Marine (Scotland) Act 2010

Marine and Coastal Access Act 2009

Best Possible Environmental Practice Assessment

Supporting an application for a licence for sea disposal of dredgings from Eyemouth Harbour ~ Maintenance Dredging 2022-2025

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1. INTRODUCTION

1.1 Background to application

Eyemouth Harbour Trust requires maintenance dredging to be carried out from within Eyemouth Harbour and its entrance channel. The maintenance dredging is undertaken as necessary from four sub-areas of the Harbour as indicated in Figure 1. Areas A, B and C were last dredged in 2021 and the Upper Harbour (Area D) in 2021. Natural siltation has since reduced the depths to levels inconsistent with navigational safety for the vessels currently using the Harbour.

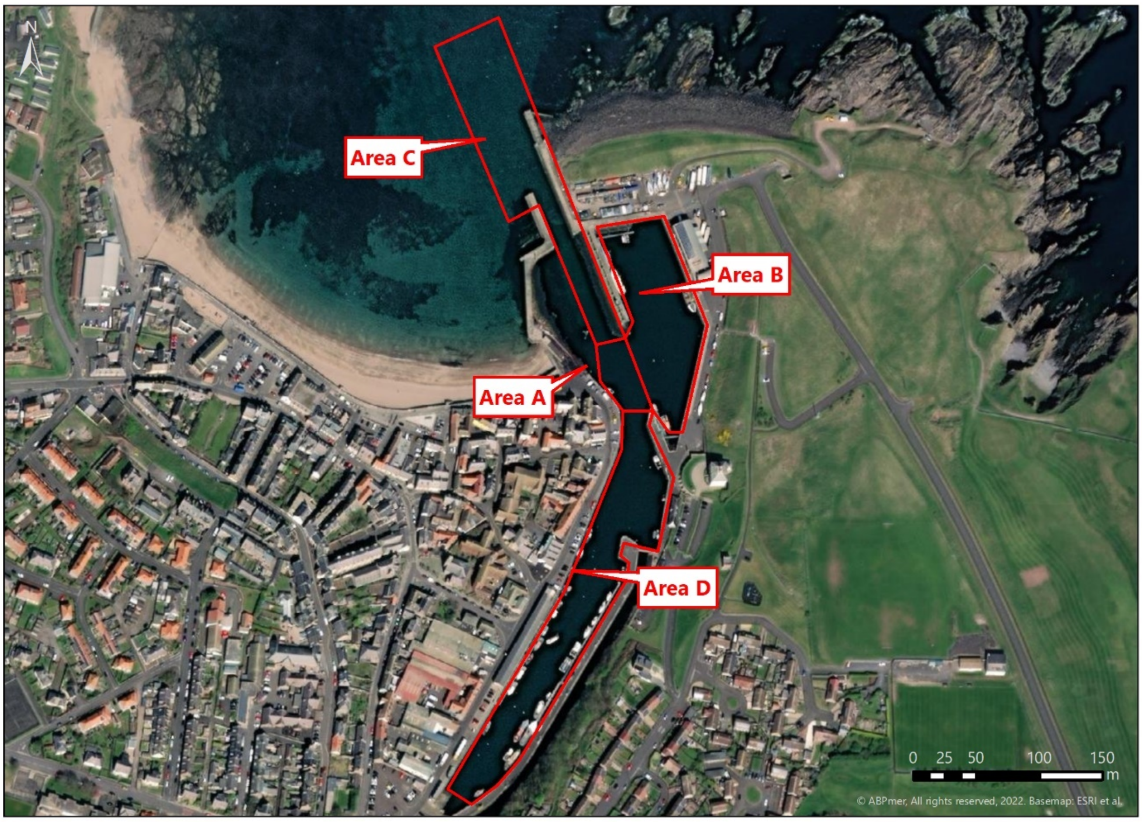

Figure 1 Maintenance dredge sub-areas

This document examines the options for disposal of dredged material to determine the Best Possible Environmental Practice in accordance with the Marine (Scotland) Act 2010 and the Marine and Coastal Access Act 2009.

1.2 Description and source of materials

The material to be dredged is an accumulation of mud, silt, sand and gravel deposited throughout the harbour by natural fluvial, tide and wave action. All material types are present within the Upper Harbour, whereas mud and fine sand predominate in Gunsgreen Basin and its immediate entrance (Areas A and B). The main approach channel (Area C) is predominantly tidal and wave driven sand with occasional gravel material. Some mud is present following high fluvial flows. The method of dredging is determined by the material characteristics and this affects the nature of the spoil. Possible methods include mechanical digging from shore; mechanical digging from floating vessel; plough dredging (dragging); suction dredging; cut and suction and water injection systems.

Mechanical digging allows loading directly to a barge or vehicle; however, a certain amount of settling/run-off time may be required before transporting on public roads. Suction dredging produces a slurry that requires separating in settling lagoons before becoming acceptable as a landfill material but can be directly disposed into the sea. Plough dredged material may be dragged directly out of the harbour or to a point where it may be recovered by land-based plant.

Due to the size of the harbour, dredge depths and material characteristics it is possible that a variety of methods may be required to optimise the dredging.

1.3 Sediment chemistry

The sediment chemistry in the Harbour has been analysed at various locations for previous dredge licences for the different harbour areas. Data is available back to 2014. These data have been analysed and historically compared, predominantly for Areas A – C and Area D in Appendix A and Appendix B respectively. These documents focus on the sediment concentrations of the PAH and TBT determinands as elevated levels were recorded at some locations in the past. For the most part heavy metal concentrations have been either below the MS-LOT Action Level 1 (AL1) or only marginally above. Heavy metals have therefore not been a concern with respect to the Marine Licences for dredging and disposal.

For the 2022 Harbour dredge licence application 9 surface were collected at MS-LOT agreed locations throughout the harbour, including one from the beach. All samples again showed heavy metal contamination to be below or only marginally above AL1. Table 1 shows the recorded PAH concentrations for each determinand from the different harbour locations shown on Figure 2. The green shading shows where the individual PAH concentration exceeded MS-LOT AL1. These data show concentration levels above AL1 in Gunsgreen Basin and the southern end of the Inner Harbour, but low levels (below AL1) in the sands through the entrance channel where most dredging is required. By far the greatest PAH concentrations are in the vicinity of Location 6 in the southern corner of Gunsgreen Basin. EHT believe the elevated levels of PAH are related to an oil spill incident around this sample location which occurred in July 2021, just prior to sampling. This was a small spill of hydraulic oil from a fishing vessel berthed in Gungreen Basin. The Harbour Master initiated a spill response and an absorbent boom was deployed which soaked up most of the spill. However, it is possible a small amount settled on the basin bed, causing localised contamination.

No MS-LOT Action Level 2 (AL2) exists for PAH so the Gorham Test is often used as an indicator of the severity of contamination. This analysis is provided in Table 2.

Table 1 Polycyclic Aromatic Hydrocarbon concentrations (July 2022)

Sample	Polycyclic Aromatic Hydrocarbons (PAHs; µg/kg Dry Weight)																						
	Bed Depth (m)	Acenaphthene	Acenaphthylene	Anthracene	Benz(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(e)pyrene	Benzo(ghi)perylene	Benzo(K)fluoranthene	C1-napthalenes	C1-phenanthrene	C2-napthalenes	C3-napthalenes	Chrysene	Dibenz(a,h)anthracene	Fluoranthene	Fluorene	Indeno(1,2,3-cd)pyrrene	Naphthalene	Perylene	Phenanthrene	Pyrene	Total Hydrocarbon Content (THC)
Area A – D July 2022																							
P1	0.00 - 0.15	6256$	72<4$	=27<$	7424$	7=26$	6:2:$	6:27$	7526$	5<27$	842<$	9924$	9429$	9<28$	7624$	:295$	942;$	82< :$	6:2 6$	5528$	;2; ;$	8<25$	8<25$	55744$
P2	0.00 - 0.15	5275$	52:4$	562<$	652<$	642;$	592:$	552:$	5726$	542:$	52:=$	5;29$	6279$	72;4$	642;$	7259$	8:27$	62= <$	582 ;$	5268$	82= 8$	6=29$	792=$	:=54$
P3	0.00 - 0.15	@5$	@5$	5256$	726;$	8244$	62=9$	62;8$	62::$	52=<$	52=7$	62<:$	5299$	5265$	7284$	@5$	8289$	@5$	62; 8$	526:$	@5$	52=;$	92:7$	8<44$
P4	0.00 - 0.15	@5$	@5$	@5$	@5$	5255$	526<$	@5$	5257$	@5$	@5$	5247$	@5$	@5$	5248$	@5$	5269$	@5$	@5$	@5$	@5$	@5$	5289$	8654$
P5	0.00 - 0.15	652<$	547$	=424$	6<=$	858$	7:;$	6=5$	79:$	664$	584$	696$	59<$	5<;$	776$	<7$	97<$	9: 25$	7=5$	5=7$	54=$	74<$	8<<$	967444$
P6	0.00 - 0.15	942:$	<62;$	885$	7554$	7554$	6984$	5<64$	5:<4$	5844$	646$	5654$	759$	748$	74<4$	849$	:4=4$	== 25$	5=8 4$	544$	;<9$	<;8$	9474$	=8<444$
P7	0.00 - 0.15	:2:;$	5926$	6927$	<825$	54;$	564$	=42:$	56;$	:;2<$	:42<$	547$	<829$	=829$	=824$	672=$	57=$	56 2:$	575$	6;2<$	7:26$	;724$	56<$	647444$
P8	0.00 - 0.15	8924$	762:$	548$	7:;$	8=5$	7<:$	779$	855$	669$	=;2<$	696$	56<$	59=$	7==$	==2<$	:;6$	96 2=$	8;7$	:42<$	5<8$	75<$	9<:$	<<4444$
P9 beach	0.00 - 0.15	@5$	@5$	526<$	52:4$	5294$	52:=$	52:6$	52<8$	528<$	7294$	7279$	62;8$	7264$	626;$	@5$	72<6$	@5$	52; :$	52:9$	@5$	6279$	824<$	6;644$
Marine Scotland Guideline Action Levels (µg/kg Dry Weight)																							
AL1		100	100	100	100	100	100	100	100	100	100	100	100	100	100	10	100	100	100	100	100	100	100	-

