MOTT MACDONALD

Best Practicable Environmental Option Assessment Report

New Islay Vessel Enabling Works Kennacraig

March 2024

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1 Introduction

1.1 Introduction

This report has been prepared by Mott MacDonald on behalf of Caledonian Maritime Assets Limited (CMAL) in support of a Marine Licence application and to determine the best disposal method of the dredge material required for the new Islay vessel enabling works. It compares various options for the disposal of dredge material and identifies the Best Practicable Environmental Option (BPEO).

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

Marine Licences for these activities are currently valid in Scotland for up to three years[1]. This application is expected to cover the period from March 2024 to December 2024. This BPEO has been updated since it was submitted with licence application MS-00010391 to reflect that the revised licence application for Kennacraig Ferry Terminal is now a dredge only application, and disposal will be to a landfill site above MHWS.

1.2 The Need for Dredging and Spoil Disposal

Caledonian Maritime Assets Limited (CMAL) seek to undertake upgrade works at the three ferry terminals (Kennacraig, Port Askaig and Colonsay (shown in Figure 1.1) on the Islay route prior to the introduction of new vessels, which are planned to be operational around mid-2024.

[1] Guidance+for+Marine+Licence+Applicants.pdf (www.gov.scot)

Figure 1.1: Terminals on the Islay Ferry Service

The new vessels are planned to have a larger beam, length, draught and displacement than the current vessels that serve the route, as well as having a hybrid diesel-electric propulsion system. Enabling works to the four terminals are therefore necessary to safely and reliably berth, moor, load and unload the vessels at all four ports together with shore power for charging the vessels at Kennacraig and Port Askaig.

The focus of this Best Practical Environmental Option Assessment (BPEO) Report is the New Islay Vessel Port Enabling Works at Kennacraig Ferry Terminal, hereafter referred to as the 'Proposed Development'. The Proposed Development would upgrade the ferry terminal to facilitate future accommodation of a new vessel with deeper draught and higher displacement. Works primarily consist of the following:

- Upgrading of existing fenders including breaking concrete at one location;
- Construction of toe protection to support secant pile walls;
- Construction of piled wall;
- Installation of new vessel shore power and connections;
- Modification to the existing fixed ramp within the ferry terminal;
- Fabrication and erection of steel grillage at infill pier;
- Dredging;
- Installation of scour protection; and
- A new longer gangway.

The focus of this BPEO Report is the dredging works at the Proposed Development. This is further explained in Section 1.3 below.

1.3 Proposed Dredging and Disposal Options

1.3.1 Location of dredging

Dredging around the Proposed Development to 5.5m below Chart Datum would be undertaken (see details in 105612-MMD-KE-ZZ-DR-C-0101 - New Islay Vessel Port Enabling Works Kennacraig Dredging Plan (Appendix E)). The approximate area dredged would be 7868m^2 and volume 6747m^3. The boundary coordinates of the proposed dredge area are in Table 1.1 below.

Table 1.1: Coordinates of dredge area

	Easting	Northing
SOP-KE-100	181779.3114	662568.3370
SOP-KE-101	181790.2115	662567.7011
SOP-KE-102	181799.6123	662553.2131
SOP-KE-103	181799.3695	662548.5295
SOP-KE-104	181812.6777	662514.1226
SOP-KE-105	181811.2427	662507.2509
SOP-KE-106	181801.9443	662493.9261
SOP-KE-107	181766.1441	662488.3964
SOP-KE-108	181749.5270	662477.9243
SOP-KE-109	181734.1243	662466.5809
SOP-KE-110	181704.2716	662464.6275
SOP-KE-111	181650.5406	662465.4165
SOP-KE-112	181640.0082	662473.7110

1.3.2 Method of Dredging

Dredging works would likely be undertaken either by a backhoe dredger only or by a trailer suction hopper dredger working in conjunction with a backhoe dredger (for areas of the structures which are inaccessible by trailer suction hopper). If required, bedrock would be pre-fractured by drilling and splitting using Cardox (a CO_2 driven hydraulic breaker). Non-explosive blasting methods would be used.

1.3.2.1 Dredging Process (backhoe dredger)

The spuds extend to the seabed and provide lateral resistance and stability for the pontoon (Figure 1.2). The dredge material will be loaded into a split hopper barge (SHB) (Figure 1.3).

The dredging process consists of:

1. Digging and filling the bucket;
2. Lifting the bucket;
3. Swinging towards the SHB;
4. Emptying the bucket into the SHB;
5. Swinging towards the next digging location;
6. Lowering the bucket;
7. Positioning at the next digging location; and
8. Digging and filling the bucket.

The excavator is located above the dredged face and digs towards itself, in an upward motion, to fill the bucket. With the pontoon positioned in one location, the excavator covers an area along an arc and dependent on, with arc length dependent on the length of boom and stick.

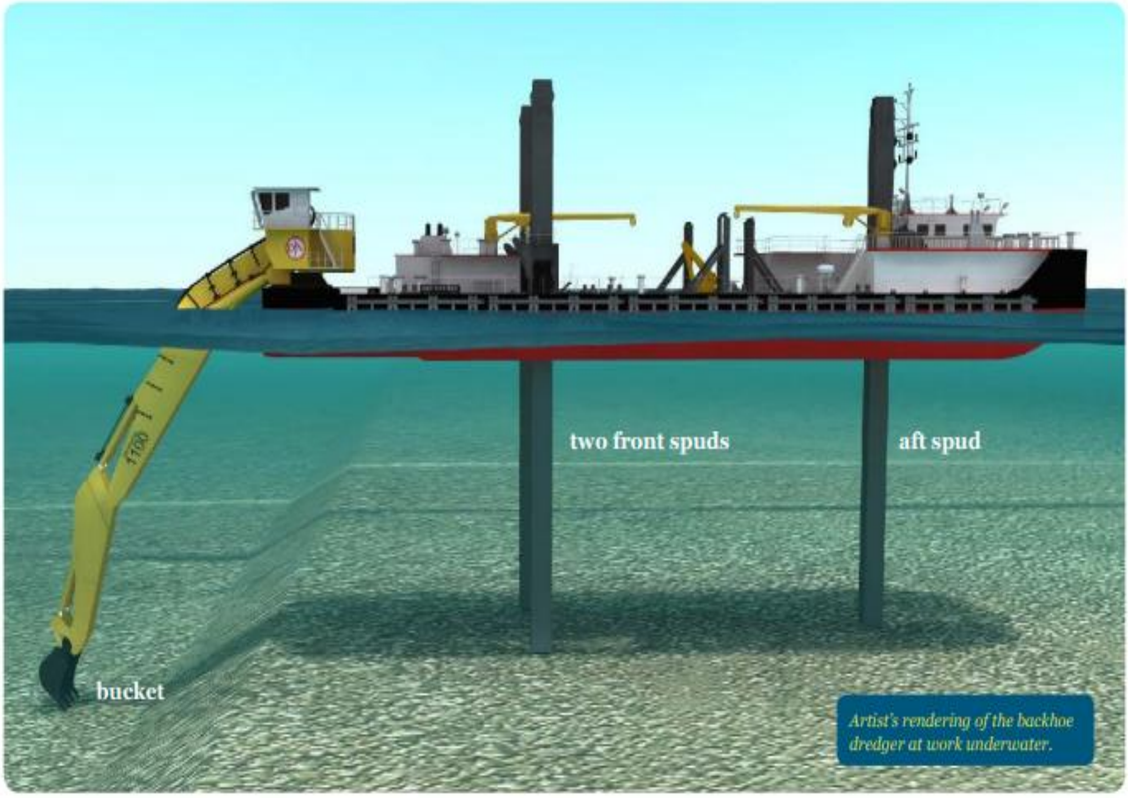

Figure 1.2: Backhoe dredger example

Source: Backhoe Dredging (graphic sourced at International Association of Dredging Companies, 2016 https://www.iadc-dredging.com/wp-content/uploads/2016/07/facts-about-backhoe-dredgers.pdf)

SHB are the self-propelled barges, which transport the dredge material once loaded by the backhoe dredger to the shore within the Proposed Development for onward travel to the assigned disposal/dump area via road transport.

