).

2.5 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) were also used where the assessment was 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 EU Habitats and Birds Directives will not be affected.	Priority species and habitats under the UK Biodiversity Action Plan and qualifying features and species under the EU Habitats and Birds Directives may be slightly affected.	Priority species and habitats under the UK Biodiversity Action Plan and qualifying features and species under the EU Habitats and Birds Directive 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 maintenance	£5m or less.	Between £5m and £10m.	More than £10m.

3. DESCRIPTION AND PRELIMINARY ASSESSMENT OF AVAILABLE DISPOSAL OPTIONS

3.1 Introduction

This section describes the seven identified disposal options, reviewing the steps required for each option, namely:

1. beach nourishment;
2. coastal reclamation;
3. spreading on agricultural land;
4. sacrificial landfill;
5. incineration;
6. other disposal options and reuse; and
7. disposal at sea.

A description of the predicted impacts of the disposal operations is presented in *Appendix B* and copies of significant correspondence are provided in *Appendix C*.

The identified disposal options are described and issues and requirements associated with each option are discussed below. The section concludes by identifying those options that are short-listed for further consideration in the BPEO process.

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.

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 some discussion of the practicalities of undertaking these steps at the Port of Grangemouth.

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 there are no existing suitable landing facilities at Grangemouth a new landing facility and storage area would be required at the port 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 construction 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 rather than a liquid. Forth Ports confirmed that 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.

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

Settling Lagoons

Settling lagoons are likely to be large, ring-dammed structures into which the dredged material would be pumped. 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) 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.

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 lagoons close to the port is considered to be low. Furthermore, as the material contains metals, PAHs and TBT (see *Appendix A* for sample analysis data) 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^3hr^{-1} depending on unit size and material solids content. Other systems may be available that can process material at different rates, however, for the purposes of this assessment a rate of 150 m^3 hr^{-1} has been used. This is typically only an option for firmer sediments made up of fine sands and muds, such as those from stations within the docks at the Port of Grangemouth. If material can be dried at a rate of 150 m^3 hr^{-1}, to dewater a total volume of approximately 1,700,000 m^3 would require approximately 67 weeks (operating 24 hours a day, 7 days a week). Other units with lower throughputs could take longer.

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 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. This drying process achieves the best level of dryness of the three options, however, can take significantly longer than using a centrifuge and is considerably more expensive than either of the other two options.

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 treatment/disposal sites. The required infrastructure would include hard standing to allow a fleet of HGVs to be loaded by mechanical excavators. Although hard standing is available at the Port of Grangemouth, there are no storage or dewatering sites in Grangemouth.

Assuming the materials can be dried to a water content of 10% (by volume) at the Port of Grangemouth, the estimated 1,589,500 m^3 (1) of dried materials would require transport 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 1,589,000 m^3 of dried (to 10% water content) material equates to approximately 2,161,040 tonnes (2). Assuming 20 tonne capacity sealed HGVs are used, this would equate to 108,052 return trips or 216,104 vehicle movements.

The significance of the number of movements will be dependent upon the distance to the disposal/treatment site and the existing volume of HGVs on the haulage routes. The access road to the Port of Grangemouth exits onto the trunk road network where the HGV count is estimated as 385,805 per year (averaged 2018 data (3)). The additional HGV movements as a result of the dredging operations would increase this current level by approximately 56% per year. There may also be an issue with regard to increase in HGV traffic flows if minor roads are used to reach disposal/treatment sites.

3.2.5 Disposal/Treatment Issues

Neither method of the drying process (*eg* lagoons or centrifuge) is likely to reduce the concentration of PCBs, PAHs, metals, TBT and salt present within the dredged material. This may 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. In line with the Environment Agency Technical Guidance it is considered likely that the dredged material would be classed as non-hazardous, however, confirmation of this would require further analysis of the material by SEPA.

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.

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 port for disposal on land it will be classed as waste. It then requires disposal at a licensed waste management facility and to be transported by a registered waste carrier. Alternatively, the material could be disposed of under an activity which was exempt from waste licencing (*eg* the treatment of land for agricultural benefit or ecological improvement), which would require approval from SEPA.

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.

(1) 1,700,000 m^3 total spoil at 85% solids content equals 1,445,000 m^3 plus 144,500 m^3 (10% water content) equals 1,589,500 m^3.

(2) Based on a weight of 1.36 tonnes per m^3 of dredge spoil derived from five sediment samples collected in the 2019 survey.

(3) Traffic counts Scotland. Data for the A904 outside the Port of Grangemouth. https://roadtraffic.dft.gov.uk/manualcountpoints/40965 Accessed 05/08/2019

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. The sediment from within the proposed dredge zone comprises fine material. The sediment from the Port of Grangemouth is not suitable for beach recharge due to the particle size distribution and the presence of contaminants such as metals, including TBT, and organics (PAHs and PCBs). SNH has previously stated that it would only be appropriate to use material on a beach of similar substrate and provided contaminant levels were not of concern.

Given the incompatibility of the fine sediment material with sandy beach sediments, the contaminant concentrations in the material to be dredged, beach nourishment is not likely to be a feasible 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 Falkirk Council 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 at a time that fits with the dredging programme. In addition, the dredged material would not be suitable for many reclamation sites due to the low compressive strength properties of mud. 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 SNH due to the potential impact on designated areas in the Firth of Forth and Forth Estuary.

3.4.3 Construction Material

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

3.5 Spreading on Agricultural Land

3.5.1 Process Description

It is possible to obtain an exemption from waste management licencing for treatment of land, usually by land spreading, with certain non-agricultural wastes such as paper waste, food waste or sewage sludge. The disposal of marine spoil to agricultural land would involve landing, dewatering, possibly storage, desalination and transport for disposal.

Dewatering the dredged material 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 Forth Estuary.

The material to be dredged has concentrations of metals, but these are generally lower than the average content in sewage sludge which is presently spread on land. This is based on Scottish Agricultural College data as provided in *Table 3.1* and concentrations of metals in the Port of

Grangemouth and Bellmouth sediments in *Table 3.2,* which compares metal concentrations in the dredged material from previous sampling efforts in the Port of Grangemouth and with levels from other ports in the Forth Estuary and Firth of Forth.

Table 3.1 Typical Concentrations of Metals in Sewage Sludge Applications to Land

	Cd	Cr	Cu	Hg	Ni	Pb	Zn
Typical Sewage Sludge metal concentration ($mgkg^{-1}$)	3	55	300	2.2	30	270	630
Normal soil concentration	0.5	50	20	0.1	25	20	80
UK max allowable soil concentration ($mgkg^{-1}$)	3	400	100	1	60	300	200
Number of applications to reach limit value -(assuming 5t/ha dry weight solids)	500	3818	160	245	700	553	113

Key: Cd = Cadmium, Cr = Chromium, Cu = Copper, Hg = Mercury, Ni = Nickel, Pb = Lead, Zn = Zinc.

Source: Scottish Agricultural College, Technical Note – Use of Sewage Sludge on Agricultural Land, 1997.

Table 3.2 Concentrations of Metals in the Port of Grangemouth Sediment (1988-2019) with those from other Forth Estuary and Firth of Forth Ports

Metal Concentration (expressed as mg kg^{-1} on air dried sediment)								
	As	**Cd**	**Cr**	**Cu**	**Hg**	**Ni**	**Pb**	**Zn**
Grangemouth 2019								
Mean	16.9	0.3	64.2	86.8	0.9	33.0	73.6	213.7
Range	12.5-29.9	0.1-1.2	29.0-121.0	15.8-326.0	0.2-3.1	18.5-41.3	30.0-174.0	82.3-549.0
Grangemouth 1988 – 2016								
Mean	14.4	0.2	73.8	47.4	1.2	32.2	69.7	143.4
Range	0.0-43.6	0.0-0.8	10.7-211.0	3.0-353.0	0.0-3.8	7.6-80.6	9.3-209.0	28.9-743.0
Rosyth 2000 – 2017								
Mean	17.1	0.2	72.2	39.7	1.0	34.2	71.7	152.3
Range	12.4-21.9	BDL-4.5	46.3-105.0	22.5-189.9	0.4-2.6	24.6-43.4	43.1-137.5	88.4-1,730
Leith 1990 – 2017								
Mean	13.1	1.1	61.4	71.1	1.2	39.8	134.5	261.3
Range	4.6-21.6	0.0-6.12	14.1-114.00	12.8-286.0	0.2-4.4	13.0-80.40	29.0-787.0	62.6-687.0
Methil 2003 – 2016								
Mean	10.0	0.4	32.4	36.8	0.2	22.3	29.5	127.8
Range	2.8-17.3	BDL-0.7	10.1-72.8	11.2-68.1	0.1-0.3	7.1-31.3	7.5-66.2	32.2-284.0

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

BDL = Below Detectable Limit. Source: Marine Scotland

The data from the 2019 Port of Grangemouth survey shows all metal concentration samples, with the exception of cadmium, to be within the range of those previously collected from Grangemouth. Due

to the presence of PCBs, the spoil cannot be applied to land without confirmation from SEPA that levels of these contaminants are acceptable.

Approximately 200,000 tonnes of sludge are recycled to agricultural land per annum across Scotland. Forth Ports are seeking to dispose of approximately 1,589,000 m^3 of dewatered material (approximately 2,161,040 tonnes at 1.36 tonnes m^{-3}) of dried material, equating to approximately 1,080% of the current volume of annually recycled sludge in Scotland.