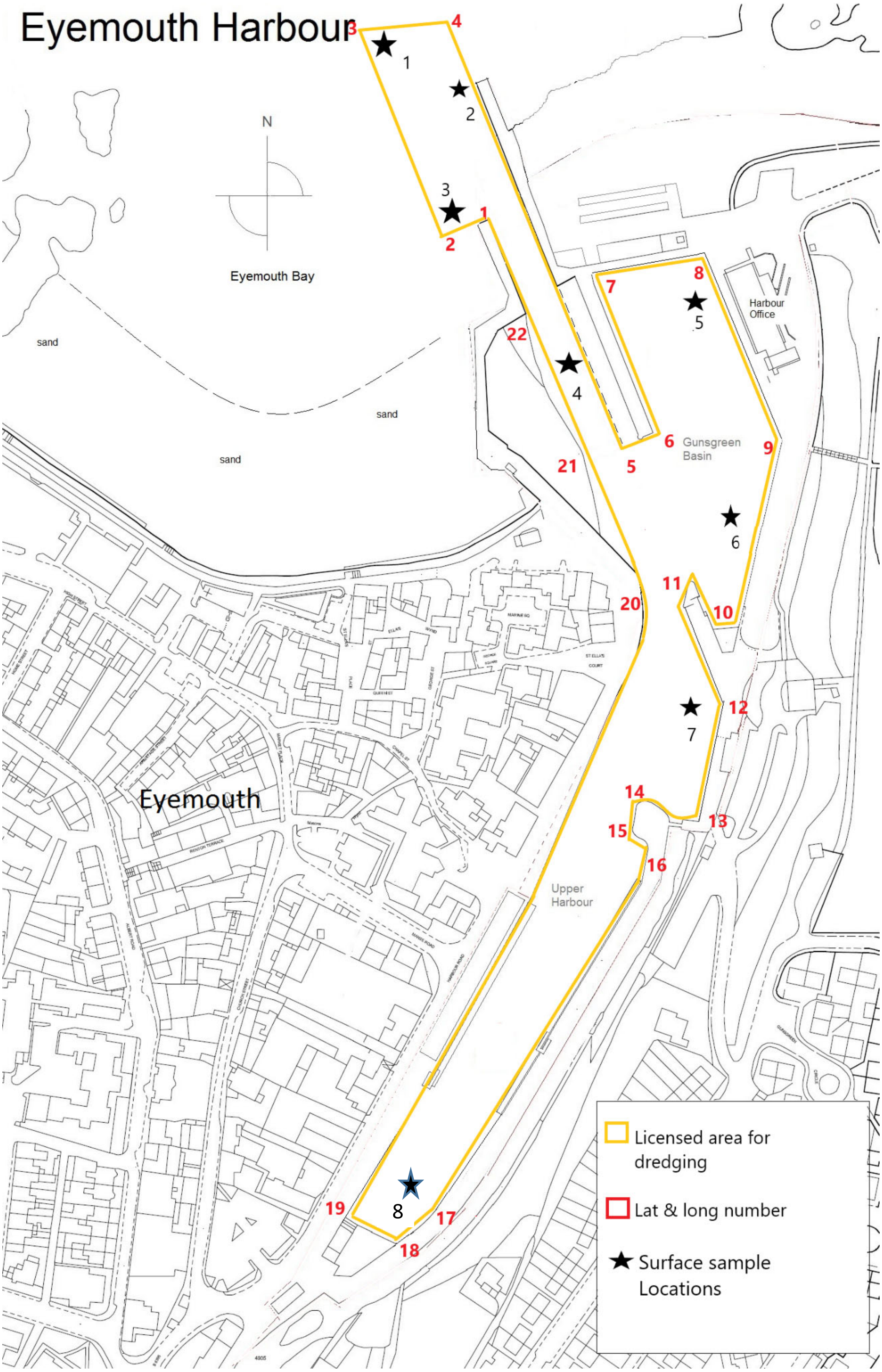

Figure 2 July 2022 Sample locations

Table 2 Gorham Test analysis

Sample ID	Low Molecular Weight -LMW (µg/kg)	High Molecular Weight -HMW (µg/kg)
P1	564$	5=<29$
P2	95$	58525$
P3	@=$	@6428$
P4	@;$	@:2=$
P5	=56$	64<:26$
P6	5<8=$	5=7=924$
P7	665$	9=:24$
P8	;55$	69782<$
P9	@56$	@572:$
ERL (AL1	**552**	**1700**
ERM (AL2)	**3160**	**9600**

ERL – Effects Range Low
ERM = Effects Range Medium

LMW = Sum of Naphthalene, Acenaphthene, Fluorene, Anthracene, C1-naphtha-lenes, Acenaphthylene, Phenanthrene
HMW = Sum of Fluoranthene, Pyrene, Benz(a)anthracene, Chrysene, Benzo(a)pyrene, Dibenz(a,h)[a,b]anthracene

The Gorham test analysis shows the exceedances of AL1 for both the low and high molecular weight determinands were generally closer to AL1 than AL2, with the exception of Location 6 where the concentration for the High molecular weight PAHs well exceeded AL2 reflecting the local spillage.

Appendix A shows that PAH contamination was recorded within Dredge Area A in 2016 and more detailed sampling in this area was undertaken in 2019 and 2020 prior the current MS-LOT agreed sampling locations. These data sets are compared in the appendix both with time and with depth for the 2020 sample set. The data clearly shows how the contamination levels had reduced with time both at the surface and at depth.

Comparison of Appendix A Table 1 and Table 1 above shows that the general level of contamination, with the exception of Location 6, is of a similar general level to the 2019 and 2020 sampling and considerably less than recorded in 2016. Even Location 6 was lower than recorded in 2016.

A similar historical analysis is undertaken for the Inner Harbour (Dredge Area D) in Appendix B. Comparison of this data with sample Location 8 in Table 1 above shows present contamination to be a similar level to that in 2019 which was again considerably less than then 2014 data set.

Overall, the data suggests a general lowering of the contamination levels with time, with the exception of Location 6, where a recent spillage occurred. With this one exception the general levels of contamination are the same order or lower than in areas that have previously been licenced for disposal at sea.

1.4 Options for relocation/ removal of materials

Possible options which have been considered for disposal of spoil from the maintenance dredging area include:

- Land incineration;
- Sacrificial landfill;
- Use on agricultural land;
- Reclamation;
- Beach nourishment;
- Other beneficial use; and
- Sea disposal.

1.5 Details of various, related options

Eyemouth Harbour Trust has carried out regular maintenance dredging programmes at intervals varying between 1 and 3 years. Amounts of material removed have varied between 5,000 and 45,000 wet tonnes p.a., as necessary. This level of maintenance has not always restored the advertised depths in all areas. A ‘backlog’ may therefore exist in some locations. Previous dredging has predominantly been undertaken by contractors using a back-hoe dredger with hopper barge and by plough dredging (dragging).

Plough dredging alone has proved the least effective method as the sediment, predominantly the sand from the entrance, is not removed far enough to prevent the material being rapidly carried back into the harbour by tide and wave action. Removal by hopper barge to an approved spoil ground, 3 nautical miles to the east of the harbour (Licensed Site FO080, marked on the Admiralty Chart attached to this report) has proved the more effective method, with assistance of a plough to level out the bed. The most recent dredging campaign was carried out between March and September 2021 using the latter method and spoil ground.

The following methods are not practical:

- Suction dredging or cutter suction dredging (with disposal to land) has not been used as there is no suitable area to construct a settling lagoon within the port area.
- Plough dredging with recovery from the quayside is not considered feasible due to the multiple operations involved.
- Mechanical digging of the required areas from land using long-reach excavators is not practicable due to access issues with respect to the heavy plant involved.

At present it is estimated that the annual maintenance requirement for the harbour, as a whole, is approximately 90,000 wet tonnes (approx. 55,600 m^3) p.a. with *circa*. 82,400 wet tonnes is from the entrance channel (Area C) to maintain navigational safety for the current commercial use of the harbour.

2. DISCUSSION OF DISPOSAL OPTIONS

2.1 Land incineration and subsequent disposal of residue

The material to be dredged from the harbour consists predominantly of incombustible and inert mineral solids with high water content and a small proportion of organic matter. Incineration would use a large amount of energy in removing the water but would not reduce the mass of mineral content or convert the spoil to a usable product, and it is therefore not considered a practicable method of disposal.

2.2 Sacrificial landfill

Disposal by landfill would require the water content of the dredged material to be separated and removed in a settling lagoon before the spoil could be accepted at a landfill site. Eyemouth Harbour does not have a suitable level site for a settling lagoon of the capacity that would be required for this operation.

At present there are no suitable landfill sites in the immediate vicinity of Eyemouth Harbour or within the region.

2.2.1 Environmental considerations

Landfill capacity is limited in this region and its use is considered unsustainable.

The movement of the dredged spoil by road transport would involve increased use of roads by heavy traffic with consequential increase in fuel use, exhaust emissions, noise, wear on road infrastructure and general nuisance to road users and local residents. It would also introduce a risk of spillage and road traffic accidents.

If a mechanical dredge and barge is used to recover material the transfer of spoil from a barge to settling lagoon and then to road vehicle involves two further loading operations. Material already loaded into a barge would be transported in a considerably less environmentally damaging means by sea.

2.2.2 Environmental impacts list

Potential impacts resulting from the haulage and final disposal of spoil on land would include:

- Danger of contamination of public roads from spillage or leakage from the loads if carried wet;
- High energy use if material is dried or compressed before transported;
- Nuisance and noise from haulage traffic using the public roads;
- Road vehicle emissions;
- Wear and damage to road infrastructure;
- Potential adverse ecological and visual impacts from landfill operations, subject to the choice of site.

2.2.3 Cost considerations

The recovery to land of spoil from the harbour would require the same floating equipment whether disposal was at sea or to landfill, however the landfill operation would additionally entail transferring the spoil from barge to settling lagoon (not-available), then reloading onto road vehicles and transporting to a site (assuming that a suitable site could be found). Charges would apply for existing sites, or new landfill development and restoration costs. These extra operations would incur a considerable increase in cost, estimated to be in excess of 100% greater than sea disposal.

2.3 Agricultural use or soil conditioning on reclamation schemes

Land use in Berwickshire is predominantly agricultural making dredge spoil spreading on farmland a possible option. There are no reclaimed land sites or reclamation schemes in the area.

The value of the spoil material for soil improvement is low. Before use as a constituent or agricultural soil it would be necessary to reduce the material's salinity by repeated washing and draining, and the high cost of such washing and the non-availability of a suitable conditioning site would render it commercially unviable compared to traditional land sourced top soil.

Use on agricultural or reclaimed land would involve the same transport operations as for landfill, with similar environmental impacts.

2.4 Reclamation

2.4.1 Strategic and Environmental Considerations

There is no reclaimed land nearby, nor are there any reclamation works planned along this part of the coast. Consideration has previously been given to depositing the spoil in shallow water in the bay, in the location of an outer breakwater which may be constructed as part of a future (Phase II) development. Whilst this may appear to offer an attractive option, it is considered not appropriate in this instance for the following reasons:

Its location in the Berwickshire and North Northumberland Coast Special Area of Conservation and proximity to St Abb's Head to Fast Castle SSSI (located approx. 4km to the north of Eyemouth), designated for its aggregations of breeding seabirds, coastal grasslands, and its geological features.

- Contamination of the rocky subtidal zone by sand and muddy sediments during placement and the associated risk of smothering of marine organisms;
- Presenting a potential hazard to navigation;
- In order for the material to remain in place in a stable condition, a properly engineered breakwater would be required, including foundations, rock armouring etc., which would add substantially to the cost and render it uneconomic;
- Loss of part of a popular area for recreational diving.

2.4.2 Cost considerations

Land reclamation is not an economically viable option due to the lack of potential reclamation areas along this rugged length of coast and the need for extensive and expensive engineering measure if a local reclamation area were to be developed. The mud material would not have suitable engineering properties.

2.5 Beach nourishment

Eyemouth Bay is the only location considered in this case as there are no beach nourishment schemes planned in the area. The Berwickshire coast is a predominantly rocky and heavily indented coastline and not prone to beach erosion.