Figure 1.3: Split Hopper Barge Example

Source: Backhoe Dredging onto SHB (graphic sourced at International Associated of Dredging Companies, 2016 www.iadc-dredging.com)

1.4 Scope of Report

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 Waste (Scotland) Regulations 2012[2]. The options on the short-list are then reviewed against environmental and cost considerations. The options are then compared and the BPEO identified through an options appraisal process.

The report also includes the results from completed sediment testing. Sixteen samples from six sampling locations were tested for a suite of contaminants including heavy metals and metalloids, total petroleum hydrocarbons (TPH), polycyclic aromatic hydrocarbons (PAH), polychlorinated biphenyls (PCBs), polybrominated diphenyl ethers (BDEs) and pesticide organochlorines. Interpretation of the results is provided in Section 2.

This report is structured as follows:

- Chapter 2: Sediment Sampling
- Chapter 3: BPEO Method
- Chapter 4: Discussion of Available Disposal Options
- Chapter 5: Conclusion

[2] The Waste (Scotland) Regulations 2012 (legislation.gov.uk)

1.5 Limitations

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2 Sediment Sampling

2.1 Description of Sediment to be Dredged and Disposed

In line with Marine Scotland guidelines on pre-dredge sampling protocol[3], sampling was undertaken on the 27 October 2022. As the dredge volume proposed is less than 25,000m^3, there were at least 3 sampling locations required. The sample locations are shown in Figure 2.1. The samples were taken in line with the Sediment Sampling and Analysis Plan within Appendix 0. The samples, along with the scheduled analyses, are summarised in Table 2.1.

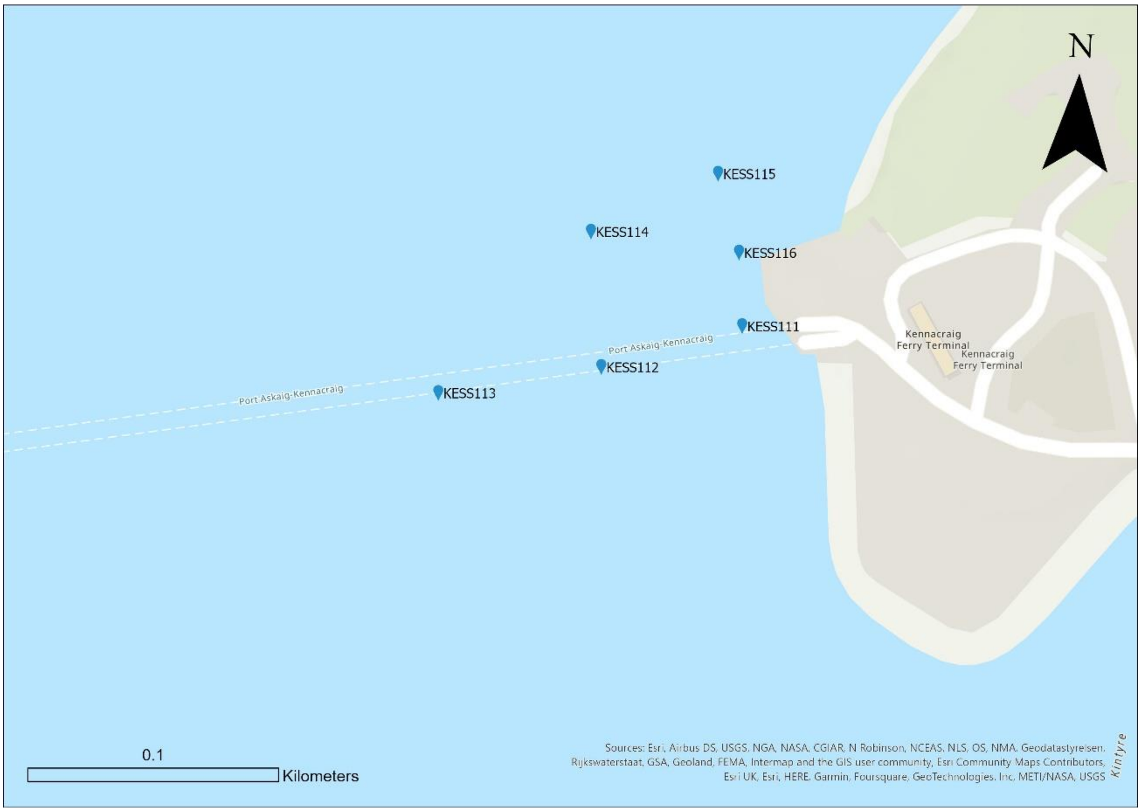

Figure 2.1: Borehole locations at Kennacraig

Table 2.1: Sampling at Kennacraig

Borehole ID	Location	Depth below chart datum (m CD)	Depths sampled (m CD)	Testing suites
KESS111	181791.15E, 66219.30N	-4.81	-4.81, -5.31, -5.81	Heavy metals and metalloids, TPH, PAH, PCBs, BDEs, organochlorine pesticides, tributyltin (TBT), dibutyltin (DBT), asbestos.
KESS112	181737.76E, 662503.82N	-6.05	-6.05, -6.55	
KESS113	181676.00E, 662494.00N	-5.13	-5.13, -5.63, -6.13	
KESS114	181733.85E, 662555.07N	-4.91	-4.91, -5.41, -5.91	

[3] Marine Scotland. 2017. Pre-disposal sampling guidance Version 2. https://www.gov.scot/binaries/content/documents/govscot/publications/advice-and-guidance/2020/02/marine-licensing-applications-and-guidance/documents/guidance/pre-disposal-sampling-guidance/pre-disposal-sampling-guidance/govscot%3Adocument/Pre-disposal%2Bsampling%2Bguidance.pdf

Borehole ID	Location	Depth below chart datum (m CD)	Depths sampled (m CD)	Testing suites
KESS115	181782.01E, 662577.00N	-4.89	-4.89, -5.39, -5.89	
KESS116	181789.94E, 662547.16N	-5.39	-5.39, -5.89	

The results of the chemical analyses are included in Appendix A and interpreted in Section 2.1.1.3.

The laboratories which performed the chemical analyses were pre-approved by Marine Scotland. Details are summarised in Table 2.2.

Table 2.2: Analytical laboratory details

Laboratory name	Address	UKAS Accreditation Number
RPS Bedford	13 St Martins Way, Bedford, Bedfordshire, MK42 0LF	1663
RPS Manchester	Unit 12, Waters Edge Business Park, Modwen Road, Cadishead, M5 3EZ	0605

2.1.1 Results of sediment sampling

2.1.1.1 Sediment description

A summary of the physical description of the sediments from borehole logs is included in Table 2.3.