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

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 above it is understood that the waste would be classified as non-hazardous 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 two sites within an hour's drive from the Port of Grangemouth able to accept the material. A suitable landfill site is located at Avondale Landfill, Polmont, approximately seven kilometres southeast of the Port of Grangemouth. However, the Avondale site is not large enough to accommodate all of the dredged material, and would only consider taking some of the dredged material upon closure of one or all of the phases within the plant.

Fife Council landfill site in Cupar, approximately 45 miles north of Grangemouth, also has the capability to accept non-hazardous material, although not the volume required (1).

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 Forth Ports own the seabed at the Port of Grangemouth, no royalties are due to The Crown Estate.

Costs are based on disposing of the maximum volume of dredged material being applied for in this Marine Licence; in this case, approximately 1,700,000 m^3.

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.

(1) SEPA Landfill sites and capacity report for Scotland, 2014.

The average organic content of the dredged material is 3.5% 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 by only 15% *i.e,* 5% organics plus 10% water content. Incinerator operators generally require material to have an organic 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 metals (including TBT), PAHs and PCBs. In a typical thermal desorption incineration process it is likely that PCBs, salt and most of the mercury (around 80%) would be removed. In addition, the leaching potential of other metals would be reduced (except for arsenic) and as a result, the ash would still be contaminated. Pre-treatment would 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 408 km 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

This would involve the construction of a pipeline to take the dredged material to a high tide point on the Kinneal mudflats and injecting it at velocity back into the mudflats. The advantage of this is that it effectively returns the sediment to its source. The disadvantage is that the re-injection at velocity would be likely to have an adverse impact on the protected mudflat habitat through disturbance and erosion and may affect the ornithological interest of the mudflats.

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. 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.

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. 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). This option would not be feasible at the Port of Grangemouth due to lack of necessary handling facilities and the potential contamination levels in the dredged spoil. In addition, there is no known demand for this material to be used in top soil production.

(1) Baldovie Waste to Energy Plant, pers comm, January 2014

(2) Permanent International Association of Navigation Congresses. Permanent Technical Committee II. Working Group 19. 1992. Beneficial Uses of Dredged Material, Issue 19.

3.9 Disposal to Sea

3.9.1 Process Description

Disposal at sea involves the dredge material being transported to a licensed disposal site in a dredging vessel. It does not require landing of dredged material. Since the BPEO process commenced in 1997, disposal to sea has been the BPEO for the spoil arising from the maintenance dredge at Grangemouth, and at the other ports and harbours with the Forth Estuary and Firth. It involves the dredger sailing to a licenced disposal site and releasing the materials, usually by lowering the excavator head into the water or through bottom doors. A differential global positioning system (dGPS) would be used to position the vessel in the disposal area and records of the spoil discharge locations would be retained.

There are seven licenced marine disposal sites 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 Grangemouth, Forth Ports would propose to use the Bo'ness spoil ground located 1.4 nautical miles from the Port of Grangemouth. This site has historically been used for the disposal of dredged material from Grangemouth and is the closest site to the port, thus minimising the distance for vessel transport.

The current disposal operations relocate the spoil to the easternmost edge of the Kinneil mudflats. The same mudflats are eroded at their western end and the mud deposited into the Bellmouth. The dredged material is therefore likely to have similar properties to the seabed material at the disposal site.

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

3.10 Conclusion

The description of the available options allows options that are evidently impracticable to be ruled out. 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 Firth of Forth and there are no beaches within the Firth of Forth or Forth estuary 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. 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 is practicable and there are two local sites. 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.	Short-list
Incineration	This option does not appear to be practicable. The material is not suited to incineration due to low organic content and large 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 the previous two dredging campaigns at the Port of Grangemouth.	Short-list

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*.

The environmental effects of disposal at sea are addressed in *Appendix B.*

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 drying the material and desalination for disposal on land. This option would be achievable if disposal sites were available adjacent to the Firth of Forth. As no sites requiring this grade of material for reclamation or construction fill have been identified, the materials would require landing, drying, storing and transporting to the disposal site.

Classification: Medium

Availability of Sites

No coastal sites within the Firth of Forth have been identified at this time through the consultation process. Avondale landfill site has indicated that it may potentially have the capacity to accommodate the dredged material, however, without further analysis of the sediment is unable to comment on the suitability of the material and the associated cost of disposal to landfill.

Classification: Low

Security of Option

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

Classification: Low to Medium

Established Practice

The use of suitable dredged materials in coastal reclamation and construction fill is common practice and the technologies and techniques are well established.

Classification: High

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 land, which may be viewed as unacceptable by local residents and road users.

Classification: Medium to High

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 proposed 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 Grangemouth 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 landed, the dredged material would be defined as controlled waste under Schedule 3 of the Controlled Waste (Scotland) Regulations 1992. As such, Section 34(7) of the Environmental Protection Act 1990 and Section 1 of the Control of Pollution Act 1974 would apply.

The disposal of dredged material will also require a waste management licence under the Waste Management Licencing Regulations 1994 and an exemption for reclamation works. Consent will be required from the planning authority and a levy paid to The Crown Estate (see Section 3.6.3).

Classification: Medium

4.2.2 Health, Safety and Environmental Considerations

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: Low

Public Health

A risk to public health due to the significant increase in HGV traffic may arise.

Classification: Low to Medium

Pollution / Contamination

The material is considered non-hazardous due to the levels of PCBs and metals and would therefore be suitable for disposal of in reclamation or construction fill. There may be localised and temporary deterioration in air quality as a result of HGV movements.

Classification: Medium to High

Ecological Impacts

There are unlikely to be any ecological risks resulting from the use of dredged materials for reclamation and there would be no impact on national or local priority species or habitats.

Classification: High

Interference with Other Legitimate Activities

The disposal of dredged material is unlikely to interfere with other activities unless the reclamation site is in a harbour or port area, in which case the dredger may interfere with other harbour or port users. 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 is no risk 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 transported by road, the estimated costs below would apply.

- discharge berth: £2 m;
- pumping material to site – approximately £8.75 per m^3 (1) £13,908,125; or
- dockside centrifuge facility capable of dewatering and desalinating 1,700,000 m^3: £20 m - £30 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): £10,805,200.

Total £12.4 m to £42.8 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 2,161.040 tonnes of dried material would require transport. Practically this is unlikely to be achievable due to difficulties relating to drying and transportation.

Classification: Low to Medium

Availability of Sites / Facilities

Under the Landfill (Scotland) Regulations 2003 the low presence of PCBs (less than 50 ppm) identified in the 2019 data would classify the material as non-hazardous rather than inert and consequently reduces the number of available landfill sites capable of accepting this material. The nearest suitable site is located at Avondale Landfill, Polmont, approximately 7 km from the Port of Grangemouth. Avondale has advised that it would be able to receive the material, however would require a more in depth analysis to include pH and total petroleum hydrocarbons before confirming acceptance and cost.

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

(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.

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 the Port of Grangemouth to potential landfill sites may be unacceptable to residents and other road users.

Classification: Medium

Likely Agency Acceptability

The National Waste Strategy establishes the direction of the Scottish Executive's policies for sustainable waste management to 2020. One such policy is to reduce landfilling of municipal waste from 90% to 30% 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.

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 will 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

4.3.2 Health, Safety and Environmental Consideration

Safety

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: Low

Public Health

A risk to public health due to the significant increase in HGV traffic may arise.

Classification: Low to Medium

Pollution/Contamination

There would be little risk of contamination because of the materials being disposed of in landfill. However, there may be a small risk of leaching of contaminants that should be contained on site. EQSs are unlikely to be breached due to protection offered by the landfill when accepting contaminated waste.

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.

Classification: High

Interference with Other Legitimate Activities

The increase in HGV movements may interfere with other road users. Baseline traffic data for the A904 in the vicinity of the Port of Grangemouth indicates that in 2018 HGVs made up an average of 10% of all traffic of road traffic in and around Grangemouth. As a result of the proposed disposal to

landfill, the total HGV movements would increase to 17% of all traffic in the vicinity of Grangemouth. Depending on the landing and storage arrangements there may be potential for interference with other harbour 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: £2 m;
- lagoons to settle dredged material - £2.5 m; or
- dockside centrifuge facility capable of dewatering and desalinating 1,700,000 m^3: £20 m - £30 m;
- 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): £10,805,200; and
- a Waste Management Licence.

Total £15.3 m to £42.8 m

Classification: Low

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 2,161,040 tonnes of dried material would require transport. There are practical difficulties relating to handling the dredged material at the Grangemouth site. The availability of suitable factories/facilities to process the dredged material and markets for the final products are also considerations.

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 or brick making.

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

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

Established Practice

Use of excavated materials for brick making or concrete aggregate is common practice but use of marine material 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.

Classification: 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

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 with the movement of materials, particularly if HGVs travel through settlements and along minor roads.

Classification: Low

Public Health

A risk to public health due to the significant increase in HGV traffic may arise.

Classification: Low to Medium

Pollution / Contamination

Pollution is not likely to be an issue provided emissions are controlled in accordance with licences.

Classification: Medium to High

Ecological Impacts

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.

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:

- discharge berth: £2 m;
- lagoons to settle dredged material - £2.5 m; or
- dockside centrifuge facility capable of dewatering and desalinating 1,700,000 m^3: £20 m - £30 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): £10,805,200.

Total £15.3 m to £42.8 m

Classification: Low

4.5 SEA DISPOSAL

4.5.1 Strategic Considerations

Operational Feasibility

Operationally disposal at the Bo'ness 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 the present discharge route, it has been proven and all necessary equipment and logistical arrangements are 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 east of the bridges have been indicated by Forth Ports as available at this time for the Grangemouth dredged material.

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 Bo'ness disposal site is the current practice for the disposal of the dredged spoil from Grangemouth. It is, therefore, established and proven as effective.