Dye tests have shown there to be an anti-clockwise movement of sediment in Eyemouth Bay, with sand migrating from the western end of the beach towards the harbour, and out to sea past the harbour approach channel. This circulation allows sediment to be drawn into the harbour by wave action.

Any additional material placed on the beach is likely to migrate quickly towards the harbour entrance, thereby increasing the potential for continuing siltation in the harbour, and the likely need to repeat maintenance dredging within a short time, hence increasing the overall maintenance dredge requirement.

The fine particle size of the spoil material allows it to be washed away very easily and the poor drainage characteristics of fine silt do not permit drying out between tides.

The mud component of the dredged material also has low load bearing characteristics and would be unsightly, offering no leisure value as a beach. The mud material is therefore unsuitable for further consideration as a medium for beach nourishment.

The sand from the entrance would have potential providing a relocation site could be found that did not cause environmental smothering, increased turbidity or rapid recirculation back to the navigation channel.

2.6 Other Beneficial Uses

It has been suggested that deposition of the dredged spoil in shallower water (say between 0 to 10m below Chart Datum) to create a reef immediately to the east of the Hurkers would offer an attractive low cost option, which could have the beneficial effect of providing increased interest for divers, this section of coast being a popular location for scuba diving.

The option would not, however, be appropriate for the fine sands and muds that comprise the maintenance dredging arisings. The material would be highly mobile in the prevailing tide and wave conditions and not form a permanent reef alone. The instability of the material in this very exposed location has the potential to spread out to cover a larger area of the Berwickshire and North Northumberland Coast SAC and Burnmouth Coast SSSI in time.

Smothering of marine organisms would possibly occur causing ecological and other potential environmental impacts. However, as a precursor to further investigation for long term dredging management, during the 2022 pre-dredge sampling, an additional sample (#9) was taken from the beach area, Sample 9 was taken with a view to exploring compatibility of material for possible beach nourishment for future dredging campaigns which may not involve disposal (e.g. plough). Sample 1 - 4 from the Entrance channel and canyon indicated no signs of contaminants and are all similar to the beach sample (9), so would appear potentially suitable for beach renourishment should a scheme be derived in the future. These results further support that the sand migrates towards the harbour entrance.

2.7 Sea disposal

2.7.1 Strategic and environmental considerations

Due to the location of the dredging work at the harbour and its entrance and the type of plant which could be used for the dredging, sea disposal is considered the Best Practicable Environmental Option (BPEO) . It would allow the dredging equipment to work efficiently and would avoid the need to re-handle dredged spoil within or adjacent to the harbour and the associated potential environmental problems and safety hazards inherent in such activities.

The location of the spoil ground is shown on the extract from the Admiralty Chart appended to the licence application. No complaints have been received from fishing or other marine interests and there is no evidence that the sea disposal has produced turbidity, discoloration, foaming, odour or floating matter either at the disposal site or on the adjacent shore. No objections have been received on amenity grounds and the Harbour Trust is unaware of the past disposal operations causing any interference with other legitimate users of the sea.

2.7.2 Cost considerations

Dredging work by vessels using mechanical methods and including sea disposal of arisings has previously represented the most economic dredging and disposal option available to the trust.

3 CONCLUSIONS

3.1 Summary of available options

The available options are the transfer to land and disposal to landfill, spreading on agricultural land, deposition in Eyemouth Bay (either for a possible future breakwater or to create a reef), beach nourishment or sea disposal.

3.2 Summary of primary objections to each option

The primary objections to both land disposal and spreading on agricultural land are on environmental grounds and are:

- The risk of spillage and dispersion during handling;
- Disturbance of public amenity;
- Possible disturbance of the adjacent SAC and SSSI;
- The nuisance and dangers of carrying high water content materials by public roads;
- A lack of a suitable landfill site;
- Ecological, visual and noise impacts from landfill operations;
- Discharge of saline leachate to inland water courses.

Use of either of the land disposal options would also considerably increase the cost of disposal of the dredged spoil.

The primary objections to deposition of the spoil in shallow water in Eyemouth Bay are also on environmental grounds and are:

- Potential adverse impacts on the adjacent Burnmouth coast SSSI and Berwickshire Coast (intertidal) SSSI;
- Contamination of the rocky subtidal zone by sediments during placement;
- Smothering of marine organisms;
- Potential hazard to navigation;
- Physical instability of the spoil in the exposed environment, requiring engineering measures to stabilise it; and
- Loss of part of a popular area for recreational diving.

The primary objection to use of the spoil as beach nourishment are:

- Exacerbation of sand accretion in the bay;
- Only the sand component of the maintenance dredgings would be suitable. A method of disposal would still be required for the muddy component, therefore, separation of the materials would also be required; and
- The sediment circulation system could in time return a large proportion of the sediments to the harbour.

3.3 Identification of Best Practical Environmental Option

The conclusion of this Best Possible Environmental Practice Assessment is that the Best Practicable Environmental Option for disposing of the spoil from maintenance dredging works planned to be carried out in Eyemouth Harbour in 2022 to 2025 is disposal by placement in an approved offshore sea disposal site.

EYEMOUTH HARBOUR TRUST – November 2022.

Appendix A

ABPmer Report R3394TN

Eyemouth Harbour Trust

Eyemouth Harbour Deepening

Dredge Area A - Sediment Contamination Analysis Update - February 2020 Sampling





Innovative Thinking - Sustainable Solutions

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Eyemouth Harbour Deepening

Dredge Area A - Sediment Contamination Analysis Update - February 2020 Sampling

March 2020

Source: GoogleEarth

Document Information

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1 Introduction

In 2018 a need for maintenance dredging of Eyemouth Harbour was identified. Contaminant sampling analysis required for the dredge licence application for maintenance dredging in Eyemouth Harbour identified contamination to varying degrees, with a spatial distribution pattern around the Harbour. Marine Scotland's Licensing Operation Team (MS LOT) required further information on the proposed dredging and contamination levels within Eyemouth Harbour before making a decision on the licence application. Analysis of the contamination concentrations and its distribution around the Harbour and for specified dredge areas (shown in Figure 1) was reported in ABPmer Report R.3169 - Eyemouth Harbour Deepening - Support for Marine Licence Application, which was submitted to MS LOT (ABPmer 2019a).

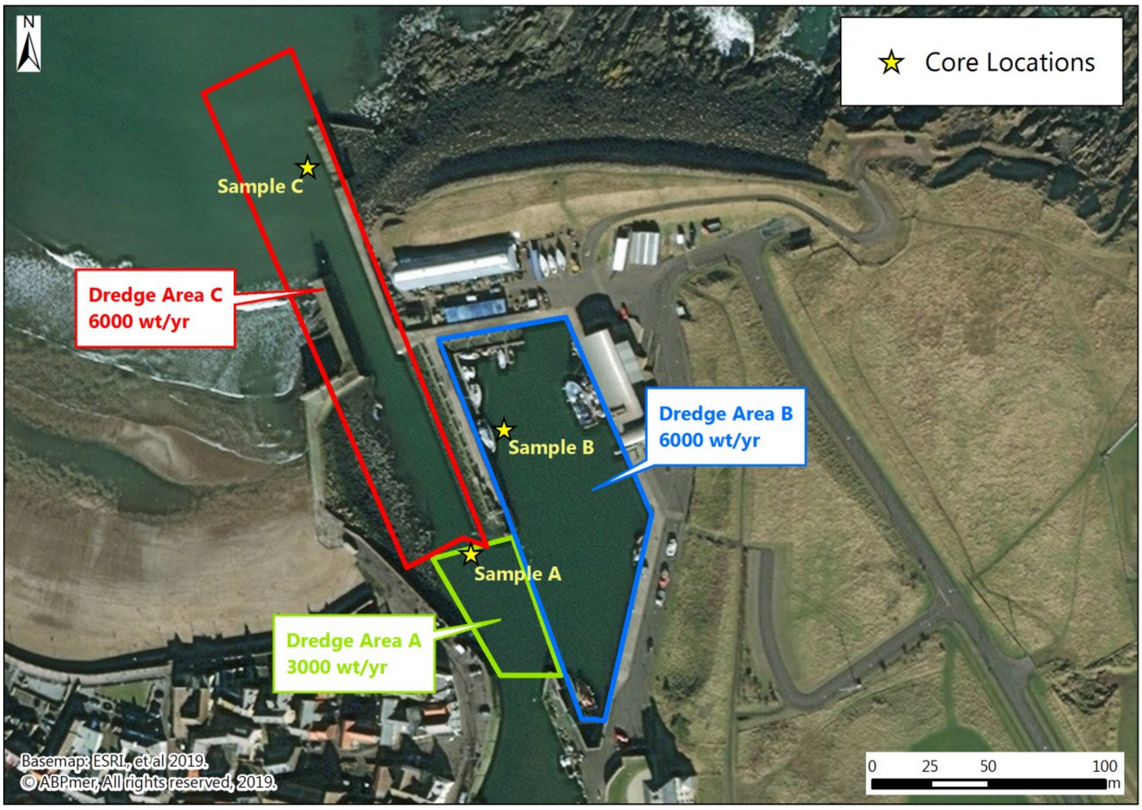


Figure 1. Dredge areas and core sampling locations within Eyemouth Harbour during September 2016

On receipt of this information MS LOT provided a licence which allowed dredging of the Outer Approach Channel and Gunsgreen Basin (Dredge Areas B and C), however the Basin entrance area, denoted dredge Area A, was excluded from the licence as the contamination, predominantly hydrocarbons, was substantially higher within this area. Further surface sampling and analysis for Polycyclic Aromatic Hydrocarbons (PAH) was undertaken to a sampling plan (ABPmer, 2019b) agreed by MS LOT from Area A in September 2019 and the results analysed and reported in ABPmer Report R.3309TN (ABPmer 2019c).

This document was forwarded to MS LOT, who responded requesting further sampling with depth as contamination was still evident in the surface layers of Area A, albeit generally lower than the initial sampling from September 2016. The MS LOT response, however, inferred that the contamination levels in the top 15 cm would potentially be suitable for sea disposal. On this basis, there was potential for a marine licence to be granted should contamination levels at depth be at the same level or lower than recorded at the surface.

Further core sampling has been undertaken from three locations at two depths, agreed by MS LOT within Area A in February 2020.

This note analyses the results of this new at depth sampling, with respect to the MS LOT contamination Action Levels (AL's), their distribution and comparison with contamination levels from the previous (September 2016) core sampling and the surface samples from Area A in September 2019.

