Agenda Item 9

OPSPAR CONVENTION FOR THE PROTECTION OF THE MARINE ENVRIONMENT OF THE NORTH EAST ATLANTIC

MEETING OF THE WORKING GROUP ON THE ENVIRONMENTAL IMPACT OF HUMAN ACTIVITIES (EIHA)

Capping of Contaminated Dredged Material Case Study Port Of Tyne UK

Presented by the United Kingdom

This document provides a summary of the trial capping of contaminated dredged material from the estuary of the River Tyne in open water offshore at the Souter Point disposal site.

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Background

1. The Secretariat had its attention drawn by a member of the public to a case in the North East of England, where there were said to be problems resulting from the dumping of contaminated dredged material.

2. The Port of Tyne had been faced with the problem of coordinating the disposal of contaminated sediments from a number of privately owned docks. The solution adopted was to dredge the material and dispose of it at sea at an existing disposal site with 'clean' silt and sand placed over the contaminated sediment to cap it i.e. to ensure it's long-term isolation from the marine environment as detailed in Annex 1.

3. Difficulties executing the plan have been exaggerated and only one load out of a total of 160 loads was dumped marginally outside the target zone for the contaminated dredge material; a considerable achievement when considering the time of year when the work was undertaken and the depth of water it was carried out in. This load nevertheless fell well within the final cap and was inside the disposal site boundary.

4. As this was the first capping exercise undertaken using level bottom capping in deep water offshore in the UK it has taken a considerable effort devising, supervising and monitoring information in regard to this project. The UK will prepare guidance notes on this type of activity within UK waters.

Action Requested

5. OSPAR is invited to consider the United Kingdom report in Annex 1 on the disposal of contaminated dredged material by dumping it at sea under a cap of clean material, and comment as it deems appropriate.

Annex 1

Capping of Contaminated Dredged Material - Case Study from the Port Of Tyne UK

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Introduction

The Centre for Environment, Fisheries and Aquaculture Science (Cefas) is an Executive Agency of the Department for Environment, Food and Rural Affairs (Defra) and acts as its marine science advisor. Cefas also has a role in advising Defra on the validity of Environmental Impact Assessments produced in support of dredged material disposal licence applications made under the UK's Food and Environment Protection Act. The advice from Cefas draws upon a wide range of scientific expertise available within the organisation including hydrography, sedimentology, benthic and fisheries ecology. Where appropriate Cefas would normally suggest further studies that may be necessary to improve confidence in the predicted scale of effect. We also advise Defra on any mitigation measures that may be necessary and review the impacts of all human activity in the marine environment by scrutiny of licensees own monitoring. Finally, Cefas also provide specific technical advice in relation to the development of national and international control procedures and guidance.

Cefas and its predecessor the MAFF Directorate of Fisheries Research have provided advice on the environmental and fisheries implications of proposed dredged material disposal operations to Defra / MAFF since 1968. In this role, Cefas provides application specific advice to Defra on all current licence applications as well as advice on ongoing monitoring operations for existing licences. Defra is the regulator with respect to dredge and disposal for England and for dredging in Wales.

Disposal Application

The Port of Tyne (PoT) originally applied for the disposal of 500,000 tonnes of dredged material to sea from 9 sites within the estuary of the River Tyne. The applicants had undertaken contaminant analyses of the material and showed that up to 160,000 m^3 (~224,000 tonnes) of it was grossly contaminated with the anti-fouling agent tributyltin oxide (TBT) and heavy metals. Contaminants were above those levels that the UK would normally allow for disposal to sea. Management options for the material were proposed. Following consultation on the application and taking into account overriding socio-economic needs for the area, a trial capping project to deal with approximately 60,000 m^3 of the of the contaminated dredge material (CDM) was agreed. All the capping options both inshore and offshore were discussed and level bottom capping offshore was determined to be a favoured option. Offshore of the Tyne are two disposal sites North Tyne (TY070) and Souter Point (TY081). Rather than impact a new area and to minimise interference with other users and fisheries, it was decided that the existing disposal site at Souter Point should be used for the site of the project. This was consented by Defra.

Design Rationale

The rationale and design of the sediment disposal trial was founded on the US Army Corps of Engineers (USACE, 1998) manual 'Guidance for sub-aqueous dredged material capping'.

The aims of the trial were as follows:

- To accurately delineate areas, depths and volumes of CDM to be removed from three priority docks in the Tyne Estuary (Wallsend Dry Docks, Neptune Quay and Swan Hunters - Slipway Ends).
- To determine the physical and chemical characteristics of the CDM.
- To remove the CDM from priority docks utilising dredging techniques that retain the material in discrete solid blocks.
- To accurately place CDM blocks in a delineated area of the Tyne Souter disposal grounds.
- To cover the CDM with a pre-designed cap, based on methods used by the US Army Corp of Engineers.
- To monitor the integrity of the cap, and to produce a UK guidance note on the procedure.

The sea-disposal and capping trial was designed to meet the following requirement:

- No loss of contaminated material during the dredging operation.
- No loss of contaminated material during transport to the capping site.
- Minimal containment loss to the water column by short-term monitoring during the placement and capping operation.
- Minimal disturbance of contaminated material during the placement of the cap material.
- Placement of adequate thickness of capping material over the whole volume of the deposited contaminated material.

- Long term maintenance of the integrity and efficacy of the cap assured by monitoring and cap maintenance when required.
- Learn from the trial and disseminate best practice.

The overall objectives of the monitoring program were to assess and verify whether operations had met these requirements, to determine the level of success of the trial and to provide information for the development of best practice.

All the capping options both inshore and offshore were discussed and level bottom capping offshore was determined to be a favoured option.