Table 2.3: Summary of sediment descriptions

Borehole ID	Depth (m CD)	Description	Remarks
KESS111	-4.81 to -5.61	Black gravelly silty organic CLAY with <3mm thick lenses of brown silty CLAY. Gravel is fine to coarse rounded to angular with fragments of shells	
	-5.61 to -6.71	Black silty organic CLAY with <3mm thick lenses of brown silty CLAY	
	-6.71 to -7.61	Brown silty CLAY	
KESS112	-6.05 to -6.35	Black sandy clayey organic fine to coarse angular GRAVEL of shells and fragments of shells. Sand is fine to coarse	
	-6.35 to -10.55	Grey slightly sandy organic CLAY with rare fragments of shells. Sand is fine to coarse	
KESS113	-5.13 to -9.03	Grey slightly sandy organic CLAY with shells. Sand is fine to coarse	
	-9.03 to -9.63	Black silty organic CLAY with <3mm lenses of brown silty CLAY	
KESS114	-4.91 to -5.41	Black sandy clayey organic fine to coarse angular GRAVEL of shells and fragments of shells. Sand is fine to coarse	
	-5.41 to -6.71	Grey brown silty CLAY	
KESS115	-4.89 to -5.29	Black gravelly silty organic fine to coarse SAND. Gravel is fine to coarse angular predominantly shell and fragments of shell	
	-5.29 to -6.79	Black silty organic CLAY with <3mm lenses of brown silty CLAY	Medium COBBLE encountered at 0.8m

Borehole ID	Depth (m CD)	Description	Remarks
			Medium COBBLE encountered at 1.0m
KESS116	-5.39 to -5.69	Black sandy clayey organic to fine to coarse angular GRAVEL of shells and fragments of shells. Sand is fine to coarse	
	-5.69 to -6.69	Black silty organic CLAY with <3mm dense of brown silty CLAY	
	-6.69 to -6.89	Yellow brown fine to coarse SAND with lenses of silt	

2.1.1.2 Environmental laboratory test results (Marine Scotland action levels)

As advised in the pre-dredge sampling protocol[4], analysis results were screened against Marine Scotland action levels 1 and 2 (AL1 and AL2; Appendix 0) where applicable. No exceedances of AL2 were noted in any sample, and no exceedances were recorded of PCBs, BDEs, or pesticide organochlorines. The results of sediment analyses are included in Appendix A.

There were thirty-six recorded exceedances across the six sampling locations for arsenic, chromium, copper, mercury, nickel, PAHs and total hydrocarbon content (THC). PAH and THC exceedances of AL1 were only measured in KESS116 at 0.00m. The exceedances are summarised in Table 2.4 and Table 2.5.

To provide a quantitative assessment of these exceedances, the values are expressed as a percentage of AL1 and AL2. Note that there are no AL2 values for PAH and THC. For further contextualisation, values are also screened against the National Oceanic and Atmospheric Administration (NOAA) Screening Quick Reference Tables (SQuiRT)[5]. SQuiRT values provide further information on the toxicity of contamination and, by extension, the risk to ecological receptors. These results are included in Appendix D.

[4] Marine Scotland. 2017. Pre-disposal sampling guidance Version 2. https://www.gov.scot/binaries/content/documents/govscot/publications/advice-and-guidance/2020/02/marine-licensing-applications-and-guidance/documents/guidance/pre-disposal-sampling-guidance/pre-disposal-sampling-guidance/govscot%3Adocument/Pre-disposal%2Bsampling%2Bguidance.pdf

[5] NOAA Screening Quick Reference Tables. 2019. https://response.restoration.noaa.gov/sites/default/files/SQuiRTs.pdf

Table 2.4: Recorded AL1 exceedances at Kennacraig (metals and metalloids)

Borehole ID:			KESS111	KESS111	KESS111	KESS112	KESS113	KESS113	KESS113	KESS114	KESS114	KESS114	KESS115	KESS115	KESS115	KESS116	KESS116
Depth sampled (m CD):			**-4.81**	**-5.31**	**-5.81**	**-6.55**	**-5.13**	**-5.63**	**-6.13**	**-4.91**	**-5.41**	**-5.91**	**-4.89**	**-5.41**	**-5.89**	**-5.39**	**-5.89**
Determinand	**Units**	**AL1**															
Arsenic	mg/kg	**20**	14.6	21.4	16.8	16.3	24.9	24.5	25.2	14.2	19.7	11.2	16.4	8.9	9.7	13.2	13.1
Chromium	mg/kg	**50**	102	128	119	75.4	117	131	123	42.6	73.4	69.3	51.7	74	69.3	43.6	111
Copper	mg/kg	**30**	23.9	29.4	26.3	9.3	14.8	15	14.3	81.4	13.5	16.5	10.4	17.4	17.1	12.9	28.3
Mercury	mg/kg	**0.25**	0.05	0.06	0.05	0.05	0.05	0.06	0.06	0.08	0.05	0.06	0.06	0.06	0.05	0.27	0.06
Nickel	mg/kg	**30**	46.7	62.7	57.6	29.5	46	52.4	48.8	16.8	29.1	29.6	19.8	32.6	30.3	19	54.4

Key: = exceedance of AL1

Table 2.5: Recorded AL1 exceedances at Kennacraig (PAH)

Borehole ID:	**Depth sampled (m CD)**	**Determinand** (mg/kg)	**Benzo(a)anthracene**	**Benzo(a)pyrene**	**Benzo(b)fluoranthene**	**Dibenz(a,h)anthracene**	**Fluoranthene**	**Phenanthrene**	**Pyrene**	**THC**
		AL1 (mg/kg)	**0.1**	**0.1**	**0.1**	**0.01**	**0.1**	**0.1**	**0.1**	**100**
KESS116	-5.39		0.112	0.108	0.12	0.0227	0.244	0.158	0.178	511.69

Key: = exceedance of AL1

2.1.1.3 Results Interpretation

As contamination has been identified which is >AL1 and <AL2, the relevant excerpt of Marine Scotland guidance[6] is included below:

" *If contamination >AL1, <AL2, the following restrictions may apply:*

- *Restriction on sea disposal of certain areas of dredge spoil*
- *Monitoring of dredge material and disposal site*
- *Treatment or mitigation measures* "

As Table 2.4 shows, total hydrocarbons are significantly elevated above AL1 at KESS116 only at a sample taken at bed level with the deeper sample (0.5m below bed level) showing no exceedance. This represents a localised impact laterally and with depth.

There are no other significantly elevated concentrations and exceedances are not consistently present across the samples. The exception to this appears to be more consistent exceedances of AL1 for chromium and nickel.

It is considered likely that this indicates a high natural background level of chromium contamination in the area.

Whilst some of the recorded exceedances are >200% of AL1 (e.g, copper at KESS114 at -4.91m CD is 271.3% of AL1), no exceedance is >41.8% of AL2 (nickel at KESS111 at -5.31m CD). Therefore, as values are not close to the threshold where treatment would be required (AL2), and treatment would have limited effects, it is not advised to treat the dredging material. See Appendix D for further information.

For more appropriate contextualisation, the values were screened against NOAA SQuiRT values. The SQuiRT values provide a higher resolution assessment of the contaminant concentrations than the Marine Scotland action levels. The values are informed by empirical research, although, as some of the research is outdated, the values are only suitable for preliminary screening.

Appendix D (Table D.3 and Table D.4) shows that there are no exceedances of the Probable Effect Level (PEL) or Effects Range Median (ERM) thresholds. However, there are ten exceedances of T_{50} – the next most stringent value –, which corresponds to the level where there is an approximately 50% probability of observing a toxicological response in some organisms. The exceedances of T_{50} consist of nickel (five), arsenic (four) and benzo(a)pyrene (one).

It is important to consider that the NOAA SQuiRT cards provide indicative values. Whilst the options of restriction and treatment of disposal sediment have been discounted as effective options, further discussion is provided about these results in Section 4.6.

2.1.1.4 Analytical Methods

The original action levels, devised by Cefas, utilised partial digestion analytical methods. Subsequent review studies[7] have found AL1 to be conservative, leading to attempts to revise

[6] Marine Scotland. 2017. Pre-disposal sampling guidance Version 2. https://www.gov.scot/binaries/content/documents/govscot/publications/advice-and-guidance/2020/02/marine-licensing-applications-and-guidance/documents/guidance/pre-disposal-sampling-guidance/pre-disposal-sampling-guidance/govscot%3Adocument/Pre-disposal%2Bsampling%2Bguidance.pdf

[7] UK Government. 2015. High Level Review of UK Action Level (MMO1053) (https://www.gov.uk/government/publications/action-levels-1053)

action levels upwards in England. Indeed, contemporary Marine Scotland requirements, as followed in the sediment analyses, stipulate full digestion via hydrofluoric acid extraction. If the action levels were devised using full digestion, they would be greater, thus reducing the magnitude of any AL1 exceedance.