2 Sampling

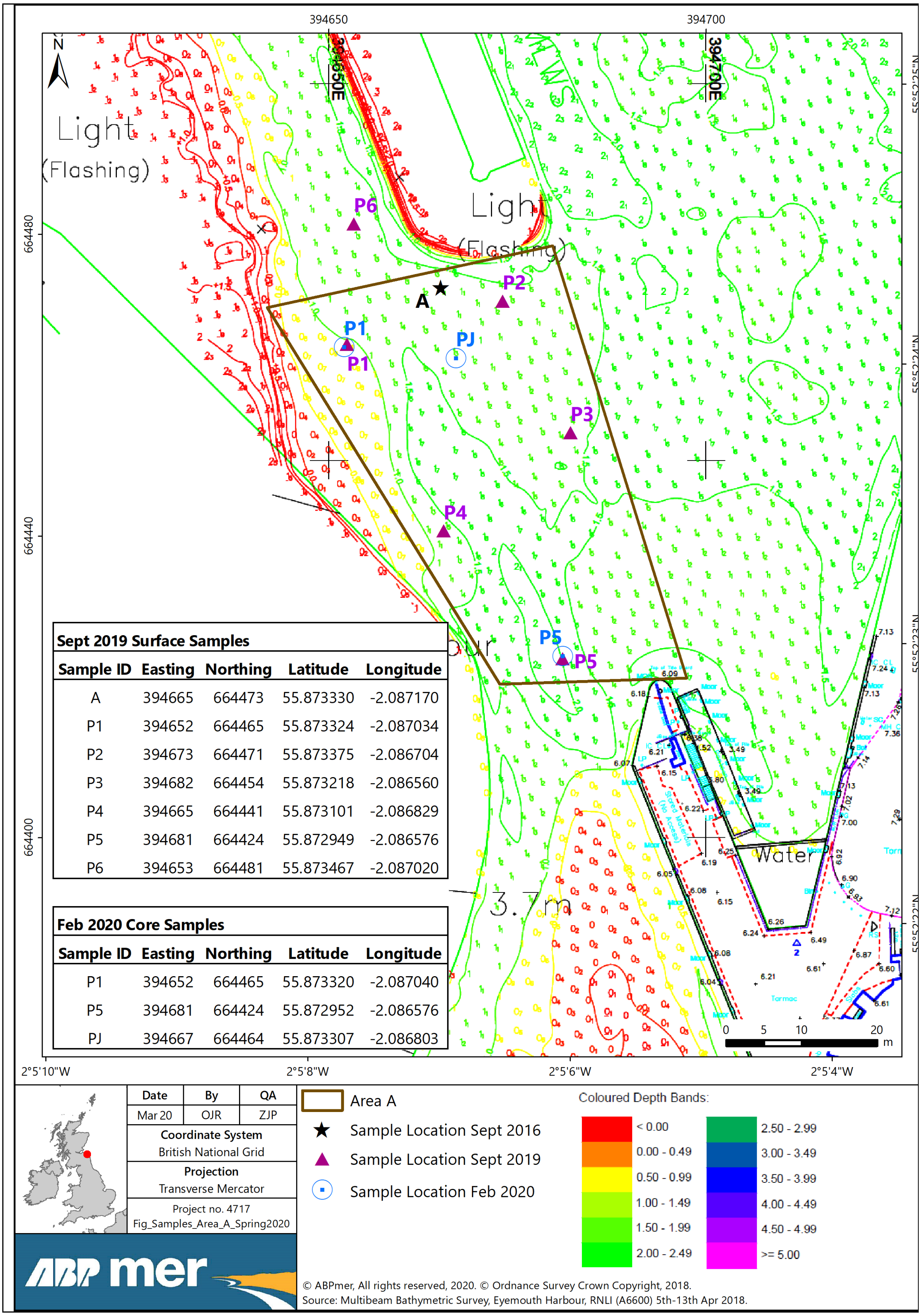
The agreed 2019 sampling plan collected surface samples from five locations distributed to provide representative information for Area A as a whole and the likely variation in material types present at the different bed thickness of required dredging. Additionally, MS LOT requested a further sample in relatively close proximity to the previous contaminated sample location, down the channel. These sampling locations (P1 - P6) along with the depths from the April 2018 bathymetric survey are shown in Figure 2.

The core locations for the 2020 sampling are located at (near) two of the previous surface sampling locations (P1 and P5) and a new location denoted PJ in close proximity to the original (2016) location that indicated the contamination (Location A).

The required dredge depth is to 3 m below Chart Datum (CD) or the underlying 'hard bed'; particularly to the west side of the area. Location A is the site of contamination identified in the earlier (2016) sampling analysis.

The Area A surface sampling (top 15 cm) was undertaken on 17 September 2019 with a Van Veen Grab. The most recent samples were extracted from cores collected by Environmental Services Ltd on 13 February 2020. Two samples were taken from each of the three cores, 50-65 cm and 85-100 cm below the surface of the bed.

The surface samples were analysed for PAH and Total Hydrocarbon Content (THC), but those from depth were only analysed for PAH as agreed with MS LOT. Both sets of samples were analysed at the Socotec Laboratory which is approved by MS LOT.



Sept 2019 Surface Samples

Sample ID	Easting	Northing	Latitude	Longitude
A	394665	664473	55.873330	-2.087170
P1	394652	664465	55.873324	-2.087034
P2	394673	664471	55.873375	-2.086704
P3	394682	664454	55.873218	-2.086560
P4	394665	664441	55.873101	-2.086829
P5	394681	664424	55.872949	-2.086576
P6	394653	664481	55.873467	-2.087020

Feb 2020 Core Samples

Sample ID	Easting	Northing	Latitude	Longitude
P1	394652	664465	55.873320	-2.087040
P5	394681	664424	55.872952	-2.086576
PJ	394667	664464	55.873307	-2.086803

Figure 2. Area A bathymetry and 2016, 2019 and 2020 sediment sample locations

3 Sediment Contamination Results

3.1 Physical characteristics

Particle size analysis was not undertaken on the samples, however, the solids content of the sediment characteristics of the material to be dredged was recorded. The solids content of the surface samples from Locations P1, P2 and P6 around Location A are likely to be predominantly sand, (*circa* 90%), with solids content around 60%, suggesting free draining sediment. The core sampling from Location P1 indicates similar material down to 65 cm below the bed. Deeper in the core (85-100 cm) the sample was slightly less free draining, indicating the potential for a greater proportion of finer silty/ mud material.

Further up the Harbour at Locations P3 to P5 the surface samples have significantly lower solid content, indicating, greater water retention and a predominantly finer silt character. The core from Location P5 indicates there is some layering through the depth, with more sandy material between layers with a higher silt/mud component.

The new location (PJ) samples at both depths have lower solids content, similar to the surface samples from Locations P3 and P4. This distribution indicates the middle of Area A is a settlement area for finer silty/mud sediment (probably brought down the river where it mixes with the sand brought up the estuary under storm conditions). The overall finer nature of the sediments results in a greater potential to contain higher levels of contamination.

3.2 Chemical contamination

3.2.1 Polycyclic aromatic hydrocarbon

The individual PAH determinands for all locations and depths sampled within Area A from 2016 to 2020 are presented in Table 1. The contamination concentrations are simply coded with respect to the Marine Scotland Action Level AL1. MS LOT does not specify concentrations for AL2. This allows comparison of the more recent PAH sedimentation levels from a wider area of dredge Area A against the three with depth samples from the original (2016) sample analysis from Location A, which led to the exclusion of the dredge area from the existing Marine licence.

This simple comparison continues to show that PAH levels from Area A are above AL1, however comparison of the actual concentrations shows that the absolute levels are considerably lower than those previously recorded at Location A in 2016, both at the surface and more so at depth. At Location P1, Table 2 shows that the PAH for nearly all determinands reduces significantly with depth below the bed, with a ratio 2-3 times lower at a depth of 85-100 cm compared to the surface.

This pattern of reduction in contamination at Location P5 is less clear but all contaminant values below the surface are generally lower or only just over the AL1 threshold (i.e. lower than Location P1). The average concentration through the depth is however significantly lower than the surface values and the highest average values only just exceed AL1.

The surface sampling data indicates that the contamination levels are higher in the finer sediments particularly at Locations P3 and P4. Even at these locations, contamination for most determinands is lower than the lowest values recorded at Location A in 2016. This interpretation remains the same when considering the 2020 core sample data from Location PJ in similar less well drained (finer) sediments.

The contamination levels at Location PJ (see Table 1) are higher than the with depth samples from Locations P1 and P5. They are however, in many cases less than half the surface values from Locations P3 and P4 where finer sediments are likely to be present and there is a significant reduction in contamination with depth, albeit most determinands remaining above AL1.

These results of the surface sampling also show that without dredging there has been a considerable reduction in maximum concentrations (*circa* 5-fold) between 2016 and 2019. The 2020 with depth sampling results also indicate similar or greater reductions are likely to have occurred below the surface of the bed. It is possible the original contamination was a 'hot spot' that has dispersed over time, possibly towards the slower flow areas opposite the middle of the Gunsgreen Basin entrance (Locations PJ, P3 and P4).

Similar to the analysis given in ABPmer 2019a and c, the combined Area A surface and with depth contamination levels have been assessed with respect to the Canadian Sediment Quality Guidelines (CSQG) for the Protection of Aquatic Life (CCME 1999) for the hydrocarbons, where data is provided, in Table 3. Discussion on the use of the various AL's and CSQG levels is provided in ABPmer, 2019a, previously supplied to MS LOT. For this analysis the CSQG Probable Effects Level (PEL) is used to assess the potential effect on the on aquatic life in the absence of a MS LOT AL2 threshold.

Table 3 clearly shows that the 2016 Location A concentrations were almost entirely above the Probable Effects Level (PEL). The 2019 surface samples and 2020 with depth sampling, however, indicate this only to be the case for the surface samples at Locations P3 and P4, but not for all determinands. The highest PAH concentrations from the 2020 with depth sampling were from Location PJ closest to the site of original contamination samples (Location A)); all, however, were below the CSQG PEL threshold. For the most part PAH contamination results since September 2019, both spatially and with depth are well less than half-way between the SQG and PEL thresholds except for the surface samples for some of the assessed determinands from the surface at Locations P3 and P4. Even these values were considerably lower than the contamination levels from the 2016 sampling from Location A.

Most samples, however, remain above the Canadian Sediment Quality Guidance (SQG) level, which is generally more 'stringent' than the MS LOT AL1 threshold.

These data sets show that in the *circa* 3.5-years between the sample results PAH contamination levels have significantly reduced, and/or the contamination has spread over a wider area of the Gunsgreen Basin Entrance within Dredge Area A. Absolute levels still remain above AL1, but to a significantly reduced level above the PEL levels in the surface samples (used here as guide for an AL2, which is not specified in the MS LOT guidance action levels). None of the with depth samples collected in February 2020 exceeded the PEL levels.

Table 4 provides a comparison of the average concentrations for the individual PAHs from the combined 2019 and 2020 sampling for Area A and the previous 2016 sample location within Dredge Area B (i.e. Gunsgreen Basin) which have been licensed for disposal at sea under the current Marine Licence. This table shows that average PAH contamination levels presently in Area A are for the most part lower than those from Area B. The exceptions are for the determinands Acenaphtylene, C1-napthalenes and Napthalene. The overall average concentration is about 30% lower than Area B.

3.2.2 Total hydrocarbon content

The Total Hydrocarbon Content (THC) was analysed for the Area A 2019 surface samples. Using the average value for all samples for the THC indicates that the contamination level is only 20% of that which existed in 2016 at Location A, or 30% comparing the surface sample data only.

These THC results therefore show the same reduction in contaminant levels as for the PAH analysis.

The THC content was lowest at Locations P1, P2 and P6 the closest three sites to the previous location of contamination and in the freer draining sediment. Also, a greater number of individual determinands had contamination levels below AL1 at the furthest extents of the sampling distribution i.e. Locations P5 and P6.