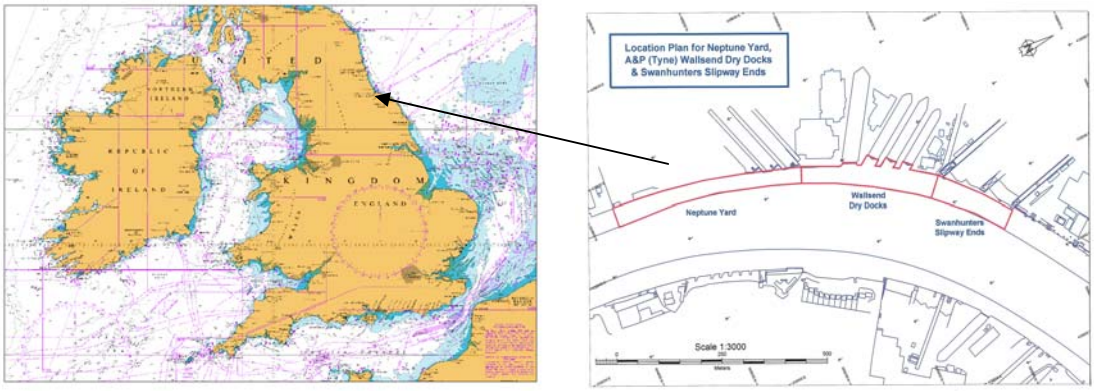


Figure 1. Priority dredge areas in the River Tyne

Table 1. Showing quantity of material to be dredged.

Quay/Dock	**Volume of sediment removal (cubic metres)**	**Volume of sediment removal including over-dredge (cubic metres)**
Wallsend Dry Docks (including Engine Works Quay)	17,455	20,959
Neptune Yard	25,346	29,314
Swan Hunters (Slipway Ends)	6,152	8,534
TOTAL VOLUME	**48,953**	**58,807**

Physical and Chemical Characterisation

Following delineation of the area and volume of material to be dredged the material was further characterised. Characterisation of CDM was required prior to the sea-disposal trial in order to understand the nature of the sediment in terms of its chemical and physical properties, and to allow a prediction of both short and long term behaviour of the sediments. In order to characterise the material, a sampling programme was devised and undertaken. The distribution and depth of sampling reflected the size and depth of the area to be dredged, the amount to be dredged and the expected variability in the horizontal and vertical distribution of contaminants as per the requirements of the OSPAR Guidance for the Management of Dredged Material.

The physical characteristics of the CDM were important in predicting the behaviour of the material during

and following placement at the site chosen for the sea-disposal trials (USACE, 1998). Data was required to evaluate dispersion (water column effects), spread during placement, mounding characteristics, long-term stability and resistance to erosion (USACE, 1998).

Geotechnical analyses were carried out to determine a range of physical properties. To estimate the cohesiveness, settling velocity/re-suspension potential and the contaminant accumulation potential, the grain size (% sand, silt, clay) and percent solids (dry matter) were determined. In addition, the bulk density and specific gravity were determined to give an indication of the potential behaviour of the material during and after deposition. These were essential to be able to determine the cap design and to interpret monitoring data. To understand how the CDM was going to behave falling through the water column, and its behaviour on the sea bed, assessments of its consolidation potential, shear testing plasticity indices and total organic carbon content were also undertaken. The permeability tests carried out gave an indication of the rate of movement of water through the material.

The material was also analysed for metals (As, Cd, Cr, Cu, Hg, Ni, Pb, Zn), organo-tins (dibutyl tin oxide, DBT and tributyl tin oxide TBT), Hydrocarbons (23 individual determinands and total hydrocarbon analysis), Polychlorinated Biphenyls (PCB) to the required dredge depth.
The elutriate testing of the CDM allowed potential contaminant release in the water column during it's fall to the seabed to be assessed. This test was carried out on one grab sample from each of the 3 docks.

This data was then assessed along with data previously collected by the PoT (The Posford Duvivier 1999 *River Tyne Contamination Study)* in June 2003. Following the characterisation of the CDM, sourcing and characterisation of the capping material was undertaken. The capping material was also tested in the same way for its chemical and physical properties.

Clean sediments from the centre of the Tyne Estuary channel were chosen for use as the first capping layer. It was thought that the silt and clay content of this material would limit the movement of water through the cap and significantly reduce chemical flux (advection and diffusion) of contaminants. Clean sand from the harbour was then chosen for use as the second capping layer, to reduce the impacts of erosion and bio-turbation and to hold the contaminated material and first capping layer in place.

It was estimated that 90,000 m^3 of cap material (sand and silty sediment) would be required. Sediment in the central channel of the Tyne Estuary and at the harbour mouth was known to be clean therefore, it was considered that two surface samples collected from representative locations in each area would be sufficient to characterise the capping material.

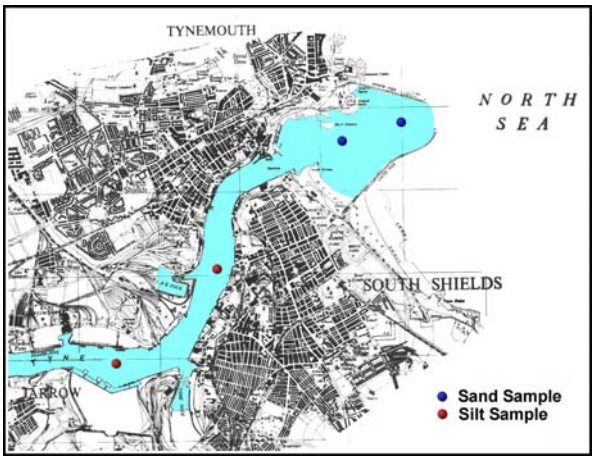


Figure 2. Potential cap material sample location

Capping

Discussion with the PoT determined that there were no options for in-situ capping or capping within the estuary due to the limited thickness of sediment overlying the underlying rock. To minimise the impacts of the activities with regards to fisheries and other users of the sea offshore, it was determined that the trial should be undertaken on one of the two disposal sites used for the disposal of dredged material by the

PoT. These areas have been used for dredge disposal since long before statutory controls came into force and have been subject to monitoring for many years. The location and conditions at the disposal site dictated that level bottom capping forming a mound on the sea bed utilising the natural shape of the sea bed, was the best choice for this trial.