Classification: High

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

General Public Acceptability

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

Classification: High

Likely Agency Acceptability

Consultations with the regulatory bodies to date indicate that there is no objection to Sea Disposal at Bo'ness. SEPA has no objection should there be no other suitable reuse options. Marine Scotland has not expressed an objection to the continued use of Bo'ness disposal site. The Crown Estate did not raise an objection and will generally consent to disposal of dredged material at sea on the condition that all other relevant consents are obtained. Scottish Natural Heritage and the National Lighthouse Board did not highlight any objections to spoil disposal at sea. The Forth District Salmon Fishery Board (FDSFB) highlighted concerns surrounding time of year of disposal coinciding with seaward migration of salmon smolts and requested that disposal is avoided during June and July. Due to the rate of sedimentation in the Bellmouth this cessation of dredging for a period of two months would not be possible. The suspended sediment maxima in the Forth Estuary is in the upper estuary in summer, where the smolts migrate through, and short term and localised increases in suspended sediment at the Bo'ness spoil ground is not considered to present a barrier to migration. This issues 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 for disposal of spoil to The Crown Estate owned sea bed, and under the provisions of the Marine (Scotland) Act 2010 it has the right to veto any consent for works in tidal waters which may constitute a hazard to navigation.

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. The contractor appointed to undertake the dredging and disposal may be subject to a health, safety and environmental audit by Forth Ports.

Classification: High

Public Health

The risk of members of the general public being exposed to contamination from the dredged material is regarded as low. Commercial species of demersal fish are not taken from the area and no food chain links between sediment contamination or contamination liberated into the water column, and human consumers leading to impacts on public health are considered unlikely.

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 and failure

to meet Water Framework Directive (WFD) objectives although based on current evidence this would be localised and short-term.

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. 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. This is discussed in *Section 4.5.1* and *Appendix B*. Under the proposed disposal proposals, cumulative impacts with other operations are not predicted to create a significant impact to the Firth of Forth SPA, Forth Islands SPA, Firth of Forth SSSI, 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 disposal activities may cause some disruption to other users of the estuary the dredging works contribute to the functioning of the Port of Grangemouth and are controlled directly by Forth Ports resulting in overall positive impacts. In addition, historic operations at Bo'ness have not resulted in any reported disruption to other Forth Estuary users.

Classification: High

Amenity/Aesthetic

The disposal activities may cause some short term disruption to other users of the Forth Estuary but the proposals will contribute to the normal functioning of the Port of Grangemouth and maintain its capacity to accommodate larger vessels.

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 £1 million.

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 Grangemouth. These were reduced to a short-list of four options based on practicality. 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 Sacrificial Landfill

Operationally, disposal to landfill will be achievable but problematic. 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 the National Waste Strategy Scotland (1999) favours a reduction in the volume of material disposed by landfill.

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, along with elevated carbon dioxide emissions. The costs of this option outweigh the other short-listed options, due to the requirement for construction of a landing and storage facility, a drying facility and high transport costs.

5.2.2 Coastal Reclamation and Construction Fill

Operationally coastal reclamation and construction fill would be possible; however it is estimated to be costly and will 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 some gravel fractions from samples in the Bellmouth, with low compressive strength properties, making it unsuitable for most types of construction. In addition, the presence of some metals and PCBs classes it as non-hazardous [(1)], which 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.

5.2.3 Other Disposal Options and Reuse

Operationally this option would be achievable but there would be difficulties associated with the requirement to land, store, dry and transport the material. 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. There would be potential for benefit through substitution of recycled material for primary minerals.

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

(1) Waste Classification (2015). Guidance on the classification and assessment of waste (1st edition 2015). Technical Guidance WM3.

amenity and little interference with other legitimate users. As with Sacrificial Landfill, Coastal Reclamation and Construction Fill, capital costs would be high because of the need for landing, storage and drying facilities and transport costs.

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 Bo'ness and this site is has been historically used for disposal of dredged materials from Grangemouth and other harbours and docks within the Firth of Forth and Forth Estuary. It is anticipated that this option will be acceptable to both public and agencies. 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 short-term effects on water quality during disposal, such as raised turbidity and suspended sediment levels, which may have slight ecological effects but these are considered to be of low significance. 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 Grangemouth. 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 sea disposal site. The preferred site for this is the Bo'ness disposal site.

Table 5.1 Summary of Assessment of Options

Consideration	Sacrificial Landfill	Coastal Reclamation and Construction Fill	Other Disposal Options and Reuse	Sea Disposal
Operational feasibility				
Availability of sites/facilities				
Security of option				
Established practice				
General public acceptability				
Likely agency acceptability				
Legislative implications				
Safety				
Public health				
Pollution / contamination				
Ecological impact				
Interference with other activities				
Amenity / aesthetic				
Capital and maintenance costs				

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

APPENDIX A SEDIMENT SAMPLE CHEMICAL ANALYSIS

A1 GRANGEMOUTH SEDIMENT SAMPLE DATA

A1.1 Introduction

Samples of the seabed sediments to be dredged were collected from the harbour and approach channel seabed by ERM and Forth Ports on 10th July 2019 and were analysed by SOCOTEC.

The survey plan followed the Marine Scotland guidance and was agreed with Marine Scotland on DATE. Based on the dredging depths of up to 1 m and estimated dredge volumes, surface samples from 29 sample stations were required. Sample station locations are presented in *Figure A1.1*.

Samples were taken using a van Veen grab and the sample retrieved from each survey station was 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 and a photograph and description of the sediment taken. Sediment photographs are presented in *Figure A1.2*.

Samples were sent by courier in coolboxes to the analytical laboratory on the same day as sampling.

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

- metals (As, Cd, Cr, Cu, Hg, Ni, PB, Zn);
- DBT;
- TBT;
- PAHs;
- PCBs;
- presence of asbestos;
- Total Organic Carbon;
- sediment solids/water content; and
- sediment particle size distribution.

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. *Table A1.1* presents the locations of the sediment samples taken from the Port of Grangemouth.

Table A1.1 Location of sediment samples

Station name	Latitude	Longitude
G19-01	56 02.31048’ N	3 40.62913’ W
G19-02	56 02.31666’ N	3 40.76315’ W
G19-03	56 02.31834’ N	3 40.91115’ W
G19-04	56 02.22697’ N	3 40.59548’ W
G19-05	56 02.24667’ N	3 40.72348’ W
G19-06	56 02.25463’ N	3 40.85149’ W
G19-07	56 02.19022’ N	3 40.75029’ W
G19-08	56 02.17134’ N	3 40.88418’ W
G19-09	56 02.23144’ N	3 41.00093’ W
G19-10	56 02.29181’ N	3 41.07652’ W
G19-11	56 02.23028’ N	3 41.13822’ W
G19-12	56 02.26802’ N	3 41.22511’ W
G19-13	56 02.25222’ N	3 41.35385’ W
G19-14	56 02.04348’ N	3 41.44112’ W
G19-15	56 01.98730’ N	3 41.38207’ W
G19-16	56 01.98892’ N	3 41.56437’ W
G19-17	56 01.87491’ N	3 41.52880’ W
G19-18	56 01.79049 ‘N	3 41.60898’ W
G19-19	56 01.57787’ N	3 41.93263’ W
G19-20	56 01.51548’ N	3 41.89414’ W
G19-21	56 01.43941’ N	3 42.08754’ W
G19-22	56 01.54460’ N	3 42.06141’ W
G19-23	56 01.45537’ N	3 42.36186’ W
G19-24	56 01.45371’ N	3 42.72063’ W
G19-25	56 01.48124’ N	3 42.98719’ W
G19-26	56 01.48214’ N	3 42.99477’ W
G19-27	56 01.48125’ N	3 43.00637’ W
G19-28	56 01.42934’ N	3 43.20054’ W
G19-29	56 01.33639’ N	3 43.38253’ W

Coordinates in degrees, decimal minutes, WGS84

Sample Location

Maintenance Dredge Area

0 100 200 300 400 500

Metres

N

Figure A1.1

Port of Grangemouth Actual Sample Sites

SCALE: See Scale Bar	VERSION: A01
SIZE: A4	DRAWN: LST
PROJECT: 0352017	CHECKED: CM
DATE: 17/07/2019	APPROVED: MI

ERM

CLIENT:

Forth Ports Ltd.

PROJECTION: British National Grid

Path: P:\Projects\0352017 Forth Ports Grangemouth2016.MI\00 GIS\MAPS\0352017_ActualGrabSampleLocations_20190716_A01.mxd

Figure A1.2 Photographs of Sediment Samples

							
G19-01	**G19-02**	**G19-03**	**G19-04**	**G19-05**	**G19-06**	**G19-07**	**G19-08**
							
G19-09	**G19-10**	**G19-11**	**G19-12**	**G19-13**	**G19-14**	**G19-15**	**G19-16**
							
G19-17	**G19-18**	**G19-19**	**G19-20**	**G19-21**	**G19-22**	**G19-23**	**G19-24**
							
G19-25	**G19-26**	**G19-27**	**G19-28**	**G19-29**			

A1.2 Marine Scotland Action Levels

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

In general, contaminant levels in dredged material below Action Level 1 are of no concern and are unlikely to influence the licensing decision. A breach of 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 (mgkg-1 dry weight)	AL2 (mgkg-1 dry weight)
Arsenic	20	70
Cadmium	0.4	4
Chromium	50	370
Copper	30	300
Mercury	0.25	1.5
Nickel	30	150
Lead	50	400
Zinc	130	600

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

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

A1.3 Metal Results

Concentrations of metals are presented in *Table A1.4*. Levels above Marine Scotland Action Level 1 are highlighted in yellow and concentrations above Action Level 2 are highlighted in blue.