Furthermore, during analyses samples were ground, thus releasing matrix-bound contaminants which may not be bioavailable, and therefore over-estimating the potential risk to ecological receptors. For instance, the level of heavy metal reflected the total concentration likely including non-bioavailable metal fraction bound in the sediment, but that fraction could be considered as representing no direct harm to the environment. The valency of chromium was also disregarded during analyses in which the toxicological effect of chromium (III) being less than chromium (VI), thus their potential risk to ecological receptors would be different.

2.1.1.5 Sediment Re-mobilisation Post-excavation

Excavation of sediments for disposal will result in nominal re-mobilisation of contaminated sediments through dispersal. However, as ecological receptors have been identified within the vicinity of Kennacraig Ferry Terminal site (Figure 2.2), this leads to identification of a contaminant linkage under Part IIA of the Environmental Protection Act, 1990 whereby:

The contaminated sediment (source) – re-mobilised through excavation (pathway) – will potentially impact the identified ecological receptors (receptor).

Nevertheless, result of modelled sediment re-mobilisation (see 105612-MMD-KE-ZZ-RP-O-0007-S2-P01-New Islay Vessel Enabling Works Kennacraig Dredge Dispersion Modelling Report for further details) represented by exceedance in suspended solids concentration (SSC) at the dredge area (Figure 2.3) indicates that the elevated SSC will remain localised. The nearest ecological receptor, which is the blue mussel beds, is not predicted to be influenced by any elevated SSC from the sediment excavation. Result of modelled deposition from the sediment suspended by dredging (Figure 2.4) also indicates that sedimentation will be localised only within approximately 100m from the dredge footprint. Therefore, no ecological receptors are expected to be affected by neither sediment re-mobilisation nor sediment deposition arising from the dredging.