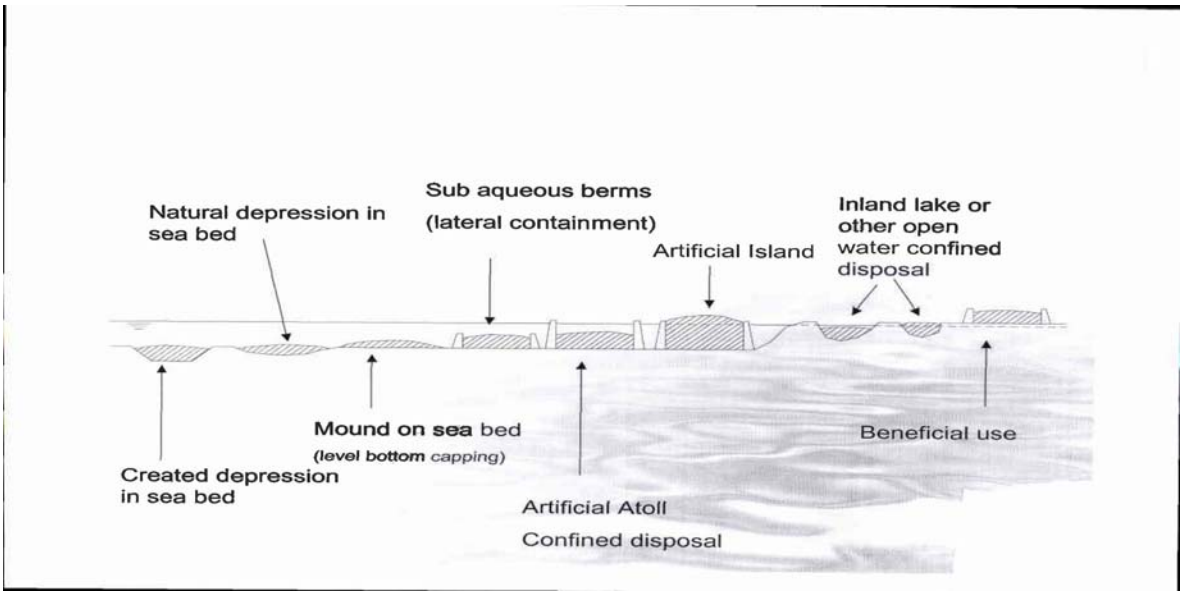


Figure 3. Types of capping

Location of trial site

Souter Point disposal site is about 4 miles from the coast in approximately 48m of water and is affected by relatively weak tides, which ebb and flow predominantly in a north - south direction with a residual flow to the south. It is a relatively large disposal site the terrain of which slopes away from the land. Souter Point is slightly less dispersive than North Tyne and is indeed probably the least dispersive major dredged material disposal site in England and Wales. Annually PoT disposes of about 180,000 m^3 (approximately 250,000 tonnes) of dredged material to the Souter Point and North Tyne disposal sites.

An assessment of sediment quality data and a multi-beam survey indicated that previous disposal operations had been concentrated in the north-west section of the disposal ground. This area was determined to be unsuitable for the sea-disposal trials. The area to the south of the location of previous disposal operations was also considered unsuitable, as there was potential for existing contaminated material to be dispersed over the trial area.

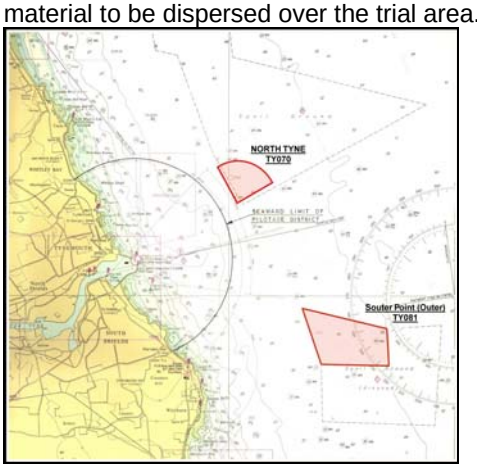


Figure 4. The location of the Souter Point outer disposal ground

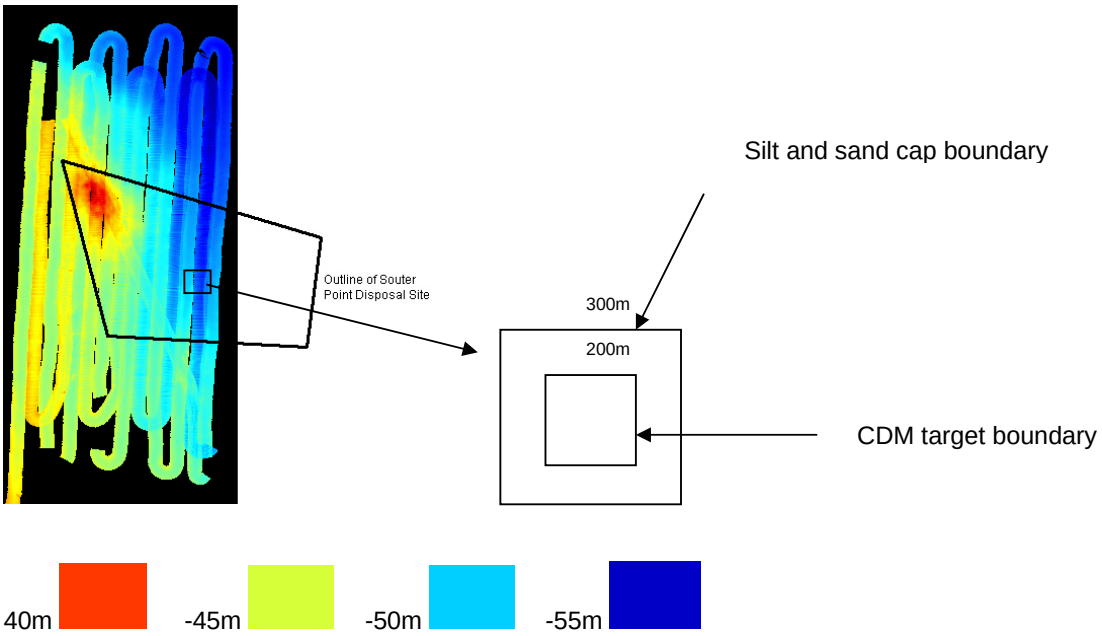


Figure 5. Bathymetry survey of Souter disposal site and proposed location of trial site.