Table A1.4 Analysis of Metal Contaminants from Port of Grangemouth (mg kg^{-1} Dry Weight) 2019

Station	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
G19-01	16.6	0.2	56.0	28.8	0.6	32.0	47.2	119.0
G19-02	33.2	0.2	33.8	20.2	0.3	22.0	33.6	95.3
G19-03	28.2	0.1	29.0	15.8	0.2	18.5	30.0	82.3
G19-04	14.2	0.2	46.4	27.2	0.5	26.5	41.1	104.0
G19-05	16.2	0.2	63.2	32.9	0.7	33.2	55.5	130.0
G19-06	17.3	0.2	54.3	29.5	0.6	29.2	49.1	122.0
G19-07	16.5	0.9	69.9	67.9	0.8	39.7	70.3	228.0
G19-08	15.2	0.2	56.3	32.9	0.7	31.5	52.1	126.0
G19-09	16.0	0.2	60.4	30.8	0.7	32.5	53.7	128.0
G19-10	29.9	0.2	51.1	26.6	0.5	28.7	55.0	126.0
G19-11	16.3	0.2	55.9	32.6	0.6	31.5	52.5	128.0
G19-12	13.4	0.2	52.3	30.5	0.6	29.5	48.9	131.0
G19-13	16.9	0.2	63.4	33.8	0.7	33.5	62.7	138.0
G19-14	14.3	1.2	70.0	101.0	0.6	39.6	66.4	282.0
G19-15	14.5	0.9	62.4	75.3	0.6	36.9	63.8	217.0
G19-16	14.7	0.2	56.5	38.4	0.7	30.4	51.0	137.0
G19-17	13.8	0.7	62.2	73.1	0.6	35.4	61.2	206.0
G19-18	15.5	1.1	71.2	89.8	0.7	40.4	72.4	262.0
G19-19	15.7	0.3	64.2	71.6	0.9	34.6	60.9	187.0
G19-20	14.5	0.2	62.7	76.0	1.0	32.9	124.0	219.0
G19-21	15.6	0.3	69.3	87.5	1.3	35.2	81.6	223.0
G19-22	13.6	0.2	69.2	89.3	1.0	35.0	70.1	202.0
G19-23	14.3	0.2	78.0	108.0	1.2	36.2	76.8	243.0
G19-24	19.8	0.4	121.0	157.0	3.1	38.2	130.0	374.0
G19-25	16.0	0.3	78.6	326.0	1.3	33.7	126.0	549.0
G19-26	15.5	0.3	85.8	265.0	1.5	41.3	135.0	542.0
G19-27	16.1	0.2	80.6	303.0	1.6	34.4	174.0	430.0
G19-28	12.5	0.2	68.7	135.0	1.3	29.6	90.4	241.0
G19-29	13.5	0.2	68.7	112.0	1.3	35.3	100.0	227.0
Mean	**16.9**	**0.3**	**64.2**	**86.8**	**0.9**	**33.0**	**73.6**	**213.7**

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 between 1988 and 2019. The ranges in results for all metals over the period for which there is available sample data are large. Mean mercury (Hg) levels were higher than Action Level 2 (1.5 mg kg^{-1}) on three occasions from 1988 to 2019.

Table A1.5 Comparison of Metal Contaminants from the Port of Grangemouth (mg kg^{-1} Dry Weight) 1988 to 2019

Year		As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
1988	Mean	17.5	0.3	91.6	41.8	1.3	24.5	53.6	116.0
	Range	8.6-43.6	0.0-0.5	25.5-170.0	4.8-74.4	0.2-2.8	12.0-36.4	15.8-92.0	48.6-185.0
1989	Mean	13.0	0.1	120.6	65.4	1.8	29.1	72.8	173.7
	Range	0.1-29.8	0.0-0.7	19.1-211.0	8.1-94.1	0.2-3.8	9.6-36.8	23.5-93.4	69.5-337.0
1990	Mean	11.7	0.0	83.9	65.6	1.1	27.7	72.8	158.8
	Range	8.2-14.1	0.0	71.1-112.0	52.0-88.3	0.0-2.3	25.1-29.1	54.5-89.4	122.0-231.0
1991	Mean	7.7	0.5	64.8	47.5	ND	26.3	70.4	135.7
	Range	0.0-20.0	0.0-0.8	18.2-80.4	14.4-59.2	ND	10.3-34.3	37.2-83.3	84.0-156.0
1993	Mean	10.9	0.0	52.5	50.8	1.2	29.0	72.6	142.1
	Range	10.5-11.3	0.0	45.2-72.6	39.6-71.4	0.9-1.8	25.7-34.8	58.9-90.2	119.0-208.0
1994	Mean	7.2	0.1	67.1	50.6	1.2	33.0	70.5	130.7
	Range	3.6-18.1	0.1-0.1	20.4-94.6	14.6-65.8	0.3-1.6	19.6-40.3	49.1-86.8	89.4-176.0
1999	Mean	16.7	0.2	73.2	53.5	1.7	44.3	71.3	157.1
	Range	8.3-18.8	0.1-0.3	47.1-93.3	34.6-76.3	0.7-3.8	18.6-80.7	49.4-88.2	95.5-236.0
2000	Mean	14.4	0.1	67.4	47.4	1.1	30.8	63.8	124.5
	Range	3.4-17.3	0.0-0.3	11.9-102.0	10.9-79.9	0.0-2.0	14.2-37.8	9.3-79.9	28.9-197.0
2001	Mean	16.6	0.2	75.2	47.7	1.3	36.0	80.4	142.7
	Range	14.4-18.2	0.1-0.3	60.7-117.0	36.4-79.3	1.0-3.3	31.7-40.6	68.4-94.3	122.0-185.0
2003	Mean	15.8	0.2	69	48.9	1.5	33.4	74.5	144.5
	Range	14.7-17.5	0.2-0.2	62.4-80.7	41.4-63.7	1.4-1.6	30.5-37.4	67.6-84.5	127.4-181.7
2004	Mean	17.2	0.1	69.7	44.1	1.2	34.2	75.4	148.9
	Range	14.8-18.5	0.0-0.4	56.4-79.9	34.1-57.1	0.9-1.4	29.6-36.9	64.8-79.0	122.6-179.5
2006	Mean	17.3	BDL	56.7	32.2	0.5	25.9	55.2	111.1
	Range	11.4-37.3	BDL	10.7-86.9	3.0-55.6	0.1-0.7	7.6-35.9	17.5-76.8	36.1-167.6
2007	Mean	14.4	BDL	68.8	41.1	0.8	32.5	62.2	128.8
	Range	11.9-16.1	BDL	53.1-83.8	27.2-89.7	0.5-1.2	27.3-36.9	49.0-77.9	103.0-190.0
2008	Mean	15.0	BDL	72.5	41.2	0.9	36.3	69.5	142.5
	Range	14.8-15.1	BDL	69.4-75.5	34.7-47.6	0.7-1.0	34.6-37.9	65.0-74.0	127.0-158.0
2010	Mean	16.0	0.2	68.4	41.0	1.3	33.7	73.0	156.7
	Range	15.5-16.6	0.2-0.2	56.2-80.6	29.1-52.8	1.0-1.6	30.2-37.3	64.3-81.8	126.8-186.7
2011	Mean	16.6	0.2	78.5	37.4	1.2	35.4	81.3	157.9
	Range	16.4-16.8	0.2-0.2	75.8-81.3	35.7-40.2	1.1-1.2	34.4-36.9	79.9-83.6	153.5-166.2
2016	Mean	16.7	0.1	75.2	48.9	0.7	34.9	65.2	165.3
	Range	12.4-20.2	0.1-0.2	42.1-117.0	14.6-353.0	0.3-1.4	20.7-49.5	36.6-209	79.5-743.0
2019	Mean	16.9	0.3	64.2	86.8	0.9	33.0	73.6	213.7
	Range	12.5-33.2	0.1-1.2	29.0-121.0	15.8-326.0	0.2-3.1	18.5-41.3	30.0-174.0	82.3-549.0
Mean	**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**	**10.7-211.0**	**3.0-353.0**	**0.0-3.8**	**7.6-80.6**	**9.3-209.0**	**28.9-743.0**

A1.4 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 (1).

Dry weight concentrations of ICES 7 PCBs from samples collected in 2019 are presented in *Table* A1.6. Ten stations exceeded Action Level 1 (0.02 mg kg-1) for the sum of the ICES 7 PCBs, all of which were located in the inner docks (Stations G19-19 to G19-21 and G19-23 to G19-29). In particular, stations G19-24 and G19-26 had much higher ICES 7 PCB concentrations than the other stations. No ICES 7 PCB levels exceed Action Level 2 (0.18 mg kg-1) in any of the samples.

(1) Forth Replacement Crossing: Environmental Statement 2009. Available online from http://www.transportscotland.gov.uk/strategy-and-research/publications-and-consultations/j11223-081.htm

Table A1.6 Analysis of PCBs (mg kg^{-1} Dry Weight) from the Port of Grangemouth in 2019

Station	Sum of ICES 7 PCB Concentrations
G19-01	0.0054
G19-02	0.0019
G19-03	0.0009
G19-04	0.0076
G19-05	0.0091
G19-06	0.0064
G19-07	0.0089
G19-08	0.0135
G19-09	0.0075
G19-10	0.0022
G19-11	0.0088
G19-12	0.0088
G19-13	0.0089
G19-14	0.0104
G19-15	0.0102
G19-16	0.0114
G19-17	0.0124
G19-18	0.0138
G19-19	0.0423
G19-20	0.0272
G19-21	0.0310
G19-22	0.0177
G19-23	0.0272
G19-24	0.1482
G19-25	0.0903
G19-26	0.1751
G19-27	0.0932
G19-28	0.0357
G19-29	0.0254
Mean	**0.0297**

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.