3.3 Conclusion

The PAH sample comparison for samples collected in 2016, 2019 and 2020 indicates that the contamination level has significantly reduced in the approximate 3.5 years period of sampling, without removal of the sediment by dredging. The present concentration distribution is more concentrated in the finer less free draining sediments of Location A. The lowest surface values are closest in proximity to the original Location A contamination site, however with depth samples indicate the main area of contamination to be the within the northern half of Area A. There is a clear pattern of reduced PAH contamination with depth below the bed with PAH concentrations 2-3 times lower at 100 cm depth than at the surface.

Most PAH levels still remain above the MS LOT AL1 level, however, only some of the surface PAH determinands at Locations P3 and P4 exceeded the CSQG PEL threshold. No depth samples from 2020 exceeded the PEL. The overall average concentrations presently in the material to be dredged from Area A are about 30% lower than the average concentration that was accepted for sea disposal in the existing licence from Area B.

On this basis there appears no reason to continue to exclude Area A from the Marine Licence.

Table 1. PAH levels of all Area A samples collected 2016 - 2020 against the Marine Scotland Guideline Action Levels

Sample	Polycyclic Aromatic Hydrocarbons (PAHs; µg/kg Dry Weight)																						
	Bed Depth (m)	Acenaphthene	Acenaphthylene	Anthracene	Benz(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(e)pyrene	Benzo(ghi)perylene	Benzo(K)fluoranthene	C1-napthalenes	C1-phenanthrene	C2-napthalenes	C3-napthalenes	Chrysene	Dibenz(a,h)anthracene	Fluoranthene	Fluorene	Indeno(1,2,3-cd)pyrrene	Naphthalene	Perylene	Phenanthrene	Pyrene	Total Hydrocarbon Content (THC)
Location A - September 2016 Data (with depth)																							
A 1/1	0 - 15	47	101	581	1,330	995	797	775	523	859	323	1,974	461	527	1,307	148	2,835	133	513	189	248	1,526	2,430	610,111
A 1/2	15- 50	533	1,014	2,718	3,247	2,263	1,659	1,701	1,302	1,764	15,478	8,445	10,702	7,606	3,148	314.	6,843	2,260	953	4,543	526	9,003	6,141	1,595,817
A 1/3	50- 85	175	200	723	1,631	1,356	1,215	1,100	824	1,236	570	1,776	741	925	1,774	202	4,675	375	830	190	384	3,474	3,494	558,380
Area A Sampling September 2019 data (surface)																							
P1	0 - 15	11.5	8.39	55.4	346	354	267	210	180	183	67.3	229	111	190	333	35.4	515	15.2	194	21.9	87.6	122	439	89000
P2	0 - 15	17.7	12.3	56.1	152	200	176	150	160	92.2	229	244	230	260	168	23.9	208	26.6	127	77.9	66.1	164	221	26400
P3	0 - 15	28.6	46	380	905	911	661	556	531	372	176	925	215	364	860	99.7	1860	74.9	513	89.2	275	934	1690	398000
P4	0 - 15	35.6	117	268	747	695	485	452	406	302	240	987	315	504	712	85.5	1310	82	369	107	168	549	1290	303000
P5	0 - 15	21.7	9.37	51.8	93.6	107	99	87.6	94	45.9	229	204	237	259	106	18.2	194	27.1	80	83.8	33.2	174	175	186000
P6	0 - 15	27	9.82	95.2	103	73.3	58.7	82.9	96.4	28.5	560	529	582	739	116	12.8	188	43.5	40.3	127	16.6	356	213	110000
Area A Sampling February 2020 data (with depth)																							
P1/a	50 - 65	12	23	88	203	194	148	118	108	62	64	223	79	98	197	26	469	36	103	23	46	251	403	-
P1/b	85 - 100	11	20	27	134	136	109	84	77	60	67	124	92	102	129	19	206	14	81	29	36	72	195	-
P5/a	50- 65	6	8	9	30	39	50	42	66	21	27	36	29	29	39	9	65	8	48	11	13	30	53	-
P5/b	85 - 100	5	17	13	116	117	123	88	81	49	40	67	46	44	126	22	120	7	86	20	34	38	111	-
PJ/a	50 65	54	36	100	287	303	292	230	224	159	428	372	379	298	305	49	498	61	197	167	91	339	453	-
PJ/b	85 - 100	15	20	52	122	144	142	115	118	78	114	203	167	164	139	23	210	25	99	46	42	119	225	-
Marine Scotland Guideline Action Levels (µg/kg Dry Weight)																							
AL1		100	100	100	100	100	100	100	100	100	100	100	100	100	100	10	100	100	100	100	100	100	100	-

Table 2. Combined surface and with depth sample PAH levels for Area A against the Marine Scotland Guideline Action Levels

Sample	Polycyclic Aromatic Hydrocarbons (PAHs; µg/kg Dry Weight)																							
	Bed Depth (m)	Acenaphthene	Acenaphthylene	Anthracene	Benz(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(e)pyrene	Benzo(ghi)perylene	Benzo(K)fluoranthene	C1-napthalenes	C1-phenanthrene	C2-napthalenes	C3-napthalenes	Chrysene	Dibenz(a,h)anthracene	Fluoranthene	Fluorene	Indeno(1,2,3-cd)pyrrene	Naphthalene	Perylene	Phenanthrene	Pyrene	Total Hydrocarbon Content (THC)
P1	0 - 15	11.5	8.39	55.4	346	354	267	210	180	183	67.3	229	111	190	333	35.4	515	15.2	194	21.9	87.6	122	439	89000
P1/a	50 - 65	12	23	88	203	194	148	118	108	62	64	223	79	98	197	26	469	36	103	23	46	251	403	-
P1/b	85 - 100	11	20	27	134	136	109	84	77	60	67	124	92	102	129	19	206	14	81	29	36	72	195	-
P1 Ave.		12	17	57	228	228	175	137	122	102	66	192	94	130	220	27	397	22	126	25	57	148	346	89000
P5	0 - 15	21.7	9.37	51.8	93.6	107	99	87.6	94	45.9	229	204	237	259	106	18.2	194	27.1	80	83.8	33.2	174	175	186000
P5/a	50 - 65	6	8	9	30	39	50	42	66	21	27	36	29	29	39	9	65	8	48	11	13	30	53	-
P5/b	85 - 100	5	17	13	116	117	123	88	81	49	40	67	46	44	126	22	120	7	86	20	34	38	111	-
P5 Ave.		11	11	25	80	88	91	73	80	39	99	102	104	111	90	16	126	14	71	38	27	81	113	186000
PJ/a	50 - 65	54	36	100	287	303	292	230	224	159	428	372	379	298	305	49	498	61	197	167	91	339	453	-
PJ/b	85 - 100	15	20	52	122	144	142	115	118	78	114	203	167	164	139	23	210	25	99	46	42	119	225	-
PJ Ave.		34	28	76	205	224	217	173	171	118	271	288	273	231	222	36	354	43	148	107	66	229	339	
Marine Scotland Guideline Action Levels (µg/kg Dry Weight)																								
AL1		100	100	100	100	100	100	100	100	100	100	100	100	100	100	10	100	100	100	100	100	100	100	-

Table 3. PAH levels of collected samples against the Canadian Interim Sediment Quality Guidelines for the Protection of Aquatic Life

Sample	Polycyclic Aromatic Hydrocarbons (PAHs; µg/kg Dry Weight)												
	Bed Depth (m)	Acenaphthene	Acenaphthylene	Anthracene	enz(a)anthracene	Benzo(a)pyrene	Chrysene	Dibenz(a,h)anthracene	Fluoranthene	Fluorene	Naphthalene	Phenanthrene	Pyrene
Location A - September 2016 Data (with depth)													
A 1/1	0 -15 cm	47.2	100.5	581.2	1,329.5	995.2	1,307.4	148.0	2,835.3	133.0	189.0	1,525.9	2,430.1
A 1/2	15 - 50 cm	533.4	1,014.2	2,718.4	3,247.3	2,263.0	3,147.5	314.1	6,843.1	2,260.1	4,543.0	9,008.3	6,141.1
A 1/3	50 - 85 cm	174.6	199.5	723.3	1,630.7	1,356.4	1,774.1	202.2	4,674.8	375.1	189.8	3,474.0	3,493.6
Area A Sampling September 2019 data (surface)													
P1	0 - 15 cm	11.5	8.39	55.4	346.0	354.0	333.0	35.4	515.0	15.2	21.9	122	439.0
P2	0 - 15 cm	17.7	12.3	56.1	152.0	200.0	168.0	23.9	208.0	26.6	77.9	164	221.0
P3	0 - 15 cm	28.6	46.0	380.0	905.0	911.0	860.0	99.7	1860.0	74.9	89.2	934	1690.0
P4	0 - 15 cm	35.6	117.0	268.0	747.0	695.0	712.0	85.5	1310.0	82	107.0	549	1290.0
P5	0 - 15 cm	21.7	9.37	51.8	93.6	107.0	106.0	18.2	194.0	27.1	83.8	174	175.0
P6	0 - 15 cm	27.0	9.82	95.2	103.0	73.3	116.0	12.8	188.0	43.5	127.0	356	213.0
Area A Sampling February 2020 data (with depth)													
P1/a	50 - 65 cm	12.1	22.5	87.7	203.0	194.0	197.0	25.5	469.0	35.8	23.2	46.0	403.0
P1/b	85 - 100 cm	11.2	20.3	26.7	134.0	136.0	129.0	19.0	206.0	13.7	9.3	36.1	195.0
P5/a	50 - 65 cm	5.6	7.5	9.2	29.9	39.2	38.5	9.0	64.6	7.9	11.0	12.6	53.1
P5/b	85 - 100 cm	5.3	16.7	13.4	116.0	117.0	126.0	21.9	120.0	7.5	19.6	34.4	111.0
PJ/a	50 - 65 cm	54.3	36.0	100.0	287.0	303.0	305.0	48.9	498.0	61.3	167.0	90.6	453.0
PJ/b	85 - 100 cm	14.6	19.5	51.8	122.0	144.0	139.0	23.2	210.0	24.5	46.0	41.8	225.0
Canadian Sediment Quality Guidelines for the Protection of Aquatic Life (µg/kg Dry Weight)													
SQG		6.71	5.87	46.9	74.8	88.8	108	6.22	113	21.2	34.6	86.7	153.0
PEL		88.9	128	245	693	763	846	135	1,494	144	391	544	1,398

Table 4. Comparison of PAH concentrations (ug/kg) between average Area A (2019 and 2020 sampling) and average for Area B (2016)

Area	Acenaphthene	Acenaphthylene	Anthracene	Benz(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(e)pyrene	Benzo(ghi)perylene	Benzo(K)fluoranthene	C1-napthalenes	C1-phenanthrene	C2-napthalenes	C3-napthalenes	Chrysene	Dibenz(a,h)anthracene	Fluoranthene	Fluorene	Indeno(1,2,3-cd)pyrrene	Naphthalene	Perylene	Phenanthrene	Pyrene
Area A ave. Sep '19 and Feb '20	20.4	27.1	99.6	269.9	272.8	217.6	184.7	178.4	121.0	186.8	345.2	206.8	254.3	269.1	35.3	486.9	35.0	161.5	66.9	75.7	262.4	455.7
Area B ave. Sep 16	26.8	21.2	152.7	336.5	304.5	387.4	306.2	268.9	289.6	175.1	788.4	349.3	724.5	434.8	60.3	610.1	110.9	275.1	57.0	148.0	277.5	747.2

Shaded areas show minimum concentrations from comparison

4 Water Quality Assessment

Similar to the assessment of the 2016 data (ABPmer 2019a), an analysis of the dissolved PAH concentrations has been made for the material if deposited at the disposal site (FO080) for the same dredge methodology as set out in ABPmer, 2019a. A comparative assessment is shown in Table 5 where the colour coding on the right provides a summary assessment relative to the water Environmental Quality Standards (EQS) for the PAH's where data exists.