The centre of the disposal site was chosen, as it was away from the main area for disposal of maintenance dredging that occurs in the top western corner of the site. Also, the sediment quality data indicated that there has been minimal dispersion of TBT east of historical disposal operations, and being towards the centre of the site meant that if any disposal had occurred out of the described target area, for either the CDM or the cap, it would have still occurred well within the designated disposal site.

Cap design

The chemical and physical testing of the material provided an understanding of the properties of the dredge material, which assisted with the design of the cap.

It was predicted that the CDM would form a layer of 1.5 m thick across the 200 m by 200 m target site for the trial. This would then need a 1m layer of silt and a 0.5 m layer of sand to ensure isolation of CDM from potential impacts like, bio-turbation (minimum 0.3 m), erosion by a number of small storms, a severe storm and human activities like trawling.

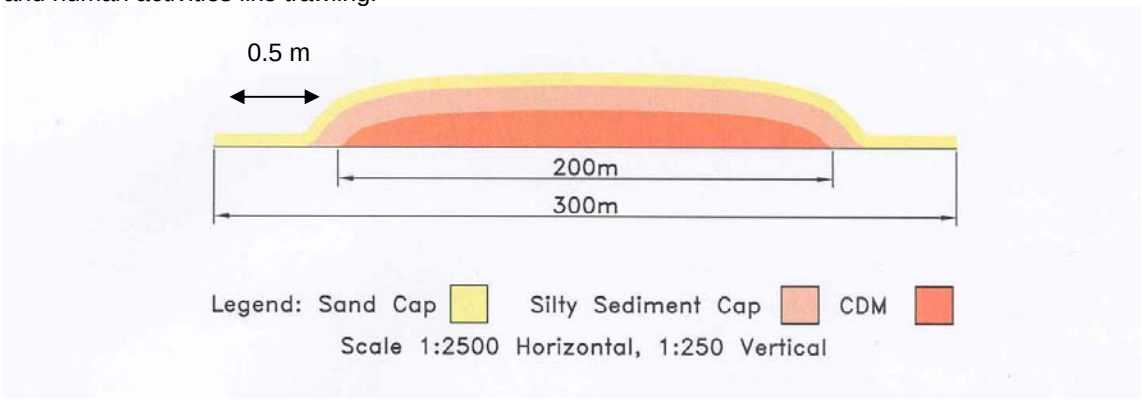


Figure 6. Schematic cross section through the cap

Dredging Activity

Contaminated Dredge Material

The dredging of the 3 priority docks commenced in December 2004. Mechanical dredging using an enclosed bucket backhoe dredger loading into split hopper barges was used to remove and transport the CDM to the disposal ground. This technique was used, as it is ideal for creating sub-aqueous mounds. It was anticipated that the CDM would be retained in discrete solid blocks and stay close to its in-situ density throughout the dredging and disposal processes (USACE, 1998). As a result less water would be entrained during the dredging and also ensure minimal stripping of material during descent of the material to the seabed. In addition, the tendency of the material to spread on the bottom would be reduced and the material was expected to mound rather than flow, particularly if combined with point dumping from a barge (USACE, 1998). Mechanical dredging allowed for the immediate placement of a cap, whereas hydraulically dredged, more fluid material would have required time for the CDM to settle before being capped.

As planned, during the dredging operation the blocks of CDM were placed rather than dropped, onto towed split hopper barges moored alongside the dredger. From observations of the material in the barge it was noted that this helped to retain the discrete and consolidated nature of the CDM blocks. The split-hopper barges were filled to a level that ensured no overspill of entrained water, and were supplied with new seals to ensure that as far as possible there was no leakage during transport to the Souter Point disposal site. Differential GPS was used to accurately locate the centre of the disposal site.

Dredging of the CDM commenced 13 December 2004. Dredging ceased for 12 days over the Christmas holiday on the 23rd December and finally ended on the 20th March 2005. 160 loads, comprising 60,000 m^3 (some 82,160 tonnes) of CDM, were excavated into split-hopper barges. The aim was to place each load in the centre of the trial site to limit spreading of the material. The CDM was accurately placed with one exception. Load 16 fell outside the target zone, 20 m south of southern edge of the CDM box, but inside the original designated capping zone. The capping zone was modified to take this into account. This was impressive considering the depth of water and the time of year the work was undertaken, and within the capabilities suggested by PoT.

Interestingly at one point during an altercation between the dredger and a fisherman, the captain of the dredger informed the fisherman that as a result of 'talking' to the fisherman he had put him off and made him miss his target. The dredger had not dumped it's load merely overshot the area. He came around and placed the material within target. Many people have misinterpreted this, as dumping out of area, which was not the case.

Capping of Contaminated Dredge Material

Dredging of the silt cap commenced 3 April 2005. A trailer suction dredger loaded on average 9 loads per day, some 67 loads in total, finishing on 12th April 05. The material was dredged using the dredger's twin-pipes and spread using the port side pipe with pumps reversed. 100,000 m^3 (about 140,000 tonnes) of silt was placed over the CDM.

A bathymetric monitoring survey following placement of CDM and the silt cap was undertaken on the 11th April illustrated that the silt cap had failed to act as predicted, and only 20 - 30% of the silt cap material could be accounted for.

Silt capping was halted and immediate placement of sand was started. EnviroCentre (the consultants overseeing the capping project) consulted Defra and Cefas and agreed new boundaries for the cap.

Due to the velocity of sand through the fall pipe and a perceived risk to the CDM mound the operators decided to spread the sand over the site by trickling the material over the area by cracking open the dredgers doors to a small extent. The cargoes were disposed of against the tide.

The quantity of sand required for the cap was therefore much more than previously anticipated and sourcing of the material would have been an issue if more had been required. Alternative sites were assessed as a contingency, although these were never required.

The 29 loads, approximately 90, 000 m^3 (144,000 tonnes) of sand was placed and the cap was completed

on 15th April 2005.