Mean dry weight concentrations of PCBs from samples collected between 1994 and 2019 are presented in *Table A1.7.* Levels above Marine Scotland Action Level 1 for total PCBs are highlighted in yellow. With the exception of 1994, 2010 and 2019, the total concentration of PCBs from all years is below Marine Scotland Action Level 1.

Table A1.7 Analysis of PCBs from the Port of Grangemouth (mg kg^{-1} Dry Weight) 1994 - 2019

Year	Sum of ICES 7 PCB Concentrations
1994	0.020
1999	0.016
2001	0.010
2004	0.013
2006	0.007
2007	0.012
2008	0.008
2010	0.020
2016	0.009
2019	0.030
1994-2019	**0.015**

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.

*surface samples only

A1.5 Polycyclic Aromatic Hydrocarbons

A comparison of mean dry weight concentrations of PAHs from samples collected between 2003 and 2019 are presented in Table A1.8. Levels above Marine Scotland Action Level 1 for individual PAHs are highlighted in yellow. No concentrations of PAHs above Action Level 2 were recorded.

Table A1.8 Analysis of PAHs from the Port of Grangemouth (µg kg^{-1} Dry Weight)

	Sample Station						
PAH	**2003**	**2004**	**2006**	**2007**	**2010**	**2016**	**2019**
Acenaphthene	-	-	-	-	-	96.6	334.6
Acenaphthylene	-	-	-	-	-	17.9	84.8
Anthracene	221.9	180.8	134.7	77.2	182.6	203.4	524.0
Benzo(a)anthracene	355.1	370.2	230.4	125.8	343.6	433.2	977.2
Benzo(a)pyrene	371.0	241.2	277.0	166.0	364.6	448.2	1,181.5
Benzo(b)fluoranthene	-	-	-	-	-	-	1,068.1
Benzo(e) pyrene	-	-	-	-	-	-	801.0
Benzo(ghi)perylene	520.1	364.5	242.1	151.9	346.9	339.5	814.7
Benzo(k)fluoranthene	-	-	-	-	-	-	524.0
Chrysene + Triphenylene	480.8	390.4	269.4	132.2	375.7	333.1	-
Chrysene	-	-	-	-	-	-	1,029.0
Dibenzo(ah)anthracene	-	-	-	-	-	78.4	168.0
Fluoranthene	637.1	568.0	418.3	234.2	595.9	787.9	1,838.6
Fluorene	109.9	89.5	61.5	38.1	76.5	120.2	271.9
Indeno(1,2,3-c,d)pyrene	376.2	395.7	238.4	171.6	335.2	348.0	821.2
Naphthalene	280.8	277.1	190.0	123.5	185.5	226.1	353.1
Perylene	-	-	-	-	-	-	399.2
Phenanthrene	522.4	449.8	310.8	172.5	389.5	577.9	1,366.2
Pyrene	788.6	643.9	523.7	284.6	695.3	727.4	1,956.7

A1.6 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.

Mean dry weight concentrations of TBT from the samples collected are presented in *Table A1.9.* Mean concentrations above Marine Scotland Action Level 1 (0.1 mg kg^{-1}) were only recorded in 2016 and 2019.

Table A1.9 Analysis of TBT from the Port of Grangemouth

Year	Mean TBT Concentration (mgkg^{-1} dry weight)
2003	0.042
2004	0.018
2006	0.034
2007	0.019
2008	<0.014
2016	0.309*
2019	0.216
Mean	0.091

* One site (G26) near a disused dry dock area returned a value of 2.5 mg/kg, without which the average TBT for the Grangemouth dredge area is 0.066 mg/kg.

(1) The development of male characteristics in females

A1.7 Sediment Particle Size Analysis

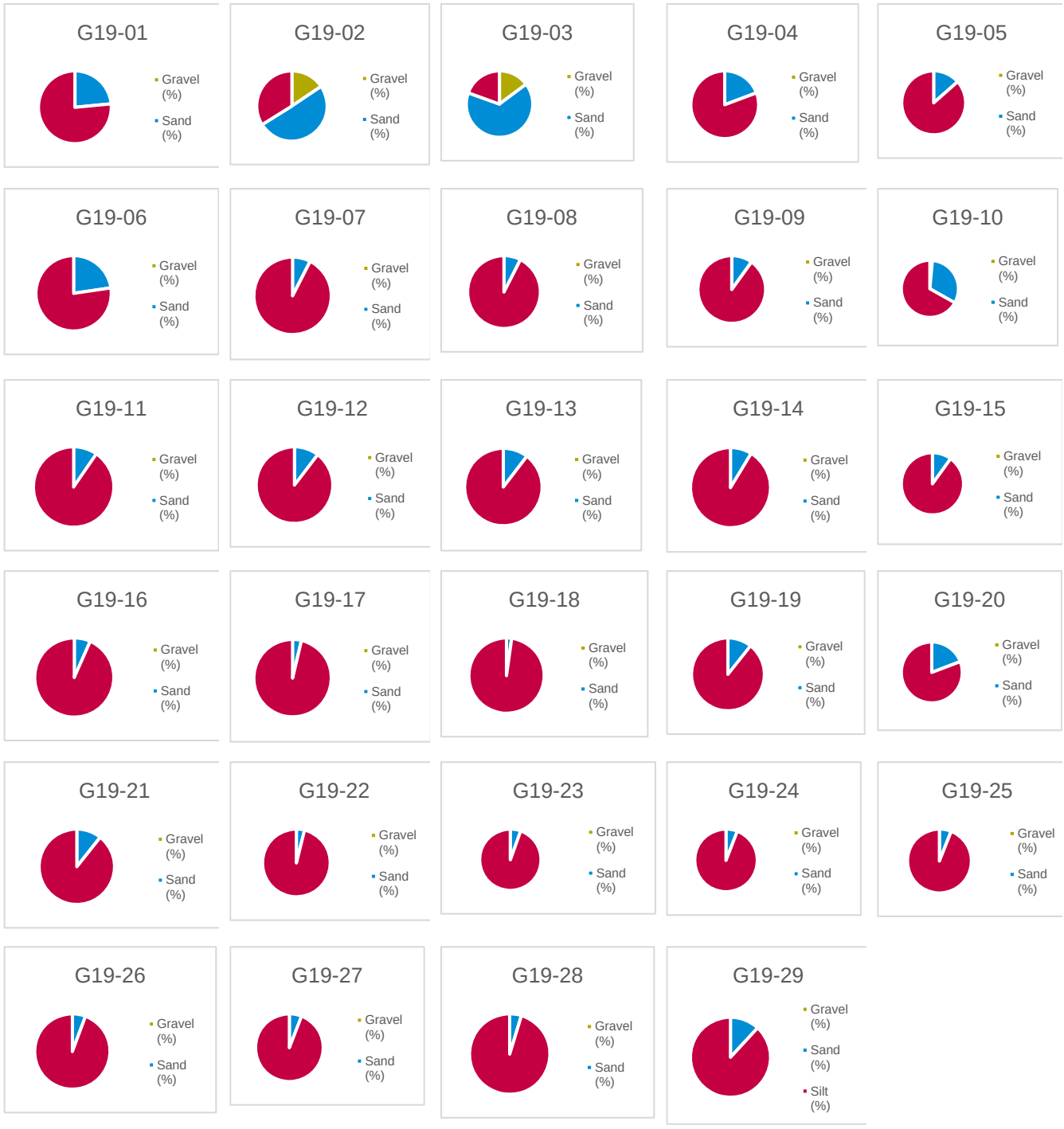
Sediment Particle Size Analysis (PSA) was undertaken on 29 sediment samples taken from the Port of Grangemouth and Bellmouth in 2019. Sediments were predominantly muddy, with smaller fractions of gravel and sand. The sandy-mud material is typical of a relatively low energy harbour environment. The samples with gravel fractions were from the Bellmouth. Table *A1.10* and *Figure A1.3* present the 2019 data.

Sediment contamination is typically higher in sediments less than 63 µm diameter *eg* silts and clays due to the increased surface area providing more adhesion sites for contaminants than the same volume of sand or gravel.