Five data sets have been analysed based on the average concentrations from PAH analysis results from different areas of Eyemouth Harbour over the period 2016 to 2020, namely:

- Location A which identified the contamination in the Harbour;
- Area B that has been licenced for disposal at FO080;
- Area A surface sampling (September 2019);
- Area A with depth sampling (February 2020); and
- Area A, combined surface and with depth samples which would represent the overall average concentration deposited at the disposal site should a licence be granted.

This analysis shows that the PAH dissolved concentrations that would result at disposal site FO080 are significantly lower for the current contamination levels compared to the 2016 samples that caused the exemption of Area A from the current Marine Disposal Licence. The average concentrations from the with depth 2020 samples would give rise to maximum dissolved concentrations at the disposal site lower than the EQS for each PAH except for (Benzo(ghi)perylene), however this is nearly nine times lower than in 2016. When the 2019 higher surface concentrations are included most PAH remain below or close to the EQS and at considerably lower levels than for the 2016 levels,

Comparison of the current average Area A maximum dissolved concentrations with the 2016 data for Area B shows fewer exceedances of the EQS and all individual concentrations are lower. Again, as Area B was licensed for disposal, this information indicates that allowing disposal from Area A would have less effect on the water quality at the disposal site, which is unlikely to be significant when the small daily volume deposited is considered.

Table 5. Dissolved PAH concentrations of potential deposited material from Dredge Area A and compared with Dredge Area B

PAH	Sediment Concentration (µg/kg)	Partitioning Coefficient (l/kg)	EQS (µg/l)	Dissolved Concentration (µg/l)
Dredge Area A - (All Area A average all depths)				
Anthracene	99.605	793	0.1	0.126
Benzo(a)pyrene	272.792	20,795	0.027	0.013
Benzo[b]fluoranthene	217.550	20,795	0.017	0.010
Benzo(ghi)perylene	178.392	25,583	0.00082	0.007
Benzo[k]fluoranthene	121.025	19,859	0.017	0.006
Fluoranthene	486.883	2,444	0.12	0.199
Indeno(1,2,3-cd)pyrene	161.458	58,607	0.027	0.003
Naphthalene	66.908	35	130	1.912
Dredge Area A - 2020 -(With Depth)				
Anthracene	48.127	793	0.1	0.061
Benzo(a)pyrene	155.533	20,795	0.027	0.007
Benzo[b]fluoranthene	143.983	20,795	0.017	0.007
Benzo(ghi)perylene	112.217	25,583	0.00082	0.004
Benzo[k]fluoranthene	71.450	19,859	0.017	0.004
Fluoranthene	261.267	2,444	0.12	0.107
Indeno(1,2,3-cd)pyrene	102.367	58,607	0.027	0.002
Naphthalene	49.350	35	130	1.410
Dredge Area A - 2019 -(Surface)				
Anthracene	151.083	793	0.1	0.191
Benzo(a)pyrene	390.050	20,795	0.027	0.019
Benzo[b]fluoranthene	291.117	20,795	0.017	0.014
Benzo(ghi)perylene	244.567	25,583	0.00082	0.010
Benzo[k]fluoranthene	170.600	19,859	0.017	0.009
Fluoranthene	712.500	2,444	0.12	0.292
Indeno(1,2,3-cd)pyrene	220.550	58,607	0.027	0.004
Naphthalene	84.467	35	130	2.413
Dredge Area A - 2016 (Average through depth)				
Anthracene	1,340.963	793	0.1	1.691
Benzo(a)pyrene	1,538.194	20,795	0.027	0.074
Benzo[b]fluoranthene	1,223.526	20,795	0.017	0.059
Benzo(ghi)perylene	882.645	25,583	0.00082	0.035
Benzo[k]fluoranthene	1,286.441	19,859	0.017	0.065
Fluoranthene	4,784.399	2,444	0.12	1.958
Indeno(1,2,3-cd)pyrene	765.185	58,607	0.027	0.013
Naphthalene	1,640.595	35	130	46.874
Dredge Area B - 2016 (Average through depth)				
Anthracene	152.735	793	0.1	0.193
Benzo(a)pyrene	304.483	20,795	0.027	0.015
Benzo[b]fluoranthene	387.382	20,795	0.017	0.019
Benzo(ghi)perylene	268.928	25,583	0.00082	0.011
Benzo[k]fluoranthene	289.571	19,859	0.017	0.015
Fluoranthene	610.083	2,444	0.12	0.250
Indeno(1,2,3-cd) pyrene	275.144	58,607	0.027	0.005
Naphthalene	57.032	35	130	1.629

5 Conclusion

The PAH contamination in Area A has significantly reduced in the period 2016 and 2020. This has occurred naturally as no dredging has been allowed from this area during this period. Contamination levels are still in excess of the MS LOT AL1 threshold and the Canadian SQG levels, however, there is a significant reduction against the Canadian PEL threshold. With depth sampling in 2020 has shown that contamination levels reduce with depth; 2-3 times lower at 100 cm depth compared to the surface and none of the new samples exceeded the PEL thresholds. At the surface four of the six sites sampled in 2019 had concentrations below the PEL level and at the other two locations the concentrations were considerably lower than in 2016. THC concentrations were not analysed in 2020 but were on average 15 times lower in 2019 compared to 2016.

Sediment from Area B (Gunsgreen Basin) was allowed for sea disposal in the existing Marine Licence, despite some contamination. The current analysis shows that concentrations within Area A are presently, for the most part, lower than the levels allowed for disposal from Area B. Analysis of the water PAH concentrations predicted at the disposal site, shows that most PAHs, if disposed, would not exceed the EQS, if the same method of dredging and disposal were to be used. These data indicate less contamination would be dissolved in the water than from the sediment deposited from Area B.

This analysis of the current sediment contamination in Area A indicates that PAH and THC contaminant levels have reduced, and probably will continue to reduce (without further contamination events). The PAH concentrations, albeit still above MS LOT AL1 are lower than the sediments licensed for disposal from Gunsgreen Basin. Less exceedance of the water quality thresholds would also occur at the disposal site.

On this basis, this analysis suggests there is no reason to continue to exclude the dredging of Area A for disposal at sea.

6 References

ABPmer, (2019a). Eyemouth Harbour Deepening - Support for Marine Licence Application. ABPmer Report R.3169.

ABPmer, (2019b). Dredge Area A, Sediment sampling plan, ABPmer Report R.3240TN.

ABPmer, (2019c). Eyemouth Harbour Deepening, Dredge Area A - Sediment Contamination Analysis - September 2019, ABPmer Report R.3309TN.

CCME, (1999). Protocol for the Derivation of Canadian Sediment Quality Guidelines for the Protection of Aquatic Life. Canadian Council of Ministers of the Environment, CCME EPC-98E, 1995 - Updated, 1999.

7 Abbreviations/Acronyms

AL	Action Level
CCME	Canadian Council of Ministers of the Environment
CD	Chart Datum
CSQG	Canadian Sediment Quality Guidelines
EQS	Environmental Quality Standards
ID	Identity
MS LOT	Marine Scotland Licensing Operations Team
PAH	Polycyclic Aromatic Hydrocarbon
PEL	Probable Effect Level
SQG	Sediment Quality Guidelines
THC	Total Hydrocarbon Content
wt/yr	Wet Tonnes/Year

Cardinal points/directions are used unless otherwise stated.

SI units are used unless otherwise stated.

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Appendix B

ABPmer Report R3329TN

Eyemouth Harbour Trust

Eyemouth Harbour Deepening

Dredge Area D – Sediment Contamination Analysis – November 2019

December 2019





Innovative Thinking - Sustainable Solutions

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1 Introduction

In 2018 a need for maintenance dredging of Eyemouth Harbour was identified with the primary focus on the entrance channel, Gunsgreen Basin and its' entrance. Applications were made to Marine Scotland's Licensing Operation Team (MS-LOT) for a marine licence to dredge these areas. The chemical sampling indicated that contamination, predominantly hydrocarbons were present, which was above Action Level 1 (AL1) (Marine Scotland, 2017), therefore MS-LOT requested further assessment to be undertaken. That assessment was reported in ABPmer report R.3169 (ABPmer 2019a).

As a result, a Marine Licence for the disposal of dredged material was permitted for the Outer Channel (Area C) and Gunsgreen Basin (Area B). Area A was excluded and subject to a request for further information. A sediment sampling plan for Area A was agreed with MS-LOT and the results were evaluated in ABPmer Technical Note R.3309TN (ABPmer 2019b). See Figure 1 for locations of harbour areas.

Consideration of the existing depths in the Upper Harbour (Area D) has now been undertaken and is the subject of this document. This has identified that maintenance dredging is also required in Area D to restore depths for navigation safety, particularly for the larger fishing vessels and commercial offshore vessels. This note provides information on the Area D dredge requirement (depths, volumes, material types) and analysis of the contamination levels from the September 2019 bed sediment sampling exercise.

1.1 Requirement

Area D was last dredged in September 2014. The total area of Area D is 10,750 m^2 and it is proposed to carry out maintenance dredging in this area to a depth of up to 1 m below existing bed levels.

A detailed bathymetric survey was undertaken in in April 2018, an image of which is provided as Figure 2. A check survey undertaken in October 2019 shows some redistribution of sediment has occurred, but overall the volume of sediment to be removed has remained similar.

The current volume of sediment to be dredged is estimated as 7,870 m^3. However, to allow for maintenance of this depth over the period of a three-year licence a total quantity of 15,000 m^3 is to be applied for. Based on the physical properties of the material to be dredged (see Section 2.2) the average *in-situ* density is estimated to be about 1,550 kg/m^3, hence for Marine Licencing purposes the wet tonnage to be dredged in a first phase would be up to 12,400 wet tonnes, with a total of 23,250 wet tonnes over three years.