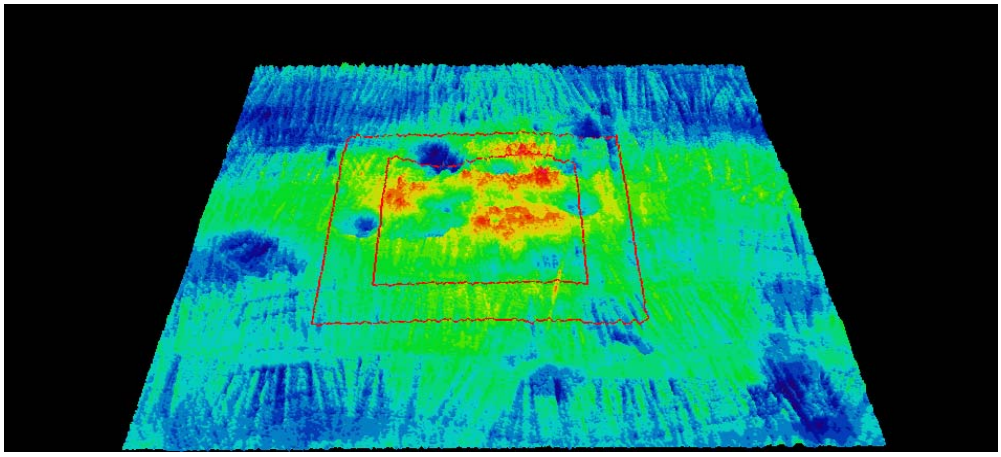
Sediment Profile Imaging SPI was fundamental in evaluating the apron (thin layers) of the CDM deposit. Discussion was held between the applicant's consultants, (Envirocentre) and Cefas on what the thickness of the significant layer was. Acoustic techniques had a poor resolution of around 20 cm. The SPI was able to resolve easily to 2 cm. In hindsight more detailed transects would have been useful.

PoT wanted the significant layer to be capped to be limited to 8-10cm thickness of CDM. Cefas opinion was that a 2cm thin layer or apron was significant (as per USA Army Corps Engineers). This led to estimates from PoT of quantities of material required to cap the CDM effectively continually being less than the quantities of material Cefas suggested.

Agreement was reached that the silt cap would cover layers 8cm – 10 cm (1 cm in places to 12 cm in others) and the sand cap would cover everything greater than 1-2cm thick. To cover the entire outline of the CDM to layers of 10cm as defined by the SPI images, the area of the cap increased from 19.0 Ha to 34.85 Ha. Bathymetric survey of the CDM showed there to be a maximum thickness of 2.06 m with a typical thickness of 1.0 m - 1.5m. Over 60% more silt and sand than originally specified was placed.

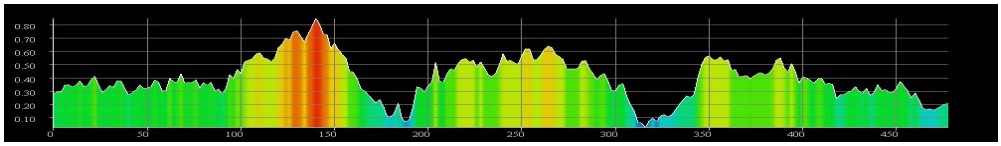
The placement is aligned in a NNW-SSE direction along the main tidal axis and extends beyond the limits of both the inner and outer proposed silt and sand cap limits. This was much greater than the predicted spread of the material. Bathymetric data indicated that the thickest part of the cap was the centre of the site with up to 1.0 m of cap.

Sub-bottom profiling however indicated that the centre of the placement site to be 0.75 m thick.
The bathymetry survey suggested consolidation of the CDM was likely to be occurring, and some uneven areas in the cap, which could be attributed to scouring, that may have occurred on depositing the sand cap. Uneven slumping of the sediment was the reason given for the difficulty to estimate the full extent of the placed cap from bathymetric data. The report notes, "to the east and west the cap has not satisfied the design intent" (Section 6.2 page 8).



Total sand and silt cap.

East west section through cap



North south section through cap
Figure 7. Swath bathymetry of total sand and silt cap.

A risk assessment of the cap calculated the median thickness of the total cap to be 0.45 m. Overall, the silt

and sand caps had not reached the required minimum 1.0 m and 0.5 m depths respectively over the whole of the CDM placement.

Consideration should have been given to further capping of the site especially in the holes and the apron around the CDM.

Monitoring

The purpose of monitoring was to ensure that capping acts as an effective control measure, that the CDM is isolated and that the long-term integrity of the cap is maintained.
The following monitoring surveys were agreed:

1. **Pre placement monitoring.**
    - This was to determine the baseline characteristics of the trial site prior to disposal and capping operations.

2. **Monitoring during placement.**
    - To determine the dispersion and loss of sediment to the water column during deposition of CDM.
    - To determine the loss of TBT/DBT to the water column during deposition of CDM.

3. **Monitoring of CDM post placement prior to placement of cap.**
    - To define the extent and thickness of the CDM deposit to guide cap placement and to monitor any fragmentation or slumping of CDM.

4. **Monitoring post placement – Short Term (2 weeks)**
    - To define the extent and thickness of the cap immediately following placement.
    - To confirm return to pre-existing SPM & TBT/DBT concentrations.

5. **Monitoring Post placement - Medium term (2-3 months)**
    - To demonstrate the integrity of the cap and provide evidence to the public and non-scientists.
    - To assess any immediate impacts on sediment quality and benthos associated with the trial.

6. **Tier One Long-term Post –placement Monitoring (Annual)**
    - To ensure the integrity and thickness of the cap is maintained.
    - To determine the cap effectiveness in isolating the CDM from the environment.
    - To provide information for risk based assessment and associated management actions.
    - To provide information that can be used in the development of best practice extendable to the UK.

7. **Tier Two Post Placement Monitoring**
    - Tier two monitoring will be undertaken if any of the management trigger values (table 2 Management actions linked to post placement) are exceeded.

8. **Management Actions linked to post placement (Tier one and Two monitoring)**

Table 2. Management actions linked to post placement

Program	Frequency	Threshold	Management Options Threshold not Exceeded	Management Options Threshold Exceeded
Storm Assessment.	As required.	Storm exceeds 1 in 10 year event. If Tier Two monitoring shows that the deposit can withstand a 1 in 10 year storm, then threshold would be increased to 1 in 20 year storm and so on.	Continue with Tier One monitoring.	Go to Tier Two Monitoring.
Tier One.	Annual.	Cap thickness decreases by 0.3m. TBT/DBT and/or heavy metals exceed limits (to be determined) in sediment at monitoring locations around the trial site and at cap surface. TBT/DBT and/or heavy metals exceed limits (to be determined) in water column. Evidence of persistent/increasing negative changes in benthic communities.	Continue with Tier One monitoring (up to three years). Reduce Monitoring Level (decision based on three years initial monitoring) Stop Monitoring (decision based on findings of three years initial monitoring).	Go to Tier Two Monitoring.
Tier Two	As required.	Cap thickness decreases by 0.5m (i.e. clay cap is exposed)	Go to Tier One Monitoring	Continue with Tier Two monitoring on an annual basis. Increase cap thickness. Replace cap material. Re-dredge and remove.