Table A1.10 Grangemouth Docks and Bellmouth Sediment PSA and TOC Data

Station	Total solids (%)	Gravel (%)	Sand (%)	Silt (%)	Total Organic Carbon (TOC)
G19-01	45.6	0.0	23.5	76.5	2.56
G19-02	62.1	15.6	50.5	33.9	1.11
G19-03	57.4	14.8	65.7	19.5	0.72
G19-04	40.4	0.0	19.3	80.7	2.98
G19-05	34.7	0.0	13.5	86.5	4.21
G19-06	37.8	0.0	22.7	77.3	4.62
G19-07	29.5	0.0	7.5	92.5	5.43
G19-08	33.0	0.0	7.5	92.5	3.90
G19-09	36.0	0.0	9.9	90.1	3.65
G19-10	56.2	1.4	31.7	66.9	1.35
G19-11	43.3	0.0	9.6	90.4	3.18
G19-12	36.9	0.0	10.4	89.6	3.20
G19-13	37.1	0.0	10.4	89.6	4.30
G19-14	33.0	0.0	8.7	91.3	5.63
G19-15	36.5	0.0	10.0	90.0	4.87
G19-16	34.9	0.0	6.6	93.4	3.81
G19-17	38.7	0.0	3.7	96.3	4.32
G19-18	37.2	0.0	2.2	97.8	5.09
G19-19	45.4	0.0	10.7	89.3	2.92
G19-20	50.4	0.0	19.2	80.8	3.03
G19-21	40.9	0.0	10.7	89.3	2.98
G19-22	43.8	0.0	3.9	96.1	2.99
G19-23	41.1	0.0	5.5	94.5	3.70
G19-24	37.9	0.0	5.9	94.1	3.38
G19-25	39.1	0.0	6.0	94.0	3.64
G19-26	37.9	0.0	5.7	94.3	4.84
G19-27	39.7	0.0	5.9	94.1	4.19
G19-28	36.8	0.0	4.7	95.3	3.01
G19-29	48.7	0.0	11.9	88.1	2.54

Figure A1.3 The Port of Grangemouth and Bellmouth Sediment PSA



2. SPOIL GROUND SEDIMENT SAMPLE DATA

Table A2.1 presents metal and PCB concentration data from sediment sampled from within Bo'ness spoil ground and from five other spoil ground sites within the Firth of Forth and Forth Estuary for comparison. Levels above Marine Scotland Action Level 1 for metals and PCBs are highlighted in yellow and above Action Level 2 in blue.

Table A2.1 Concentration of Metals and PCBs (mg kg^{-1}) from Bo'ness Spoil Ground with five other Firth of Forth and Forth Estuary Spoil Grounds

Site Name	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn	Sum ICES 7 PCBs
Oxcars 2015	15.7	0.3	79.6	41.6	1.0	35.8	78.1	141.7	0.008
(*n=3*)									
Narrow Deep 2015	52.2	11.7	0.2	63.8	24.6	0.6	30.0	58.4	0.030
(*n=5*)									
Methil 2015	8.7	0.1	18.0	9.6	<0.06	11.2	14.5	72.8	0.000
(*n=1*)									
Kirkcaldy 2015	8.9	0.1	43.1	17.0	0.2	22.0	30.6	62.9	0.000
(*n=3*)									
Blae Rock 2011	17.2	0.1	39.6	21.9	0.5	21.4	52.1	80.3	0.001
(*n=6*)									
Bo'ness 2015	18.6	0.1	59.6	26.5	0.7	27.5	54.2	114.0	0.000
(*n=5*)									

* Data provided by Marine Scotland (2019)

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

The metal data in *Table A2.1* indicate that concentrations of metals and PCBs within sediment samples from the Bo'ness spoil ground are comparable with those from the other Firth of Forth spoil grounds sampled. Both metals and PCBs are lower than the original material dredged as part of the capital dredge from Grangemouth (refer to *Table A1.4, Table A1.5, Table A1.6* and *Table A1.7*), which would be expected from a dispersive spoil ground such as Bo'ness.

Note that monitoring of spoil grounds is not mandatory therefore, the data presented in *Table A2.*1 are the most recent data available.

APPENDIX B ENVIRONMENTAL IMPACTS OF DISPOSAL OPERATIONS

B1 INTRODUCTION

This Appendix addresses the environmental impacts of the disposal of dredged material from the maintenance dredging at Port of Grangemouth at the licenced Bo'ness disposal site. Impacts on water quality, sediment quality, and habitats and species are considered. Table B1.1 presents the impact summary.

The identification and assessment of environmental impacts of dredged material in this Appendix follows recent guidance from the Environment Agency, Clearing the Waters for All [(1)].

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 IMPACTS OF DISPOSAL

B2.1 Introduction

As described in *Section 1.3* it is proposed that approximately 1,700,000 m^3 (wet weight comprising approximately 255,000 m^3 water and 1,445,000 m^3 solids) of material would be disposed at Bo'ness over a period of approximately four days per month, totalling 48 days per annum.

The material to be dredged and disposed consists primarily of sandy mud, with some gravelly fractions in the Bellmouth. The concentrations of contaminants in the material sampled are presented in *Appendix A*. In 2019, samples were taken at 29 stations (G19-01 – G19-29) and the results are summarised here.

- The mean concentrations of metals were all above Action Level 1 but below Action Level 2 with the exception of arsenic and cadmium, which were below Action Level 1. However, concentrations of copper above Action Level 2 were recorded from stations G19-25 and G19-27 and concentrations of mercury above Action level 2 at stations G19-25, G19-26 and G19-27.
- The concentration of total PCBs were below Action Level 1 in 19 of the 29 stations sampled and above Action Level 1 in 10 stations, all of which are located in the inner docks.
- For individual PAHs most were above Action Level 1 but all were below Action Level 2. This pattern was observed in the previous data from samples analysed in 2017.
- TBT concentrations were below Action Level 1 at stations G19-01 – G19-22, above Action Level 1 at stations G19-23, G19-24 and G19-29 and above Action Level 2 at stations G19-25 – G19-28. All exceedances of Action Level 1 and 2 were from samples taken from the inner docks.

Metal and PCB concentration data from sediment sampled in the Bo'ness spoil ground are presented in *Appendix A* and indicate that levels are similar those from other spoil grounds within the Firth of Forth.

B2.2 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 are also usually low, and average 3 mg l^{-1} [(3)]. In the

(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
(3) 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/

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 [(1)].

There are no designated bathing waters within 5 km of the dredging or disposal sites. The nearest is Aberdour Harbour which is approximately 25 km from the dredging site and approximately 20 km from the disposal site.

The material disposed at Bo'ness will fall to the sea bed by gravity and consist 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. There are no data available that indicate the concentration or dispersion of suspended solids from the disposal operations at Bo'ness. Data from SEPA cited in the Transport Scotland (2009) report showed sediment concentrations from June, between 2000 and 2008 at Kincardine was 130 mgl^{-1} and from Longannet was 16 mgl^{-1}. Data available from Middle Bank, located approximately 12 nm downstream from Bo'ness during dredging operations in 2008 [(2)] recorded the baseline mean suspended solids concentrations between 8.87 mg l^{-1} and 10.3 mg l^{-1} (mean 9.1 mgl^{-1}).

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)]. 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)]. Significant increases in suspended sediments associated with the disposal operations are therefore likely to be confined to the immediate area of the disposal site. Similar studies were undertaken for the Forth Replacement Crossing (Transport Scotland 2009)[4] which showed that increases in suspended sediment concentrations from dredging works were short-lived and localised.

The oxidation of anoxic sediments released into the water column has been shown to reduce oxygen concentrations by up to 58% [(5)]. 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 for EC Freshwater Fisheries Directive of oxygen concentration greater than 6 mg l^{-1} would not be met [(6)]. 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 disposal site and the extent of the area potentially affected.

Increased nutrient levels 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.

Sediment bound metals liberated during the disposal operations will rapidly become complexed with the settling sediments and re-deposited on the sea bed. Previous studies have shown that metal concentrations in the water column remained consistent following sediment disposal [(1)]. However, the continual re-suspension of sediment containing absorbed metals might cause desorption of pollutants to the water column [(7)].

(1) SEPA (1998). Winter Nutrient Distribution in the Firth of Forth, 1987 - 1997. Report TW 01/98, January 1998.
(2) ERM, 2008. Middle Bank Aggregate Production Licence: Monitoring Report. A report for Westminster Gravels Ltd.
(3) Kennish M.J. 1992. Ecology of Estuaries Anthropogenic Effects Dredging and Dredged Spoil Disposal p357-397
(4) Transport Scotland, 2009. Forth Replacement Crossing: Environmental Statement.
(5) Brown C. 1968. Observations on Dredging and Dissolved Oxygen in a Tidal Waterway. Water Resources Research Vol 4, No 6, p1381.
(6) 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-dangerous
(7) Goossend, H. and Zwolsman, J. 1996. An Evaluation of the Behaviour of Pollutants during Dredging Activities. Terra Et Aqua Mar 6, No 62 p20 (9).

Studies of the behaviour of sediment bound organic micro-pollutants (*eg* PCBs) suggest that they will reach equilibrium with the water during disposal. As the dispersed sediment falls through the water column it will be continually exposed to uncontaminated water. Consequently, the concentration of organics in the water will not reach equilibrium, and desorption will occur.

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

Although there may be some release of contaminants such as metals and PAHs 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 rapidly become complexed with particulate matter in the water column and be re-deposited on the sea bed. It is therefore not anticipated that the disposal operation at Bo'ness 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 status of the Forth Estuary and the inner and outer Firth of Forth with respect to the Water Framework Directive.

The PAHs in the sediment comprise both low molecular weight (LMW) (two and three benzene rings) and high molecular weight (HMW) (more than 3 benzene rings) compounds. PAHs tend not to be volatile and 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.

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

For all the sediment samples analysed from Grangemouth the Ph/An ratios were between 1.8 and 3.8 and the Fl/Py ratios were between 0.7 and 1.1. This suggests that these contaminants are from both combustion and petroleum hydrocarbon sources. This supports the view that recorded contamination in the sediments has been transported into the port with the accumulated sediments from the wider Firth of Forth sediment circulation system.

There was a large reduction in point source discharges of hydrocarbons and metals 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. Trace 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

(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

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 [1].

Although there may be some release of contaminants such as metals, PCBs, TBT and PAHs 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 rapidly become complexed with particulate matter in the water column and be re-deposited on the sea bed. It is therefore not anticipated that the disposal operation at Bo'ness 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 within the seabed sediments at the disposal site; however, the deposited sediment will disperse over time.

B2.3 Impacts on Benthic Ecology

The benthic macrofaunal communities recorded in proximity to Bo'ness disposal site are expected to be typical for estuarine 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].