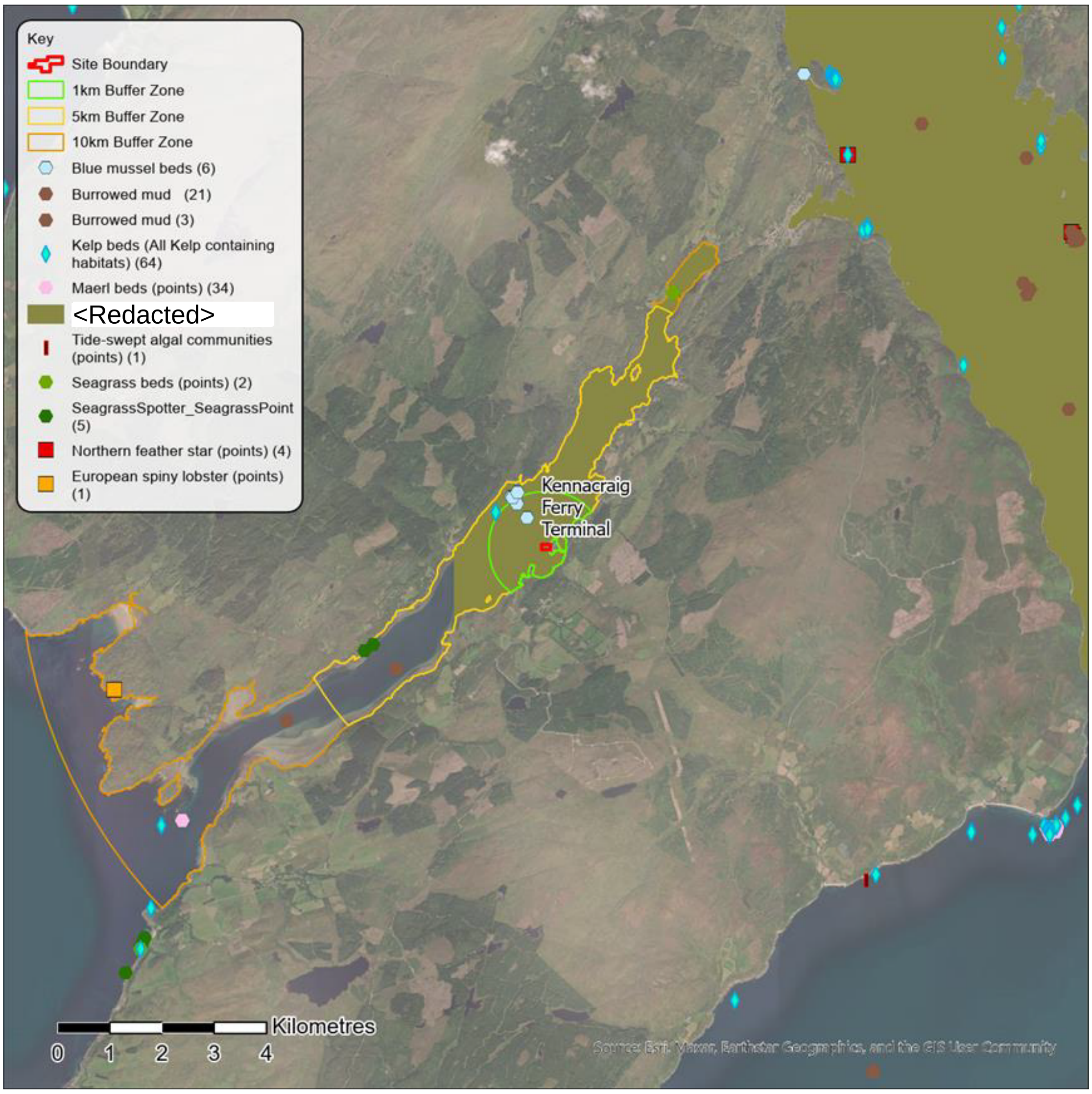

Figure 2.2: Kennacraig ecological receptors map

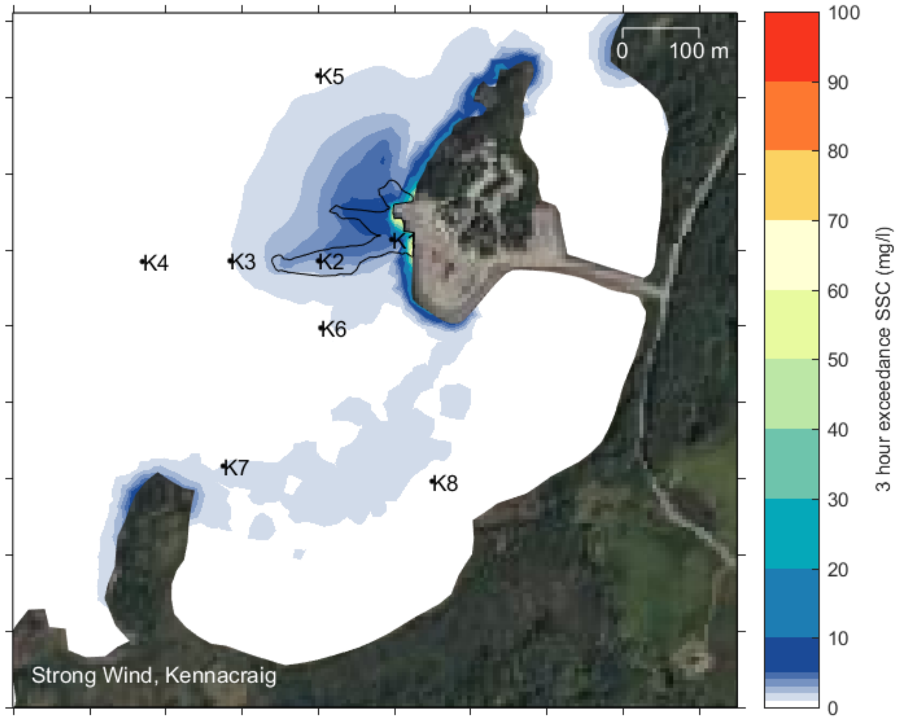

Figure 2.3: Kennacraig modelled 3-hour SSC exceedance at the dredge area

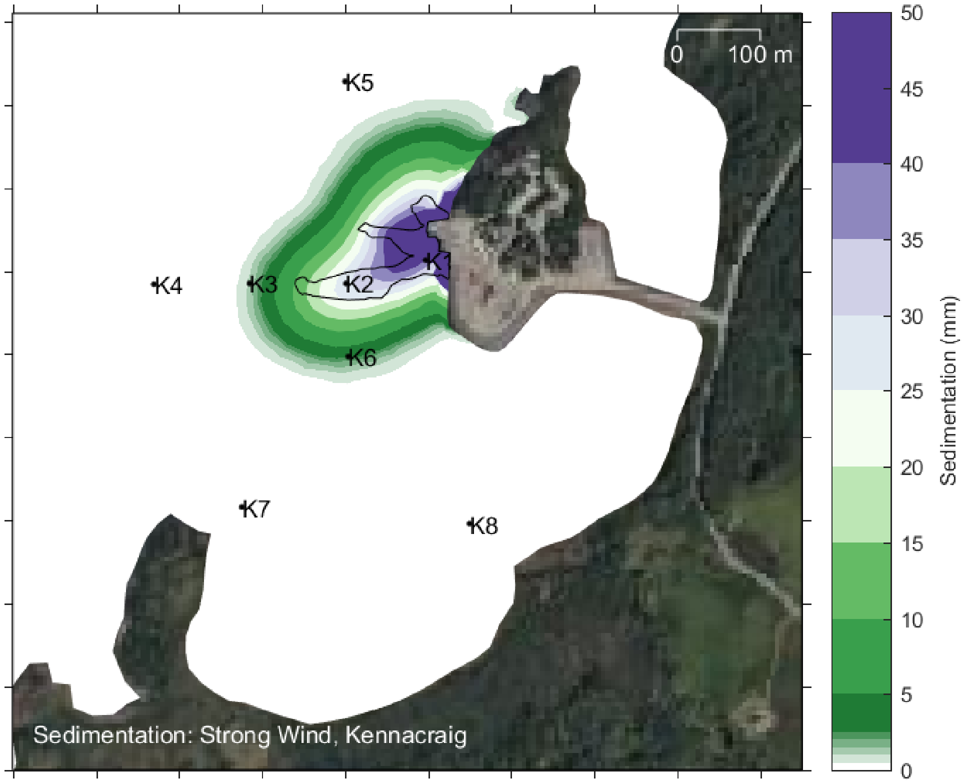

Figure 2.4: Kennacraig modelled sedimentation

2.1.1.6 Bioavailability of Contamination

As sediment re-mobilisation constitutes an identified pollutant linkage, this is analysed below.

Firstly, considering the potential receptors, Figure 2.2 indicates that, of the known priority marine features, there are blue mussel beds (*Mytilus edulis*), native oysters (a range), and kelp beds present within the wider vicinity of the Kennacraig Ferry Terminal area. The re-mobilised sediment would have to disperse over 5km to affect ecological receptors. After evaluating the characteristics of the harbour environment, and general literature analysing the distance of re-suspended sediment from dredging, >5km is viewed as too far to require assessment of additional ecological receptors.

When sediments are disturbed there is potential that some of the contaminants could be within the interstitial pore water and thus released to the water column where it would travel wider than the sediments that would settle out. These unbound contaminants are likely to be a small proportion of the sampled sediment concentrations though it is unclear what proportion would end up in the water column. A conservative value of 10% sediment re-mobilisation of the total dredge volume (=674m^3) has been used to determine a worse case example of magnitude of contamination that these receptors are likely to be exposed to outside of the sediment settlement areas.

After re-assessing the screening values at 10% of their measurements reported values, this leads to each exceedance being measured as <42% of the generally lowest SQuiRT threshold value (T_{20}), and each value being <AL1. Consequently receptors are unlikely to be affected.

It should be noted that this assumes that the sampling is completely representative of the contamination at the site. Whilst a structured pattern was utilised in the sampling approach (Figure 2.1), the non-uniform nature of contamination distribution in sediments[7] (evidenced by the hydrocarbon elevation at KESS116 at bed level), indicates that it is likely that there are "hotspots" of contamination in the Kennacraig sediment. Indeed, it is viewed that the sampling was sufficient to accurately characterise the sediment – meeting Marine Scotland requirements – and the presence of unidentified hotspots are a common limitation of ground investigation works. This also implies that contamination appears in only a certain layer within the total dredging volume, so as dispersed the received concentration of contaminants would reduce.

To mitigate against this limitation, a further literature review of the bioavailability and bio-uptake of contamination was undertaken, specifically focusing on potentially sensitive ecological receptors to assess which mitigation measures are required and to tailor any measures to increase their efficacy.

- Bioavailability of contaminant during dredging:
  - The bioavailability of heavy metals and trace organic contaminants could be indicated from elutriate test, as it simulates the degree of mobilisation of contaminants from sediment into the water column during dredging operation or open water disposal of dredged material[8].
  - A review of elutriate test results from another project of dredging sediment with contaminant levels similar to that of Kennacraig sediment samples was conducted. From contaminated sediment samples with exceedances of the relevant sediment quality, the elutriate test results indicated that the measured concentrations in water were mostly

[7] Vale C., Canario J., Caetano M., Lavrado J., and Brito P. 2008. *Estimation of the anthropogenic fraction of elements in surface sediments of the Tagus Estuary (Portugal).* Marine Pollution Bulletin 56, pp. 1353-1376

[8] Sartori, D., Macchia, S., Layglon, N., D'Onofrio, S., Mission, B., Piccione, M.E., Bertolotto, R.M., Scuderi, A., Pilato, F., Giuliani, S., Pellegrini, D., Gaion, A. 2021. *Elutriate preparation affects embryo development test with Paracentrotus lividus: An in-depth study on the differences between two protocols and three different sediment/water mixing times*. Ecotoxicology and Environmental Safety 212, 112010

below the detection limits[9]. Except some elevated levels in arsenic concentration, there were no exceedances of the relevant water quality criteria for heavy metals or trace organics.
  - These elutriate results could be reasonably implied to the Kennacraig sediment that potential impact on water quality and subsequent risk to ecological receptors by contaminant release during sediment dredging would unlikely be significant.
- Bio-uptake of contamination by blue mussel (*Mytilus edulis*):
  - The key sources for contaminant uptake in mussels are chemicals dissolved in the ambient seawater and in contaminated food particles (mainly phytoplankton).
  - Effect on *Mytilus edulis* exposed to PAHs in contaminated sediment was reported from Pruell et al. (1986)[10]. The experiment indicated that the dissolved phase was the direct source of PAH accumulated by the mussels. Only slight changes in the concentration of two- and three-ring compounds as well as fluoranthene occurred in exposed mussel. Uptake of 4-, 5- and 6-ring compounds was rapid, while the depuration rates for PAHs was relatively fast. Thus, the sub-lethal effect of PAHs is not expected to be significant.
  - Effect of heavy metal exposure on *Mytilus edulis* was reported from MarLIN (2022)[11]. The effect concentration (EC_{50}) of ten metals on the embryos of *M. edulis* represented by abnormal development were tested in 1981 and established the 48-hour EC_{50} value of arsenic, chromium, copper, nickel and mercury to be >3 mg/l, 4.469 mg/l, 5.8 µg/l, 891 µg /l and 5.8 µg/l respectively. Nevertheless, it is worth noting that even if these metals and metalloids in the Kennacraig sediment distributed into the water column during dredging, in the natural and dynamic marine environment their concentration would be diluted and unlikely elevated to such effect concentration to cause any lethal effect on the mussels.
- Bio-uptake of contamination by native oysters:
  - Monitoring of heavy metal uptake by native oyster due to a major discharge of mine water at the Fal estuary was reported from Cefas[12]. The results did not indicate any direct correlation between the levels of metals in the oysters and those in the water and there did not appear to be any general increase in the metal levels in the oysters due to the input of contaminated mine water.
- Bio-uptake of contamination by kelp beds:
  - Chemical pressure by heavy metals and PAH contamination on *Laminaria digitata* and *L. hyperborea* were not accessed, according to information available on MarLIN.
  - Bryan (1984)[13] suggested that the general order for heavy metal toxicity in seaweeds is: Organic Hg > inorganic Hg > Cu > Ag > Zn > Cd > Pb.