Cap risk assessment

Cefas undertook a risk assessment of the cap. The main risk scenarios were perceived to be from a single severe storm, a number of small storms and human activity like trawling (Jon Rees 29/11/05).

Bathymetric surveys of the trial site indicated that Total cap (silt + sand) had a maximum thickness of 1.0 m with median thickness of between 0.2 m and 0.25 m– significantly less than the designed thickness of 1.5 m (0.5+1.0m). The coverage of the cap was very patchy with significant variations in the thickness of the cap.

A realistic thickness of the cap was calculated by subtracting the digital elevation models generated by each bathymetric swath survey. Thus, from the either the estimate of the accuracy from the histograms of 0.2m or from the vertical accuracy of the instrumentation of 0.2 m and adding this to the histogram of thickness gives a median thickness of 0.45 m (0.2 + 0.25 m).

Using a worst-case scenario in terms of sediment transport, the highest risk to the integrity of the cap was determined to be a series of moderate storms that are capable of removing 15 cm from the cap on each storm. This modelling was heavily qualified due to the need for better wave data not being available, due to one of the pieces of monitoring equipment being held to ransom by fishermen at the time.

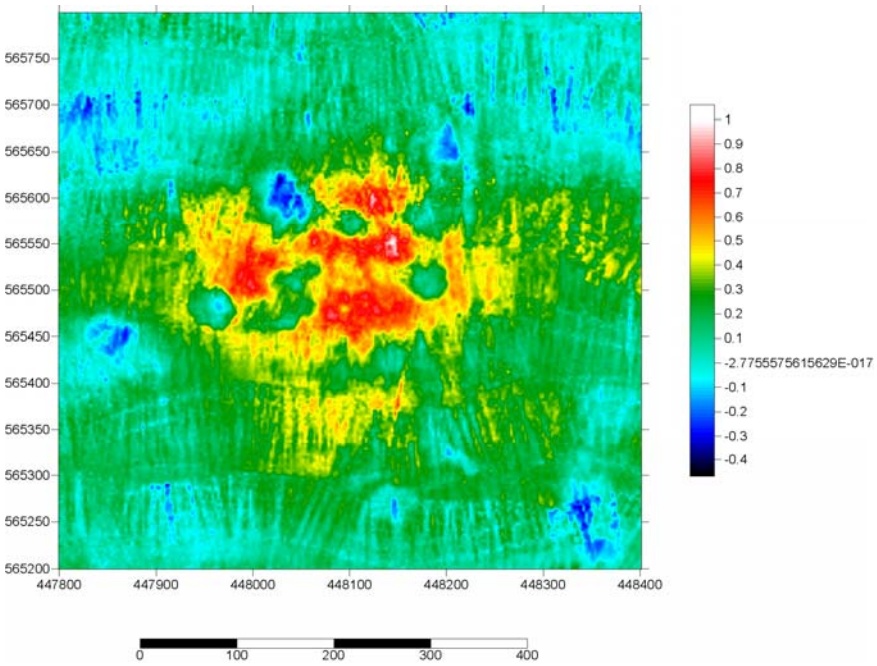


Figure 8. Surfer contour plot of total cap thickness

The weaknesses in this risk assessment were the estimates of the surge current, the wave height and wave period for various return wave periods, along with the worst-case scenario of sediment transport (total loss of sediment from the cap). It is recommended that to reduce these uncertainties (i) in the absence of observations of surge currents estimates of surge currents are computed from calibrated high resolution numerical models and (ii) high quality estimates of wave height and period are made for various return periods from preferably observations, and if not available from Met Office predictions of wave height at "Offshore nodes". Even assuming that this model is incorrect the relative magnitudes of the storm impacts are not in error and therefore a series of moderate storms is still the highest risk to the cap.
Thus, the highest risk scenario (moderate storms) are capable of eroding to the median thickness of the cap. Which could have exposed significant area of CDM.

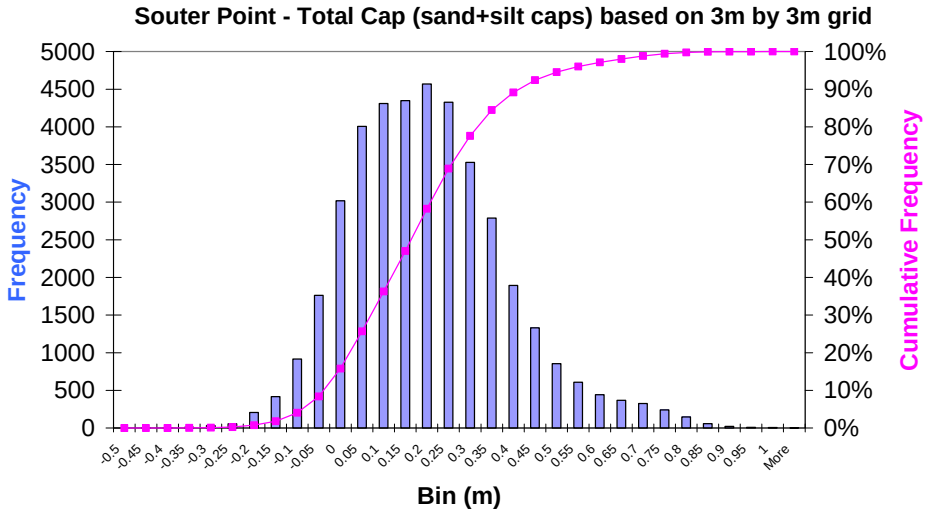


Figure 9. Histogram of total cap thickness based on 3m by 3m grid along with a cumulative representation of the thickness

The histogram (Figure 12) of Total cap thickness shows a median size of between 0.2 m and 0.25 m. Note also the negative estimates of thicknesses, which give an indication of the error bars associated with this method i.e. up to 0.2 m as it is highly unlikely that the seabed surrounding the trial cap site has been eroded by 0.2 m.