The impact on benthic communities will depend on the comparative rates of natural deposition (currently unknown) and the deposition due to the dredging disposal operations. It is anticipated that the deposition of dredged material at the Bo'ness disposal site may result in the loss (burial) of the benthos within and in the immediate vicinity of the 'deposition zone' within the disposal site. Localised impoverishment of the fauna (in terms of abundance and diversity) is likely along the axis of tidal flow as a result of secondary impacts comprising sediment deposition subsequent to the disposal activities.

Given the relatively homogenous nature of benthic communities [3] and their exposure to the naturally high levels of suspended levels during periods of low river flow and 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 unlikely to be significant. Dredge spoil from ports and harbours within the Firth of Forth and Forth Estuary has been deposited within the Bo'ness spoil ground for over 20 years and significant impacts on benthic ecology outside of the disposal ground are not predicted.

B2.4 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 proposed SPA are designated under the Birds Directive [4] 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 Grangemouth and the disposal site during the four days per month dredging campaign, a round trip of approximately 3.0 nautical miles.

The Forth Islands SPA supports breeding seabirds that forage over a wide area. The disposal of the dredged material will result in localised increases in suspended sediment that may reduce the ability of fish eating birds to forage around the disposal site due to impaired visibility. However the area

(1) SEPA, 2014. Scottish bathing waters 2013-2014. Available online http://www.sepa.org.uk/media/39125/scottish-bathing-waters-report-2013-2014.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) 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

(4) European Communities (1979) Council Directive 79/409/EEC on the conservation of wild birds.

affected is a small percentage of the total available foraging habitat, with alternative sources of prey available close by.

The results of sediment dispersion studies undertaken by HR Wallingford [(1)] for aggregate extraction activities on Middle Bank involving the disposal of 68,000 m^3 sediment overburden (estimated 40% silt, 60% sand content) at the Narrow Deep spoil ground (approximately 15 nm southeast of Bo'ness) indicated that the maximum levels of dispersion were achieved with disposal during spring tides. The study showed that at peak tidal velocity the plume would extend 7 km west and 5 km northeast of the disposal site, *ie* along the axis of tidal flow with very little movement to the north or south and therefore not impacting coastal or intertidal areas within the SPA[(2)].

It is noted that Bo'ness is an established and long term spoil ground with disposal activities being ongoing at the time that the area was designated as an SPA. 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 SPA.

B2.5 Impacts on Fish and Marine Mammals

The River Teith Special Area of Conservation (SAC), the Isle of May SAC and the Moray Firth SAC are designated under the Habitats Directive [(3)] for their habitats and fish and mammals species of European importance.

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 Bo'ness disposal site. 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. The Forth District Salmon Fishery Board has advised that smolts are likely to be passing through the lower estuary during June and July.

A potential effect of disposal at sea is for increased levels of suspended solids to disturb fish migration routes and areas they occupy. The concentration of suspended sediment at which the passage of salmonid fish is affected has been observed to be approximately 500 mg l^{-1}[(4)]. 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 (eg exposure of between 488 to 19,364 mg/l for 96 hrs) (Bash et al 2001) [(5).]

The disposal activities will take place within a small area of the lower estuary where river and sea lamprey and salmon smolts may be present or may pass through. The fish species that may be present are mobile and able to avoid the relativity small area of elevated suspended sediments during and immediately after disposal operations. The suspended sediment maxima in the Forth Estuary is in the upper estuary with mean concentrations approximately eight times higher than in the lower estuary (130 mgl^{-1} at Kincardine and 16 mgl^{-1} from Longannet) [6] and higher than the recorded elevation in suspended sediment concentrations recorded during the Middle Bank dredging and disposal operations.

The dredging process is not continuous: the time required for one cycle (dredging - travelling - discharging - travelling) is approximately 1 hour and 30 minutes. Additional delays to avoid interactions with other vessels are common, e.g, the dredger returning from the disposal site may be

(1) HR Wallingford Ltd, 1998. Middle Bank Aggregate Dredging - Dispersion Studies. Report EX 3874.
(2) ERM, 1998. Aggregate Production Licence Application, Middle Bank, Firth of Forth: Environmental Statement. Report to Westminster Gravels Ltd.
(3) European Communities (1992) Council Directive 92/43/EEC on the conservation of natural habitats and of wild flora and fauna.
(4) 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, Vol116 pp737-747
(5) Bash J, Berman, C and Bolton S. 2001. Effects of Turbidity and Suspended Solids On Salmonids. Prepared for Washington State Transportation Commission, Department of Transportation and U.S. Department of Transportation, Federal Highway Administration
(6) Transport Scotland, 2009. Forth Replacement Crossing: Environmental Statement.

instructed by Vessel Traffic Services to wait outside the harbour to allow other vessels to enter/leave. A localised, short-term and non- continuous increase in suspended sediment concentration 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.

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 Narrow Deep spoil ground, approximately 14 nm east of Bo'ness. 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 disposal site.

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

- The small area of potential foraging affected by disposal activities at the Bo'ness disposal site.
- The short duration of disposal activities (up to four days per month).
- The small increase in total 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 Appendix 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).

Potential effects on bottlenose dolphins resulting from the disposal activities include disturbance and noise due to vessel movements and displacement of prey species as a result of increased levels of suspended sediment at the disposal site.

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

- The distance between the disposal site and the SAC is large and the proportion of the bottlenose dolphin population anticipated to pass through the area affected by disposal activities is anticipated to be low.
- The extent of vessel movements associated with the disposal activities relative to total vessel movements within the Firth of Forth.
- The short duration of disposal activities each month (four days).
- The long term existing disposal operations in the area.

B2.6 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.

(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).

Table B1.1 Summary of Significance of Impacts

Receptor	Impact Significance Justification	Impact Significance
Water quality at disposal site	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 disposal site	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 disposal site	Bo'ness is designated as a disposal site. Disposal will occur over a relatively short period and similar habitat is available in close proximity to the site.	Not Significant
Seabirds	Proposed disposal operations are over a relatively short period each month and the area affected is a small percentage of the total available foraging habitat, with alternative sources of prey available close by. Both SPAs were designated after the Bo'ness spoil site was designated, and have not been impacted by historic and ongoing disposal operations.	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.	Not Significant

B3 CUMULATIVE EFFECTS WITHIN THE FIRTH OF FORTH AND FORTH ESTUARY

B3.1 Introduction

The potential impacts of the sea disposal option have been assessed within *Section B1.2* in isolation from other activities within the Firth of Forth and Forth Estuary. 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 to activities and proposed activities with the potential to directly impact the water and / or sediment quality within the SPAs and SACs.

The limitations of assessing the cumulative impact of disposal activities with other operations, for example, commercial fishing activities, is recognised given the lack of historical and current environmental data and a detailed understanding of sediment transport regimes within the Firth of Forth and Forth Estuary.

(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

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.

Petro-Chemicals and Power Generation

The INEOS refinery and petro-chemical complex at Grangemouth are historically a dominant source of oil related PAHs in the Forth Estuary and the Firth of Forth. In 2016, INEOS constructed Europe's largest ethane storage tank, with the capacity to store up to 33,000 tonnes of liquid ethane, together with the associated pipework and jetty modifications. The ethane gas will be transported from the USA to Grangemouth by sea, increasing shipping movements and the use of Grangemouth Dock.

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 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.

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 Longannet.

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. As with Cockenzie power station, Methil abstracted water from and discharged water to the Firth of Forth for use as cooling water.

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) Regulations 1994* to the outer Firth of Forth, including Forth Bridge to Granton Harbour and from Leith Docks to Joppa. This Order, implemented in March 2003, was revoked and reissued in 2006, and still stands [(3)].

(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 Scotland. Available online http://www.scotland.gov.uk/Publications/2012/08/2345/1 .
(3)http://gateway.snh.gov.uk/sitelink/siteinfo.jsp?pa_code=8499

B3.3 Other Dredging Disposal Activities

In addition to the intended maintenance dredging activities at the Port of Grangemouth with proposed disposal at Bo'ness, Forth Ports manages five other dredging operations within the Forth Estuary and Firth of Forth. The operations comprise the following.

- 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 in Spring.
- Trailer suction dredging in Leith with disposal at Narrow Deep spoil ground: maximum capacity for maintenance dredging is 90,000 m^3 per annum, undertaken over one to two days per month.
- Trailer suction dredging in Rosyth with disposal at Oxcars spoil ground: maximum capacity for maintenance dredging is 400,000 m^3 per annum, undertaken over three days per month, as required.
- 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.
- Grab dredger and plough at Kirkcaldy with disposal at Kirkcaldy spoil ground: maintenance dredging of approximately 5,000 m^3 undertaken annually.

Other licenced dredging activities in the Firth of Forth include the following.

- Maintenance dredge of 100,000 tonnes at Rosyth for Babcock Marine 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 (DM) Crombie, maximum quantity of disposed material is 22,000 m^3 per annum for maintenance [(1)] 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, with disposal on the adjacent foreshore where it is dispersed on the incoming tide.

All the above maintenance 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.

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 will support 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 [(2)]. This spoil was disposed of at Oxcars.

(1) Rosyth International Container Terminal. Operational In-combination Assessment of Maintenance Dredging and Implications for the River Teith SAC. Jacobs, 2011.
(2) Hochtief (UK) Construction (2016). Forth Road Bridge Replacement - Queensferry Crossing. Available online http://www.hochtief-construction.co.uk/bridges_Forth_Road.shtml

B3.4 Foreseeable Future Activities within 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. 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 March 2014 2-B Energy secured investment to fund the establishment of two full-scale test units at the site (two six megawatt turbines to be located approximately 1.5 km offshore standing at 109 m above the lowest tide, 186 m to top of blade). A marine Licence was granted in January 2017 and planning permission has been granted. A scoping Report has now been submitted to Marine Scotland to erect a further seven turbines. This extension would be subject to separate consenting and if approved the developer expects that the turbines would be in place by 2020.