Arial Imagery from Google Satellite, 2019

Figure 1. Dredge areas and 2019 grab sampling locations proposed dredging activity

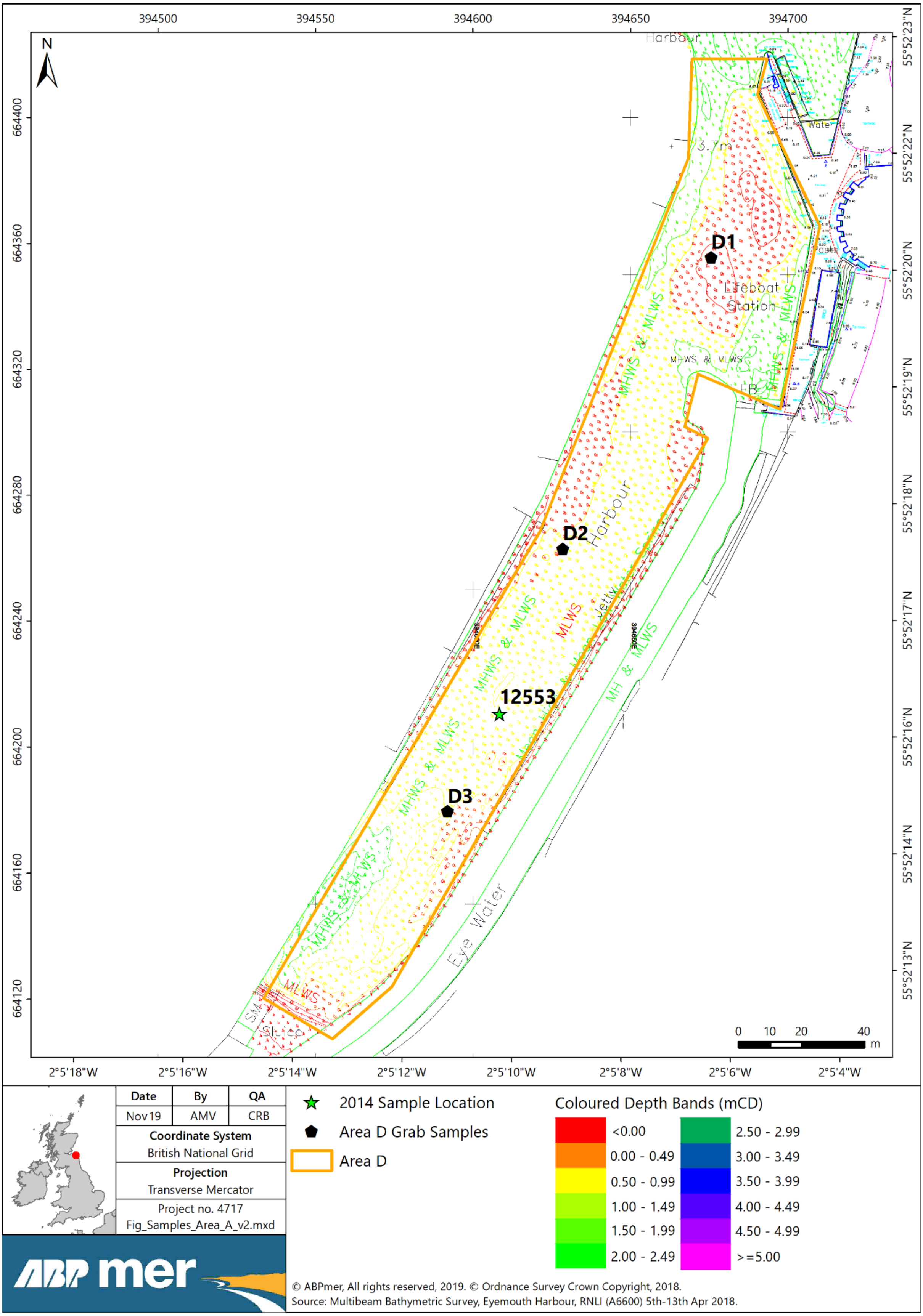

Figure 2. Bathymetry showing 2014 and 2019 sediment sample locations

1.2 Material type

Surface sediment sampling was undertaken on 17 September 2019 with a Van Veen Grab at three locations (see Figure 2) close to where the greatest depths of sediment are to be dredged.

For the purpose of the licensing process and assessment of the physical and chemical analysis, the material grain size is graded into three categories. These are:

- Silt – defined as <63 µm in size;
- Sand – defined as ranging between 63 µm and 2 mm; and
- Gravel – defined as > 2 mm in size.

The results of the laboratory analysis indicate that:

- Grab Location D1 (north) is predominantly sand (74%) and silt (21%) with a small contribution (5%) of gravel. The Total Organic Contents (TOC) of the bed material is general low (<1%). The total solid content is 49% which indicates the material to be relatively free draining and non-cohesive in character. The approximate average in *situ* density (i.e. wet bulk) is estimated to be about 1,700 kg/m^3 or higher;
- Grab Location D2 is predominantly silt (67%) and sand (32%) with a small contribution (1%) of gravel. The bed material contains about 6% TOC and retains a significant volume of water with the solid content being only 28%. This indicates that the bed material is likely to have cohesive properties and the *in-situ* density is likely to be around 1,550 kg/m^3; and
- Grab Location D3 (south) is predominantly silt (80%) and sand (20%) with a TOC content <5%). The total solid content is about 26%, therefore the material is likely to have some cohesive properties but with a an *in-situ* density of around 1,500 kg/m^3.

In summary, the sediment sampling shows the material to be dredged varies from predominantly sand in the north of the area opposite the RNLI berth, currently where the shallowest depths exist. The sediment fines southwards to sandy silt with *circa* 5% organic material. Here the sediment becomes more cohesive and retains more water, lowering the bulk density, hence the mass of sediment per unit volume to be removed.

1.3 Proposed dredge method

Dredging will most likely be undertaken by a small self-propelled hopper barge with backhoe bucket, e.g. MV Sandsend. The dredger will have a maximum carrying capacity of up to 400 tonnes of wet sediment in the hopper. Based on the assumed average density of the bed materials the maximum *in situ* volume removed each load will be about 260 m^3. This means that the total disposal requirement to restore depths in the first phase would be equivalent to about 31 dredger loads. Assuming a bucket size of about 1.5 m^3 with an average 2 minute cycle time (allowing for vessel manoeuvring) the average loading time would be about 5.5 hours.

The FO080 licensed deposit ground is *circa* 3 nautical miles from the Harbour entrance, therefore with a representative service speed of about 8 knots and time for disposal the overall cycle time will be of the order of 6.5 hours. Given the tidal range in the Harbour and the depths in the entrance channel and the loaded draught of the vessel, dredging will be tidally restricted, particularly on spring tides. This means that realistically only one dredge load will be deposited per tide.

To remove the full volume for Phase 1 (the initial maintenance) would take about 16 days (assuming no weather delays). The maximum rate of disposal at FO080 would therefore be a single load of up to 260 m^3 of Harbour dredge material approximately every 12.5 hours for 16 consecutive days per year, assuming all dredging is undertaken in a single campaign.

2 Sediment Contamination Results

The three surface samples (locations D1 to D3 on Figure 2) were analysed for Heavy metals, Tri-Butyl Tin (TBT) Aromatic Hydrocarbons (PAH) and Total Hydrocarbon Content (THC) at the approved Socotec Laboratory.

Contamination information is also provided from the 2014 sample; sample reference 12553 on Figure 2. This information gives an indication of how the contamination may have changed over the 5 years, noting that dredging occurred followed by sedimentation during this time.

2.1 Heavy metals and organotins

Comparison of the contamination levels is shown as Table 1 and for the most part the 2019 Heavy Metal concentrations were for many determinands lower (in some cases by around 50%) than the levels present in 2014 and no determinands exceeded MS-LOT AL2.

Contamination from Copper and TBT are, however, higher particularly in the sandier sediments of the northern part of the area. Comparison with the MS-LOT ALs show that Copper, Nickel and Zinc contamination at most locations still exceeds AL1, albeit most levels except for Copper, being relatively close to the threshold value.

The TBT concentration at the northerly site (D1) has increased significantly from relatively close to AL1 to 75% of the way towards the AL2 threshold concentration. Concentrations are considerably lower at Locations D2 and D3 and below AL1, suggesting that the concentration at Location D1 could be a localised ‘hot spot’.

Overall, the Heavy Metal and Organotin contamination in the sediment, whilst some determinands still exceed AL1, will have lower environmental effects than the previous dredging campaign from Area D.

It should be noted the 2014 concentrations were allowed to be disposed at sea in the subsequent dredge.

Table 1. Heavy metal contamination levels against Marine Scotland Action Levels

Sample	Bed Depth (m)	Dry Weight (mg/kg)									
		Arsenic (As)	Cadmium (Cd)	Chromium (Cr)	Copper (Cu)	Mercury (Hg)	Nickel (Ni)	Lead (Pb)	Zinc (Zn)	Dibutyltin (DBT)	Tributyltin (TBT)
February 2014 Data											
12553	0.00-0.15	14.9	0.42	57.7	55.5	0.13	34.3	42.0	181	0.013	0.175
Area D Sampling September 2019 Data											
D1	0.00-0.15	6.6	0.21	28.2	106	0.02	27	34.3	108	0.0405	0.738
D2	0.00-0.15	8.8	0.31	37.1	60.2	0.08	28	31.4	154	<0.005	0.0592
D3	0.00-0.15	8.3	0.39	33	63.7	0.1	25.4	28	199	<0.005	0.088
Marine Scotland Guideline Action Levels (mg/kg Dry Weight)											
AL 1		20.0	0.40	40.0	40.0	0.30	20.0	50.0	130.0	0.100	0.10000
AL 2		100.0	5.00	400.0	400.0	3.00	200.0	500.0	800.0	1.000	1.000

2.2 Polycyclic aromatic hydrocarbons and total hydrocarbons

2.2.1 Action levels

Table 2 provides a similar comparative analysis for PAH contamination levels to that for the Heavy Metals. At Location D1, where the bed material is predominantly sand the PAH contamination is substantially lower for all determinands compared to 2014. Most concentrations are reduced below the AL1 threshold with the exceptions of Benzo(b)fluoranthene, Fluoranthene and Pyrene, however, these were at levels of only circa 25% of those that occurred in 2014.

The contamination levels increase southwards as the sediment fines to predominantly silt, with about 5% organic content. In this area, the overall contamination level is lower or similar to that in 2014, however, some individual determinands are marginally higher than previously existed. Overall, the sediment has lower PAH concentrations than occurred in 2014.

2.2.2 Canadian Sediment Quality Guidelines (CSQG)

As for the previous PAH analyses for the other harbour areas (for example Area A, where MS-LOT had concerns over the concentration) the levels, in some cases considerably exceeded AL1, however as there is no AL2 threshold it is difficult to 'gauge' the significance of likely, environmental effect.

To aid the assessment of potential environmental effect, should disposal at sea be licensed, Table 3 provides a similar comparison against the Canadian Sediment Quality Guidelines for the Protection of Aquatic Life (CSQG) (CCME, 1999) for some of the PAH determinands. Discussion on the use of the various ALs and CSQG Probable Effects Levels (PEL) is presented in ABPmer 2019a, previously supplied to MS-LOT. The comparison against the PEL provides some guidance in the absence of a MS-LOT AL2 threshold for PAH determinands.

Table 3 shows a similar result to the AL1 assessment above in that contamination exceeds the lower SQG level, however, none of the PAHs analysed exceed the PEL level. Consequently 'probable' effects on the biological environment are considered unlikely. In general, the contamination levels are considerably less than 50% of the concentration difference between the SQG and PEL levels.

Table 4 provides a comparison of the 2019 average PAH contamination levels between Area D, Area A and Area B, where PAH concentrations were generally above AL1. This table shows that for most determinands the average contamination level is lower than both Areas A and B, in a number of cases substantially. For example, the maximum PAH determinand reduction was for C1-phenanthrene at 75%, with an overall average percentage reduction compared to Areas A and B of about 37%. The final column in Table 4 shows that the Total Hydrocarbon Content (THC) was 81% lower in Area D than elsewhere in the harbour.