Recommendations from the risk assessment

Cefas recommended that the cap thickness be increased at the earliest opportunity to secure the integrity of the cap.

A recommendation was also made that the critical wave height and periods be specified in any supplementary licence conditions as critical wave parameters for triggering Tier 2 monitoring. The applicant has also agreed in future to specify the distribution of the thickness not just as a minimum value but the median thickness will be given together with percentage coverage of the capped area. The minimum percentage coverage of the area to trigger top up of the cap is yet to be agreed.

Additional Capping

Over the first year the cap endured more than 8 small storms with apparently no significant change. In late June/early July of this year, PoT eventually, as they had been requested, placed a further substantial quantity of estuarine silts and sands to provide additional thickness to the cap. This was without consultation with Defra or Cefas on how or what material should be placed. They used maintenance dredge material, which unwittingly could have compromised part of the monitoring. The silt and sand was added using a conventional Trailer Suction Hopper Dredger with multiple bottom opening doors, which were carefully opened to place the loads over the centre of the target area. The final report of the tier two monitoring undertaken (Table 2) is to be sent to Defra imminently, but looking at raw bathymetry data the cap thickness after considering consolidation of the CDM and original cap layers, the cap mean thickness has increased to approximately 0.8 m.

Investigation of the source of the maintenance dredge material used confirmed that it was fit for purpose and, future maintenance and capital dredge materials will be consented for use on the cap following consultation with Cefas to ensure quality. The cap thickness will be monitored and replenished as and when required. Storm events will also trigger monitoring and potential action. Coverage of 0.8 m over the site as a percentage of the total area of the cap is yet to be agreed, but will provide another trigger to top up the cap.

Cefas Monitoring

In addition to monitoring work undertaken by the PoT, Cefas also undertake monitoring of disposal sites on behalf of Defra. Annually a number of the 150 disposal sites around the UK are chosen for monitoring depending on current issues and historical events. Also, a number of sites are routinely monitored. Monitoring of the sites includes chemical analysis of sediments, benthic monitoring as well as bathymetric and side scan surveys.

North Tyne and Souter disposal sites have been subject to monitoring in the past and the Cefas undertook a survey of the site again this year. Samples from 2005 and 2006 are currently being processed and the work will be reported in due course. A SPI survey was carried out in 2005 after the capping exercise. Transects covered the trial site, outside the trial site but within the disposal site, and reference sites away form Souter Point. The images below show how there are benthic organisms in the disposal site but not yet established within the trial site.

SPI Image from outside the cap site SPI Image from within the capping site

Figure 10. SPI taken over the disposal site during the Endeavour Survey summer 2005

Potential Constraints of capping trial

1. The weather could have proved to be a limiting factor given the time of year the activity was undertaken, in the end this was not a major issue. However the weather and therefore sea conditions were an issue for the monitoring of the project. Poor weather conditions could effect the size of the vessel getting to the site in 40-50 m of water. Large swells also made it difficult for the acoustic monitoring. Therefore any future project should consider the ability of the monitoring vessel as well as the capability of the dredger.

2. The disposal of silt layer using the dredgers twin pipes with pumps reversed to allow the silt to be disposed closer to the seabed did not work effectively. The material was widely dispersed. The disposal of silt and sand using the multiple bottom opening hull doors of a conventional trailer suction hopper dredger over the centre of the site in July 2006 has apparently been a more effective method of ensuring the silt reached the target area on the seabed.

3. SPI was considered a research tool and not a proven technology before the start of the project. The device was available from only one small sub consultancy company in the UK and the equipment was quite bulky and unwieldy to mount on a modest size survey vessels in the open sea. Also the sea conditions had to be relatively calm to undertake meaningful surveys and provide quality results. The resolution of 20 cm of the other acoustic techniques was insufficient to effectively delineate the significant apron of the cap. The SPI was able to resolve the apron of the CDM to 1 cm to 2 cm effectively ensuring the majority of the CDM was covered.

Future Look

Cefas, PoT and their consultants Envirocentre are working towards providing a best guidance document with regard to capping offshore in deep water in the UK.

It has been identified during the course of the trial that there is also a need to provide an assessment of the limitations and effectiveness of the individual techniques used, and the best tools to use from the toolbox to provide fit for purpose cost effective monitoring.

PoT and their consultants initially saw the SPI as an expensive research tool that was a supplementary survey device that would be ‘nice to have’ rather than essential. However, this device proved an invaluable asset in the toolbox, without which it would have been difficult to resolve the significant apron and ensure the isolation of the cap.

ANNEX 2

Documents Reviewed

1. FEPA licence application and supporting documentation for the dredging and sea disposal of contaminated sediment. February 2003. Produced by Posford DuVivier.
2. Pre-Placement Monitoring report no 1999
3. Report 1740 – Assessment of i) characterisation of contaminated sediments and capping material ii) Modelling of disposal operations iii) Sedimentation Experiment – June 2004
4. Report 1709 – Monitoring programme of sea disposal trials of contaminated Tyne Estuary sediment. August 2004

5. Report 1613 – Workplan for sea disposal of contaminated Tyne Estuary sediment
6. Operational report during placement of contaminated dredge material (CDM)
7. Monitoring During Placement of CDM Report No:2033
8. Operational report during placement of capping material
9. Monitoring Following Placement of CDM and prior to Capping Report No:2034
10. Post Placement Monitoring - short term post cap Report no:2045
11. Post Placement Monitoring - medium term report no:2275
12. Cefas Risk Assessment - November 2005
13. Annual Tier 2 Monitoring Report

If delegates wish to see any of reports Nos 2 – 12 above, they are available from the Port of Tyne contact at the following email address:

brian.reeve@portoftyne.co.uk

Monitoring Surveys undertaken

i) Pre-disposal (December 2004) reported in EnviroCentre 2005a
ii) During Disposal (January and March 2005) reported in EnviroCentre 2005b
iii) Post CDM Disposal and Prior to Capping (April 2005) reported in EnviroCentre 2005c
iv) Post-placement – Short term (May 2005) reported in EnviroCentre 2005d
v) Post-placement – Medium term (August 2005) reported in EnviroCentre 2005e
vi) Annual Tier 2 Monitoring report (August 2006)