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 on June 2019. This scope reduced the number of wind turbine generators from 110 to 73. The turbines will occupy an area of 150 km2. Construction is expected to begin in 2021. Once fully operational the wind farm will have an export capacity of approximately 1,000 megawatts.

Seagreen Offshore Wind Farm

Scottish and Southern Electric (SSE) and Fluor joint venture partnership Seagreen Wind Energy has been awarded the exclusive development rights for the Firth of Forth Zone by The Crown Estate. 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 pf 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. Construction is expected to start in 2020.

Neart na Gaoithe Offshore Wind Farm

Mainstream Renewable Power 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. The wind farm is expected to be operational by 2023.

B3.5 Conclusions

None of the dredging operations listed in *Section B3.3* dispose of dredged material at Bo'ness spoil ground. None of the projects listed in *Section B1.3.4* have yet been constructed, so there are no predicted direct cumulative impacts from these operations associated with the disposal of dredged material from Grangemouth at Bo'ness disposal site (although vessel activity in the wider area may increase). Any significant future developments are likely to be subject to their own Environmental Impact Assessment and Habitats Regulations Assessment. The disposal impacts at Bo'ness will be localised and no significant impacts to SAC or SPA integrity are predicted.

APPENDIX C CONSULTEE RESPONSES

SEPA
Scottish Environment Protection Agency
Buidheann Dion Àrainneachd na h-Alba

ERM
6th Floor
102 Westport
Edinburgh
EH3 9DN

Our Ref: 44/10/000/0932/CW/LM

If telephoning ask for:
Calum Waddell

3 September 2019

Dear Ms Munro

ENIRONMENTAL PROTECTION ACT 1990 (AS AMENDED)
THE WASTE MANAGEMENT LICENSING (SCOTLAND) REGULATIONS 2011
DREDGE SPOIL DISPOSAL: GRANGEMOUTH MAINTENANCE DREDGE SPOIL DISPOSAL WASTE MANAGEMENT OPTIONS

Thank you for your letter concerning the above site, which I have been asked to respond to.

The waste hierarchy, as set out in the European Waste Framework Directive (2008/98/EC) should be used as a framework for any options for the use or deposition of the dredged material. Before any possible re-use or disposal to land options are identified, the dredged material will require to be suitably characterised and the composition known.

Provided the dredge 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 are detailed in schedule 1, paragraphs 7 and 9 of the above regulations. For these exemptions detailed analysis and testing of the dredged spoil and, if relevant, the receiving soil or land would need to be carried out. There are limitations on the quantities that can be used in accordance with each exemption. 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 again need to be suitably analysed to determine which landfill site(s) can accept it. Further details on waste acceptance procedures that would apply can again be found on SEPA's website.

If any dredged spoil is to be used on land in accordance with the BPEO study, I would encourage yourselves or Forth Ports Ltd to discuss the options in detail with the local SEPA office at the earliest opportunity.

SEPA Stirling Office
Strathallan House, Castle Business Park,
Stirling FK9 4TZ
tel 01786 457700 fax 01786 446885
www.sepa.org.uk • customer enquiries 03000 99 66 99

Please do not hesitate to call me on 01786 457700 for any queries regarding the Grangemouth Docks site, or of you have any further queries regarding the above.

Yours sincerely

[Redacted]

Calum Waddell
Senior Environment Protection Officer
Falkirk, Alloa & Stirling Team

Northern Lighthouse Board

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Edinburgh EH2 3DA
Switchboard: 0131 473 3100
Fax: 0131 220 2093
Website: www.nlb.org.uk
Email: enquiries@nlb.org.uk

Your Ref: 0352017
Our Ref: GB/D007_19

Ms Catriona Munro
Consultant
Environmental Resources Management
6th Floor
102 Westport
EDINBURGH
EH3 9DN

14 August 2019

Dear Catriona

PRE-APPLICATION CONSULTATION FOR MAINTENANCE DREDGING AND SPOIL DISPOSAL – GRANGEMOUTH DOCK COMPLEX AND BELLMOUTH AREA, FIRTH OF FORTH

Thank you for your correspondence dated 12 August 2019 regarding the proposal by **Forth Ports Limited** for consent to undertake maintenance dredging and disposal operations at Grangemouth Docks, Firth of Forth.

We note that the works are for a 3 year period, focusing on the Grangemouth Dock complex and the bellmouth area to maintain a safe navigable water depth for vessels accessing the docks.

Northern Lighthouse Board has no objections to the proposed dredging and/or disposal of dredged spoil to the charted and approved spoil grounds at Bo'ness.

However, we would advise that on completion of the maintenance dredging operations, that Forth Ports Limited advise the UK Hydrographic Office (sdr@ukho.gov.uk) of the revised water depths in order that Admiralty Chart BA 741 can be update as necessary.

Yours sincerely

[Redacted]

Peter Douglas
Navigation Manager

SNH (Personal Information Redacted)

Thank you for your letter of 12 August 2019 regarding the BPEO for dredge spoil disposal from Grangemouth. I note that the composition is likely to be 80-95% silt content.

Grangemouth has been dredged for many years, and disposal at the Bo'ness site is long-established. As such sea-bed habitats and mobile species at this location are accustomed to disposal operations. We therefore suggest that this method of disposal remains suitable.

--
Malcolm Fraser | Operations Officer - Forth
Scottish Natural Heritage | Silvan House | 3rd Floor East | 231 Corstorphine Road | Edinburgh | EH12 7AT |

The Crown Estate (Personal Information Redacted)

We have received your letter of 12 August 2019 in relation to the BPEO study at Grangemouth. Crown Estate Scotland does not approve or require specific disposal methods or locations for dredged material and will generally consent to disposal of dredged material at sea on the condition that all other relevant consents are obtained.

I trust that this is helpful, if you require any additional information then please get on touch.

Best Regards,

Peter

BIDWELLS

Peter Galloway BEng (Joint Hons) PhD
Associate

Broxden House, Lamberkine Drive, Perth, Scotland. PH1 1RA
DD: 01738 494126

FORTH
DISTRICT SALMON FISHERY BOARD

The Clubhouse, 106 Biggar Road,
Edinburgh, EH10 7DU

Tel: 0131 445 1527
Email: clerk@forthdsfb.org

Catriona Munro
ERM
102 West Port
Edinburgh
EH3 9DN

15th August 2019

Dear Catriona

Forth Ports Limited: Grangemouth Maintenance Dredge Spoil Disposal

Thank you for contacting the Forth District Salmon Fishery Board (FDSFB). We have reviewed your communication and would make the following comments.

The application is for a particularly large volume of dredge to be disposed of in the Firth of Forth and this is of grave concern to the FDSFB. Whilst the FDSFB acknowledges that the management of sediment is required in the Forth Estuary, this process could have a negative impact on migratory fish species such as Atlantic salmon and sea trout. The FDSFB remit is for the protection and enhancement of these migratory salmonids and this duty extends to the Estuary and the Firth. Currently salmon are in decline and the majority of the Forth District is deemed by Marine Scotland to have un-sustainable harvestable stocks. The vast majority of Forth salmon stocks have been rated as Category 3 which means that those fish caught must be returned unharmed to the water and this includes the Estuary and Firth areas as well as the rivers. The conditions in the estuary and firth, as the route of migration of these fish from the freshwater to marine environment, are key to the survival and protection of these fish. We remain concerned that there is limited information on the impacts of disposal at sea (including any cumulative effect) and that this does not appear to assessed as part of the usual application process.

The impact that sediment disposal at sea has on migratory salmonids in the Firth of Forth is not clear and therefore it is difficult for the FDSFB to make informed comments on this application. A degradation of water quality and clarity accompanies sediment disposal. Research has shown that contaminants and toxins can be released from sediment plumes into the surrounding water column and prolonged exposure to suspended sediments causes damage to gill structure in fish. BPEO reports, if they give any consideration to migratory fish, tend to rely on the untested assumption that fish are able to avoid areas during periods of suspended sediments and that they will find alternative routes through the area, but there is no evidence provided to support this theory.

For information, when salmonids make their seaward migration through the Firth of Forth, they are very fragile, physiologically stressed and can be as small as 10cms in length. Therefore they may not physically be able to avoid sediment plumes. In any case it is not known how large an area the plumes might cover. The Grangemouth Docks complex dredge is of a particularly large scale, and the spoil will be spread over a wide area, almost the entire width of the Forth estuary. The lack of information is therefore of grave concern to the FDSFB as the negative impact on migrating salmonids has the potential to be profound.

These smolts are likely to be passing through the Firth of Forth during the summer months. **Until data is made available to support the assumption that there is no impact of sediment plumes on migrating smolts, a sensible precautionary approach would be to avoid sea disposal taking place in the Firth during June and July.** We will be raising these points with Marine Scotland as well, and would, of course, welcome any thoughts from ERM on the suggestion made above.

Should you wish to discuss or require any further information please do not hesitate to contact me.

Kind regards

Alison
[Redacted]

Alison Baker
Clerk to the Forth District Salmon Fishery Board

ERM has over 160 offices across the following countries and territories worldwide

Argentina
Australia
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Chile
China
Colombia
France
Germany
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Italy
Japan
Kazakhstan
Kenya
Malaysia
Mexico
The Netherlands
New Zealand
Norway
Panama
Peru
Poland
Portugal
Puerto Rico
Romania
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