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[9] Mott MacDonald Hong Kong Ltd. 2010. Providing Sufficient Water Depth for Kwai Tsing Container Basin and Its Approach Channel: Environmental Impact Assessment (final).

[10] Pruell, R.J., Lake, J.L., Davis, W.R. and Quinn, J.G. 1986. Uptake and depuration of organic contaminants by blue mussels (*Mytilus edulis*) exposed to environmentally contaminated sediment. Marine Biology 91, 497-507.

[11] Tyler-Walters, H., Williams, E., Mardle, M.J. & Lloyd, K.A., 2022. Sensitivity Assessment of Contaminant Pressures - Approach Development, Application, and Evidence Reviews. MarLIN (Marine Life Information Network), Marine Biological Association of the UK, Plymouth, pp. 192. Available from https://www.marlin.ac.uk/publications

[12] Cefas. 1997. Monitoring and surveillance of non-radioactive contaminants in the aquatic environment and activities regulating the disposal of wastes at sea, 1994. Aquatic Environment Monitoring Report No. 47.

[13] Bryan, G.W., 1984. Pollution due to heavy metals and their compounds. In Marine Ecology: A Comprehensive, Integrated Treatise on Life in the Oceans and Coastal Waters, vol. 5. Ocean Management, part 3, (ed. O. Kinne), pp.1289-1431. New York: John Wiley & Sons.

– Hopkin & Kain (1978)[14] demonstrated sub-lethal effects of heavy metals on *Laminaria hyperborea* gametophytes and sporophytes, including reduced growth and respiration.

Considering potential disposal at the licensed site (Portnahaven - Site ID MA035 south of Port Wemyss), the ecological receptor identified within 5km is generally bedrock/stony reef communities only (Figure 2.5). The rapid deposition over a large area will disperse and dilute contaminated sediment below threshold levels by the time it reaches the seabed. This is indicated in the modelled result[15] of maximum SSC from sediment resuspension at the disposal site (Figure 2.6) showing that the resultant plume has very low SSC concentrations due to the relatively fast flows in the area and the limited sediment mass predicted to be resuspended at any time. Furthermore, the pollution prevention and control measures present at site will limit off-site migration and the site was selected as a disposal site due to the absence of nearby ecological receptors. Thus, this will provide limited risk to ecological receptors.

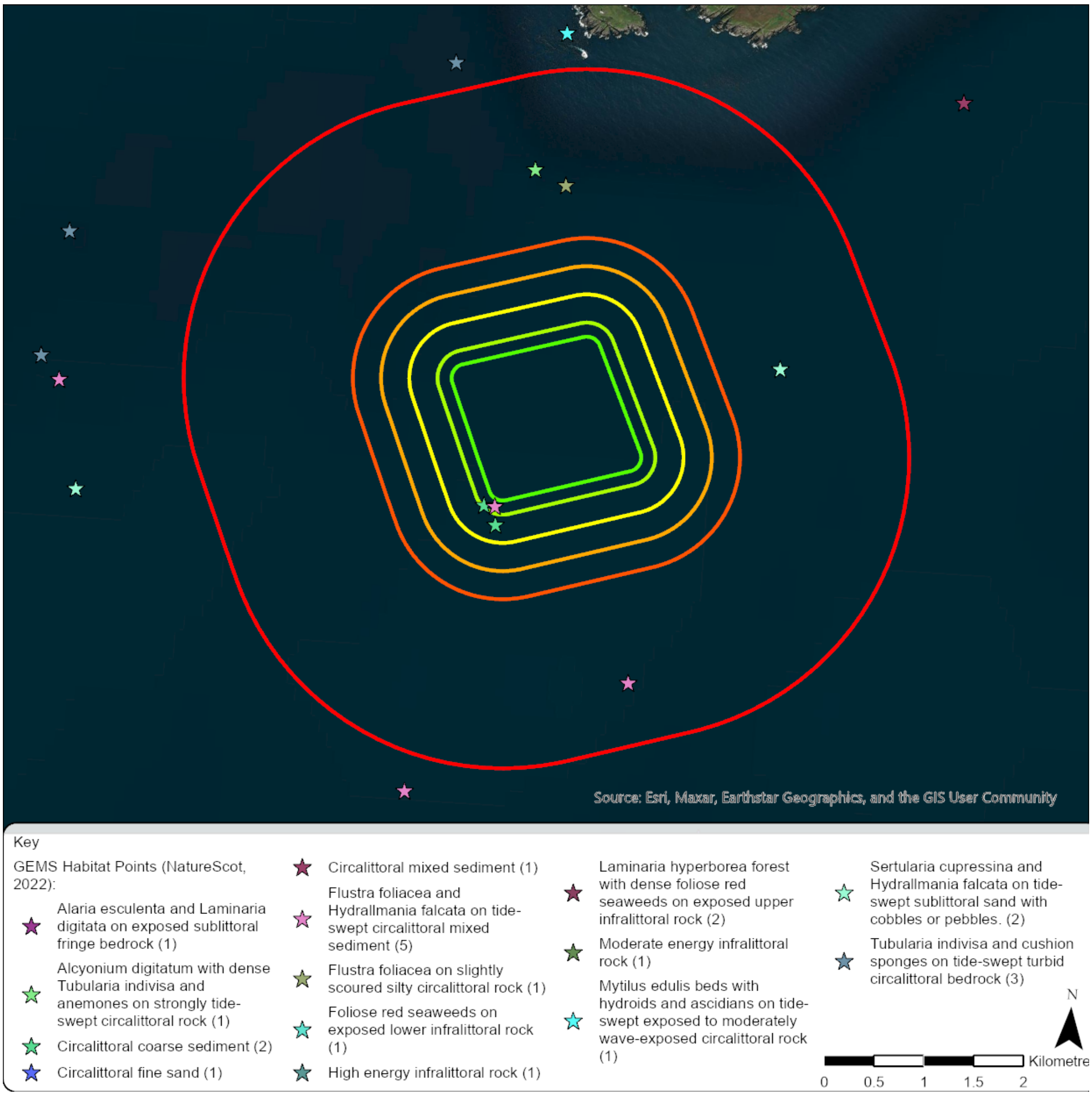

Figure 2.5: Disposal site ecological receptor map

[14] Hopkin, R. & Kain, J.M., 1978. The effects of some pollutants on the survival, growth and respiration of Laminaria hyperborea. Estuarine and Coastal Marine Science, 7, 531-553.