These data suggest that should disposal at sea be licensed the effect on the marine environment would be small, particularly as the rate of delivery, due to the small dredger size and low frequency of disposal (one load per tide). The overall contamination level is *circa* 37% of the levels in the areas of the harbour already licensed for disposal at sea.

Table 2. PAH levels of contamination against the Marine Scotland Guideline Action Levels

Sample	Polycyclic Aromatic Hydrocarbons (PAHs; µg/kg Dry Weight)																							
	Bed Depth (m)	Acenaphthene	Acenaphthylene	Anthracene	Benz(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(e)pyrene	Benzo(ghi)perylene	Benzo(K)fluoranthene	C1-napthalenes	C1-phenanthrene	C2-napthalenes	C3-napthalenes	Chrysene	Dibenz(a,h)anthracene	Fluoranthene	Fluorene	Indeno(1,2,3-cd)pyrrene	Naphthalene	Perylene	Phenanthrene	Pyrene	Total Hydrocarbon Content (THC)
February 2014 Data																								
12553	0.00-0.15	22.7	5.9	62.2	296.2	344.9	470.9	279.8	324.9	203.4	163.5	523.2	347.7	910.3	268.1	69.4	646.6	53.5	355.8	77.7	122.0	258.2	545.8	1044
Area D Sampling September 2019 data																								
D1	0.00-0.15 m	8.6	7.0	23.4	73.9	98.3	113.0	90.7	89.0	40.7	46.6	82.3	56.0	85.7	97.4	19.8	148.0	12.3	83.3	22.4	43.3	70.5	132.0	8.6
D2	0.00-0.15 m	23.1	32.2	75.7	247.0	338.0	358.0	288.0	306.0	201.0	170.0	248.0	183.0	274.0	308.0	48.7	461.0	42.6	287.0	96.7	124.0	218.0	430.0	23.1
D3	0.00-0.15 m	18.9	113.0	85.7	306.0	430.0	406.0	337.0	338.0	214.0	166.0	261.0	149.0	236.0	373.0	69.7	587.0	44.1	339.0	222.0	145.0	273.0	535.0	18.9
Marine Scotland Guideline Action Levels (µg/kg Dry Weight)																								
AL1		100	100	100	100	100	100	100	100	100	100	100	100	100	100	10	100	100	100	100	100	100	100	-
AL2		No AL2 levels defined for PAH																						

Table 3. PAH levels compared to the Canadian Sediment Quality Guidelines for the Protection of Aquatic Life

Sample	Polycyclic Aromatic Hydrocarbons (PAHs; µg/kg Dry Weight)												
	Bed Depth (m)	Acenaphthene	Acenaphthylene	Anthracene	Benz(a)anthracene	Benzo(a)pyrene	Chrysene	Dibenz(a,h)anthracene	Fluoranthene	Fluorene	Naphthalene	Phenanthrene	Pyrene
February 2014 Data													
12553	0.00-0.15 m	22.7	5.9	62.2	296	345	268	69.4	647	53.5	77.7	258	546
Area D Sampling September 2019 Data													
D1	0.00-0.15 m	8.55	7.04	23.4	73.9	98.3	97.4	19.8	148	12.3	22.4	70.5	132
D2	0.00-0.15 m	23.1	32.2	75.7	247	338	308	48.7	461	42.6	96.7	218	430
D3	0.00-0.15 m	18.9	113	85.7	306	430	373	69.7	587	44.1	222	273	535
Canadian Sediment Quality Guidelines for the Protection of Aquatic Life (µg/kg Dry Weight)													
SQG		6.71	5.87	46.9	74.8	88.8	108	6.22	113	21.2	34.6	86.7	153.0
PEL		88.9	128	245	693	763	846	135	1,494	144	391	544	1,398

Table 4. Comparison of PAH contamination levels between Area A (2019), Area B (2016) and Area D (2019)

Area	Acenaphthene	Acenaphthylene	Anthracene	Benz(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(e)pyrene	Benzo(ghi)perylene	Benzo(K)fluoranthene	C1-napthalenes	C1-phenanthrene	C2-napthalenes	C3-napthalenes	Chrysene	Dibenz(a,h)anthracene	Fluoranthene	Fluorene	Indeno(1,2,3-cd)pyrrene	Naphthalene	Perylene	Phenanthrene	Pyrene	Total Hydrocarbon Content (THC)
Area A Ave. Sep 19	23.7	33.8	151.1	391.1	390.1	291.1	256.4	244.6	170.6	250.2	519.7	281.7	386.0	382.5	45.9	712.5	44.9	220.6	84.5	107.8	383.2	671.3	185,400.0
Area B Ave. Sep 16	26.8	21.2	152.7	336.5	304.5	387.4	306.2	268.9	289.6	175.1	788.4	349.3	724.5	434.8	60.3	610.1	110.9	275.1	57.0	148.0	277.5	747.2	2,802,844.9
Area D Ave. Sep 19	16.9	50.7	61.6	209.0	288.8	292.3	238.6	244.3	151.9	127.5	197.1	129.3	198.6	259.5	46.1	398.7	33.0	236.4	113.7	104.1	187.2	365.7	519,333.3
% Diff for Area D**	-37	+50	-60	-47	-26	-25	-22	-9	-48	-49	-75	-63	-73	-40	-24	-44	-70	-14	+35	-30	-51	-51	-81

Shaded area shows minimum concentration from comparison
** Base for % is highest concentration from any area

3 Water Quality Assessment

Should sediment from Area D be licensed for disposal then the sediment PAH concentrations will have the potential to increase the dissolved concentration of each determinand in the water around the disposal site (FO080). Table 5 shows the maximum likely dissolved concentration in the water column of the PAH determinands where partitioning coefficients are readily available and water Environmental Quality Standards (EQS) exist for marine waters. Again, a comparison is made against equivalent calculations for other sediments that have been, or are licensed, for disposal at the site.

This analysis shows that in general the effects on water quality are similar for the contamination levels that would occur from the Area A 2019 contamination levels and considerably lower than for the 2016 levels. The maximum dissolved concentrations would be lower than for the sediment that has been licensed for disposal from Area B.

Overall, six of the eight determinands are below the respective EQS values and one is relatively close (Fluoranthene). Only Benzo(ghi)perylene remains substantially above its EQS, however this is lower than the licensed disposal from Area B.

These data like the sediment PAH concentration analysis against the sediment quality ALs and CSQG values, along with the relatively small volumes and low frequency of disposal, suggest that any environmental effect around the disposal site will be low and unlikely to cause significant impacts on the biological environment.

Table 5. Maximum dissolved PAH concentrations from deposited material

PAH	Sediment Concentration (mg/kg)	Partitioning Coefficient (l/kg)	EQS (µg/l)	Maximum Dissolved Concentration (µg/l)
Dredge Area A – 2019				
Anthracene	151.083	793	0.1	0.191
Benzo(a)pyrene	390.050	20,795	0.027	0.019
Benzo[b]fluoranthene	291.117	20,795	0.017	0.014
Benzo(ghi)perylene	244.567	25,583	0.00082	0.010
Benzo[k]fluoranthene	170.600	19,859	0.017	0.009
Fluoranthene	712.500	2,444	0.12	0.292
Indeno(1,2,3-cd)pyrene	220.550	58,607	0.027	0.004
Naphthalene	84.467	35	130	2.413
Dredge Area D – 2019				
Anthracene	61.600	793	0.1	0.078
Benzo(a)pyrene	288.767	20,795	0.027	0.014
Benzo[b]fluoranthene	292.333	20,795	0.017	0.014
Benzo(ghi)perylene	244.333	25,583	0.00082	0.010
Benzo[k]fluoranthene	151.900	19,859	0.017	0.008
Fluoranthene	398.667	2,444	0.12	0.163
Indeno(1,2,3-cd)pyrene	236.433	58,607	0.027	0.004
Naphthalene	113.700	35	130	3.249
Dredge Area A - 2016				
Anthracene	1,340.963	793	0.1	1.691
Benzo(a)pyrene	1,538.194	20,795	0.027	0.074
Benzo[b]fluoranthene	1,223.526	20,795	0.017	0.059
Benzo(ghi)perylene	882.645	25,583	0.00082	0.035
Benzo[k]fluoranthene	1,286.441	19,859	0.017	0.065
Fluoranthene	4,784.399	2,444	0.12	1.958
Indeno(1,2,3-cd)pyrene	765.185	58,607	0.027	0.013
Naphthalene	1,640.595	35	130	46.874
Dredge Area B - 2016				
Anthracene	152.735	793	0.1	0.193
Benzo(a)pyrene	304.483	20,795	0.027	0.015
Benzo[b]fluoranthene	387.382	20,795	0.017	0.019
Benzo(ghi)perylene	268.928	25,583	0.00082	0.011
Benzo[k]fluoranthene	289.571	19,859	0.017	0.015
Fluoranthene	610.083	2,444	0.12	0.250
Indeno(1,2,3-cd) pyrene	275.144	58,607	0.027	0.005
Naphthalene	57.032	35	130	1.629

4 Conclusion

The chemical analyses of the material to be dredged from Area D shows that contamination levels have generally reduced in the 5 year period between the 2014 and 2019. This may be due to dredging that has occurred following the 2014 sampling. Heavy Metal, Organotin and PAH levels are still in excess of the MS-LOT AL1 threshold and the Canadian SQG levels, particularly in the southern part of Area D where the material is predominantly lower density silt with about a 5% organic content. The sandier material to the north is cleaner with many determinands below the MS-LOT AL1 threshold.

Whilst a large number of individual PAH determinands remain above AL1 and the SQG value, none exceeded the PEL threshold value. Comparison with samples from Areas A and B show the sediment in Area D is generally cleaner.

Calculations of the maximum dissolved concentrations that could occur in the water column around the disposal site, should a Marine Licence be granted, indicate that most determinands assessed would be below their respective EQS values.

Overall, the chemical analysis along with the relatively small volumes to be disposed and low disposal frequency (i.e. one load per tide) suggests environmental effects around the disposal site will be low, short lived and unlikely to cause significant impacts on the biological environment.

5 References

ABPmer, (2019a). Eyemouth Harbour Deepening – Support for Marine Licence Application. ABPmer Report R.3169.

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Canadian Council of Ministers of the Environment, CCME 1995, (1999). Protocol for the Derivation of Canadian Sediment Quality Guidelines for the Protection of Aquatic Life. CCME EPC-98E.

Marine Scotland, (2017) Pre-disposal Sampling Guidance Version 2 (Scottish Government).

6 Abbreviations/Acronyms

AL	Action Level
CCME	Canadian Council of Ministers of the Environment
CSQG	Canadian Sediment Quality Guidelines
DBT	Dibutyltin
EQS	Environmental Quality Standards
ISQG	Interim Sediment Quality Guideline
MS-LOT	Marine Scotland Licensing Operations Team
MV	Motor/Merchant Vessel
PAH	Polycyclic Aromatic Hydrocarbon
PEL	Probable Effect Level
RNLI	Royal National Lifeboat Institution
SQG	Sediment Quality Guidelines
TBT	Tributyltin
THC	Total Hydrocarbon Content
TOC	Total Organic Contents

Cardinal points/directions are used unless otherwise stated.

SI units are used unless otherwise stated.

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