[16] Guidance+for+Marine+Licence+Applicants.pdf (www.gov.scot)

(NB: red line – 5km from the disposal site Habitat Source: NatureScot GeMS dataset)

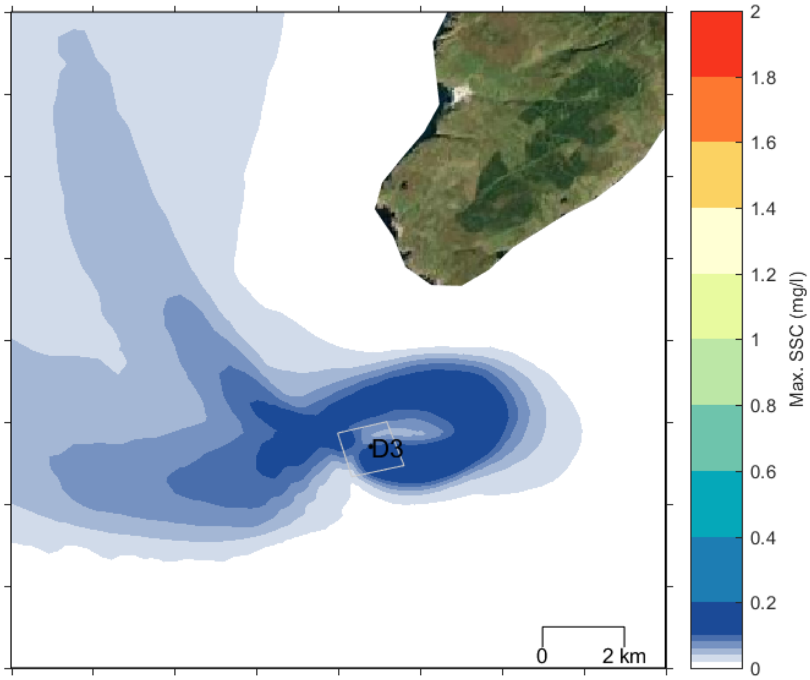

Figure 2.6: Modelled maximum SSC at the disposal site for the resuspension run

3 BPEO Method

3.1 Options Identification

A review of dredge material disposal options was undertaken through a desk-based review of typical disposal options. The long list of options identified during the review are summarised in Section 4.4.

3.2 Screening of Long List Options to Short List of Options

The long list options were screened through a desk-based study which considered:

- Feasibility of the option in relation to the physical constraints in proximity to the Proposed Development;
- Availability of on-site areas where dredge material could be re-used;
- Availability of off-site areas where dredge material could be reused or disposed of within the vicinity of the Proposed Development; and
- Suitability of the material following chemical screening.

3.3 Attribute Identification and Scoring of Feasible Options

3.3.1 Comparison of Short-List Options and Identification of the BPEO

MS-LOT's general licensing guidance[16] states the following in relation to BPEO assessment: 'consideration must be given to the availability of practical alternatives when considering any applications involving disposal of material at sea. In order for MS-LOT to assess the available alternative options, all sea disposal licence applications must be supported by a detailed assessment of the alternative options. This should include a statement setting out the reasons, including financial, that have led to the conclusion that deposit of the materials at sea is the BPEO.'

There is no formal guidance available in Scotland on BPEO assessment for disposal of dredge material. This BPEO assessment adopts an approach that considers the following aspects: strategic, health, safety and environmental and cost. The short-list of options were assessed against these aspects, details of which are provided in Sections 3.3.2 to 3.3.4 below.

[16] Guidance+for+Marine+Licence+Applicants.pdf (www.gov.scot)

3.3.2 Strategic Considerations

Strategic considerations include the following:

- Operational feasibility – whether the option is technically practicable.
- Availability of sites/facilities – whether there are any sites or facilities which can accept the dredge material.
- General public acceptability – whether the public are likely to object to or support the proposal.
- Likely agency acceptability – whether public agencies are likely to object or support the proposal.
- Legislative implications – assessing compliance with relevant legislation and any potential management controls required.

3.3.3 Health, Safety and Environmental Considerations

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

- Public health – assessing whether there would be any risk of detrimental effect on public health based on predicted pathways and receptors.
- Safety – considering potential sources of hazard and the probability that there would be any risk to the general public or workers.
- Contamination/pollution – evaluating whether there is potential for pollution or contamination.
- Ecological impact – assessing the significance of any potential impact on important habitats or species including designated sites.
- Interface with other legitimate users – considering whether they are likely to be impacts on other activities such as other users of the port.
- Amenity/Aesthetic – assessing whether there is likely to be visual or noise impacts resulting from the disposal or any impact on local amenity.

3.3.4 Cost Considerations

The cost of disposing of dredge material was considered in terms of capital costs (construction of facilities and equipment hire/purchase costs).

3.3.5 Comparison of Options and Identification of the BPEO

The performance of each option was evaluated on a scale from Low to High according to definitions presented in Table 3.1. Intermediate grades (Low to Medium and Medium to High) were also used where the assessment was marginal between Low, Medium or High based on professional judgement.

Table 3.1: Definitions of Performance

	Classification		
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).
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			

	Classification		
Consideration	**High**	**Medium**	**Low**
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 (This will be reviewed in line with the Marine Scotland Action Levels identified in Table C.1)	Compliant with emission standards and water quality objectives. Low risk of harm from substances released to environment.	Marine Scotland action levels may be approached or breached occasionally. Some risk of harm to environment.	Marine Scotland action levels may be breached regularly and there is a moderate or high risk of harm to environment.
Ecological impact (This will be reviewed in line with the Marine Scotland Action Levels identified in Table 2.1)	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 affected but effects are unlikely to be significant.	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.

	Classification		
Consideration	**High**	**Medium**	**Low**
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 costs for the disposal	More than £10m	Between £5m and £10m.	£5m or less

4 Discussion of Available Disposal Options

4.1 Introduction

This section describes the various options that are available to dispose of the dredged material. A long list of options are described and are screened to identify a reasonable short list of options, with section 4.5 providing an assessment of the short listed options.

4.2 Long list of Options

The long list of options are listed below and can generally be split into land-based or sea-based disposal options. They are described in more detail in Section 4.4:

- Option 1a/1b: Do Nothing/Do Minimum;
- Option 2: Reuse in land-based construction on site;
- Option 3: Reuse as construction material off site;
- Option 4: Disposal to landfill;
- Option 5: Beach restoration / other coastal protection;
- Option 6: Offshore sea disposal; and
- Option 7: Spreading on agricultural land.

4.3 Common Activities for Land-Based Disposal Options

The disposal options that have land-based components include:

- Option 2: Reuse in land-based construction on site;
- Option 3: Reuse as construction material off site;
- Option 4: Disposal to landfill;
- Option 5: Beach restoration / other coastal protection; and
- Option 7: Spreading on agricultural land.

The activities that are common to land-based disposal options are:

- Landing the dredge material;
- Storage of dredge material
- Dewatering the dredge material; and
- Loading and transport for disposal.

4.4 Common Activities for Sea-Based Disposal Options

The steps that are common to sea-based disposal options are:

- Transporting the dredge material to the disposal location; and
- Dispose of the material at licenced sea disposal location.

4.5 Screening of Long List Options

Section 4.5.1 to 4.5.8 set out each option in further detail and describe the screening of each. During the screening process, options that are considered to be impracticable (based on considerations set out in Section 3.2) have been discounted.

Conversely, short-listed options that have been considered as potentially practicable are further considered in Section 4.6. The options are then assessed based on strategic, environmental, health and safety and cost implications outlined in Section 3.3.

4.5.1 Option 1a/1b: Do Nothing / Do Minimum

Option 1a/1b is the baseline scenario which considers the current situation where no dredging would take place. For this option, the new vessels which are under construction would not be useable at the Kennacraig Ferry terminal due to their larger size. As such, in a do-nothing / do minimum scenario no dredging would take place and it would be expected that existing vessels would be used in the short-term. The existing vessels are currently prone to breaking down and requiring regular repairs. Under a do-nothing scenario, these vessels would no longer be repaired and ferry services through these vessels would cease to exist. Under a do minimum scenario, the vessels would be repaired in the short term, however, in the long-term the existing vessels would no longer be operational due to their age and would reach a stage whereby they are no longer repairable. As such, the ferry services via these vessels would cease to exist. This option is impractical as the new vessels would ground if no dredging were to be carried out and therefore has been discounted.

4.5.2 Option 2: Re-use In Land-based Construction on Site

This option would re-use any dredge materials within other areas of the construction site. Any material that is re-used on site will need to be assessed to ensure it is geotechnically suitable.

For the Proposed Development, there would have been potential to re-use some of the dredge material on site, e.g. use as infill in a small area of the Proposed Development. However, there are limitations with the suitability of materials and even where suitable, not all dredged material would be able to be used.

The saline content of the dredge material makes it unsuitable as a construction material. The sediment generally consists of black, silty organic clay with gravel and shell fragments. There were cobbles noted in KESS115. The grading and washing required coupled with the drying and storage challenges (suitable land for drying lagoons is not available within vicinity of Kennacraig) makes this option uneconomical and impractical. This option has been discounted.

4.5.3 Option 3: Re-use as Construction Material off Site

This option would re-use dredge material off-site at another construction site, within the vicinity of the Proposed Development. Any material that is re-used off site will need to be assessed to ensure it is geotechnically suitable, however as noted above there are limitations with the suitability of materials.

The saline content of the dredge material makes it unsuitable as a construction material. The sediment generally consists of black, silty organic clay with gravel and shell fragments. There were cobbles noted in KESS115. The grading and washing required coupled with the drying and storage challenges (suitable land for drying lagoons is not available within vicinity of Kennacraig) makes this option uneconomical and impractical. This option has been discounted.

4.5.4 Option 4: Disposal to Landfill

This option would dispose dredge material within a landfill site on land. The most common use of dredge material within landfill sites is as capping or restoration material. Material would need to be brought ashore within the port estate and dewatered before being transported to landfill via HGVs.

The Clachan Quarry, Corran, Clachan, By Tarbert, PA29 6XN approximately 7km south west of the Proposed Development is the proposed site for land disposal (pending SEPA licenses). The alternative proposed site is McFaddyens Quarry, Sound of Kintyre, West Darlochan, Campbeltown, PA28 6NU approximately 42km south of the Proposed Development. Disposal on land would minimise the potential disturbance to moulting birds within the Proposed Development and avoid the associated programme restrictions that would be required for sea disposal.

4.5.5 Option 5: Beach Restoration / Other Coastal Protection

This option would use dredge material for beach recharge as a sustainable beneficial use, generating a purpose for the material that benefits a local amenity. Material is typically deposited direct from the dredging vessel via a pipeline or by ‘rainbowing’ onto the beach, where it is reprofiled using land-based plant. As previously discussed, the dredged sediment is expected to generally consist of black, silty organic clay with gravel and shell fragments which is unlikely to be suitable for beach recharge. There were cobbles noted in KESS115.

There are no known sites available within close proximity to the Proposed Development that require beach recharge and as such, this option has been discounted.

4.5.6 Option 6: Offshore Sea Disposal

Disposal at sea involves the dredge material being transported to a licensed disposal site in a dredging vessel. This approach takes place at sea and does not require the landing of any materials.

Whilst the dredged material meets the chemical requirements for deposition at sea (<AL2), due to the measured exceedances of AL1 and T_{50}, engagement with Marine Scotland would be required to agree disposal strategies (see Section 2.1.1).

The Proposed Development is located within Sound of Gigha Special Protection Area where eider, great-northern diver and red-breasted merganser moulting birds are present. Following consultation with NatureScot it has been established that Offshore Sea Disposal would introduce additional programme to minimise disturbance. To avoid the additional programme constraints, associate this option is not considered feasible.

This option has therefore been discounted.

4.5.6.1 Disposal at the Site

Portnahaven - Site ID MA035 south of Port Wemyss has been identified to receive the dredged sediment. As this is a licenced disposal site, it is assumed that Portnahaven - Site ID MA035 south of Port Wemyss has effective pollution prevention control measures to limit sediment dispersal. Records should be sought pertaining to compliance to permitted pollution control measures prior to sediment disposal by contractors. However, due to the limited dredged volume of disposal sediment (<6,800m^3) and the comparative size of the disposal site, the resultant contaminant concentrations post-disposal will be diluted far below AL1, AL2, and SQuiRT value levels.

Option 6 is considered not practical, and therefore has been discounted.

4.5.7 Option 7: Spreading on Agricultural Land

This option would involve placing dredge material on agricultural land. The island of Islay is a rural farming area with an abundance of good arable land however, there is no known requirement for a supply of imported material. The dredge material would have to be de-watered and desalinated to make it suitable for soil conditioning or spreading, and no land is available within the port estate to locate a drying lagoon. Additionally, there is unlikely to be available agricultural land which is able to use the volumes of dredge material taken from Kennacraig.

Transportation of material from the harbour to agricultural land would generate significant vehicle movements on local roads, contributing to traffic congestion and air and noise pollution with associated carbon emissions.

This option has been discounted.

4.5.8 Summary of Short listed Options

The above screening of potential options concluded that options 1-5 and 7 are not viable for reasons described in Section 4.4 above. A summary of screening the long list of options is outlined in Table 4.1.

Table 4.1: Short-listing of options

Option	Screening Assessment	Result
Option 1a/1b: Do Nothing/Do Minimum	No dredging is practical. However, in the long-term ferry services from existing vessels would cease to exist. This would not meet the project requirements however it has been included in the assessment as a baseline comparison. New vessels will ground if dredging is not undertaken.	Discounted
Option 2: Reuse in land-based construction on site	Unsuitable as a construction material. Although some material could be re-used on site, the majority cannot.	Discounted
Option 3: Reuse as construction material off site	Unsuitable as a construction material. The grading and washing required coupled with the drying and storage challenges (suitable land for drying lagoons is not available within vicinity of Port Ellen and would be impractical) makes this option uneconomical and unpractical.	Discounted
Option 4: Disposal to landfill	Dredged material could be disposed at the Clachan Quarry, Corran, Clachan, By Tarbert, PA29 6XN approximately 7km south west of the Proposed Development is the proposed site for land disposal (pending SEPA licenses). Disposal on land would minimise the potential disturbance to moulting birds within the Proposed Development and avoid the	Short-Listed

Option	Screening Assessment	Result
	associated programme restrictions that would be required for sea disposal.	
Option 5: Beach restoration / other coastal protection	Unsuitable as a beach recharge material. There are no known sites available within proximity to the Proposed Development that require beach recharge and as such, this option has been discounted.	Discounted
Option 6: Offshore sea disposal	Additional programme restrictions would need to be in place in order to minimise disturbance to moulting birds within the Sound of Gigha (SPA) if material was to be disposed at sea. Furthermore, due to exceedances of AL1, agreement with Marine Scotland would be required prior to disposal.	Discounted
Option 7: Spreading on agricultural land	The dredge material would have to be de-watered and desalinated to make it suitable for soil conditioning or spreading, and no land is available within the port estate to locate a drying lagoon. Additionally, there is unlikely to be available agricultural land which is able to use the volumes of dredge material taken from Kennacraig and transportation of material would have a number of environmental impacts.	Discounted

Following the screening the only option that was considered to be suitable was Option 4: Disposal to Landfill .

4.6 Assessment of Feasible Options

Following the revision of the screening assessment the only option considered for disposal is Disposal to Landfill. No further assessment was carried out and a Dredge Only Licence Application will be submitted to Marine Scotland.

5 Conclusion

This report has been prepared in support of a Marine Licence application and to determine the best disposal method of the dredge material required for the new Islay vessel enabling works. It compares various options for the disposal of dredge material and identifies the Best Practicable Environmental Option (BPEO).

A long-list of options were considered which included do nothing/do minimum, reuse within construction, disposal to landfill, use for beach restoration, offshore sea disposal and spreading agricultural land. These options were screened against a number of different criteria to develop a short list. Only one option was taken forward to short-list – Option 4: Disposal to landfill.

It will therefore be highlighted in the licence revision submitted to Marine Scotland that the licence application is for Dredge Only.

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