Cefas Modelling

i) Risk of dispersion of CDM before capping
ii) Risk assessment of potential impacts on cap integrity

ANNEX 3

Monitoring Programme

1. Pre-placement

Monitoring Techniques	Information provided	Data Availability/Need	Responsible for action	Responsible for finance
Bathymetric survey (multi beam) of the trial site and immediate surrounding area (vertical accuracy 20 cm or less). Sweeps across the survey area	Baseline bathymetry data including depth contour maps.	Indicative bathymetry of the current proposed disposal location is available from CEFAS. This data is subject to errors and cannot not be used to provide absolute depths.	PTA (except boat hire which will be the responsibility of EC on award of contract where the bathymetric survey can be undertaken in parallel with other surveys)	PTA – Regeneration Funds
Sidescan sonar of the trial site and immediate surrounding area	Visual presentation of morphology of seabed at trial site	Sidescan sonar data of the western part of the site is available from CEFAS. More extensive coverage of the eastern part of the disposal ground including the trial site will be provided during Cefas cruise in May 04.	CEFAS	CEFAS / DEFRA
Sub-bottom profiles across the trial site	Visual presentation of sub-surface layering of sediment.	Sub-bottom profiling of the trial site be undertaken by Cefas in May 2004	CEFAS	CEFAS / DEFRA

Sediment Profile Imaging (SPI) – transect across site	Visual presentation of surface roughness and bio-turbation at the trial site	Sediment profile imaging undertaken by Cefas in May 2004	Cefas	Cefas/ Defra
Near seabed currents (Landers and upward looking ADCP)	Near seabed currents.	May 2004 LANDERS with upward looking ADCP, will be deployed for two weeks to measure seabed currents.	Cefas	Cefas/ Defra
Upward looking ADCP for SPM in water column	Background SPM levels.	In May 2004, Cefas will undertake ADCP in-situ sediment concentration data will be collected.	Cefas	Cefas/Defra
Water sampling to depth for SPM (5 locations, at depths of 1m, 20m & 20m, duplicated)	Background SPM levels	The collection of water samples for SPM was not conducted by Cefas in the May 2004 cruise	EC under contract to PTA (Note: suitable laboratories will be contracted by EC for sample analysis)	Cefas/Defra originally. Now PTA regeneration furnds
Surface sediment grab samples for contaminants (TBT/DBT & Heavy Metals) and particle size distribution (psd) taken at seventeen locations.	Background levels of contaminants in surface sediments and psd.	Historical Cefas sediment contaminant data (TBT, metals, PSA etc) is available for the Souter Point Outer disposal ground and the surrounding area. The data may be used opportunistically and may not be fit for purpose.	EC under contract to PTA (Note Cefas and Mountain Heath will be contracted by EC for sample analysis)	PTA – Regeneration fund
Sediment cores for geo-technical testing, taken at five locations within the trial site.	Geo-technical data to verify trial design.	Non available	EC Under contract to PTA (Note: suitable laboratories will be contracted by EC for sample testing)	PTA-Regeneration funds
Surface sediment grab for in-fauna taken at seventeen locations. Repetitive sampling will be undertaken at eight sampling stations to provided a total of thirty three in-fauna samples. Initially twenty-eight of these samples will be analysed	Background in-fauna types and abundance.	Historical Cefas benthos data is available for the Souter Point Outer disposal ground and the surrounding area. The data may be used opportunistically and may not be fit-for purpose.	EC under contract to PTA (Note: suitable laboratories will be contracted by EC for sample analysis)	PTA regeneration fund

Beam trawl (2m beam, 5-10 minutes tow) for epifaunal, taken at five locations in a N-S transect through the disposal site. One sample from each station will be taken for community analyses. One sample from each station will be taken for analysis of TBT in flesh of a target species.	Background epi-fauna types and abundance Levels of contaminants in tissues.	Historical Cefas benthos data is available for the Souter Point Outer disposal ground and the surrounding area. The data may be used opportunistically and may not be fit-for purpose.	EC under contract to PTA (Note: suitable laboratories will be contracted by EC for sample analysis.	PTS – Regeneration Funds
In-situ water sampling for TBT/DBT levels.	Background TBT/DBT levels in water.	Water samples will be collected for TBT/DBT analysis by Cefas in May 2004.	Cefas	Cefas

2. Monitoring During Placement of CDM

Monitoring Techniques	Data Availability/Need	Responsibility for action	Responsibility for finance
Boat-mounted downward looking ADCP to measure SPM in water column. Sweeps across the survey area.	Extent of sediment plume and SPM concentrations with plume. Comparison with background levels will allow assessment of loss of sediment during placement.	EC under contract to PTA	PTA – Regeneration Funds
Water sampling to depth for TBT/DBT and SPM (5 locations; depths of 1m, 20m and 40m: duplicated).	Comparison with background levels will allow assessment of loss of contaminant to the water column during placement.	EC under contract to PTA	PTA – Regeneration Funds – analytical costs for TBT/DBT from part of licensing cost.

3. Monitoring Following Placement of Contaminated Sediment and Prior to Placement of Capping Material

Monitoring Techniques	Data Availability/Need	Responsibility for action	Responsibility for finance
Bathymetric (multi-beam) survey of the site & immediate surrounding area(vertical accuracy 20 cm). Sweeps across the survey area.	Bathymetric data and depth contour maps allowing determination of morphology, aerial extent and thickness of the CDM to guide cap placement and monitor fragmentation or slumping of CDM. Comparison of volume of CDM observed on the seabed with known volume deposited by barge.	PTA (except boat hire which will be the responsibility of EC pn award of contract where the bathymetric survey can be undertaken in parallel with other surveys).	PTA – Regeneration Funds.
Sub-bottom profiles sweeps across the survey area.	Determination of thickness of contaminated material prior to any consolidation due to weight of capping material. Comparison with pre-placement data will provide an indication of any consolidation of seabed. and to indicate any consolidation of seabed.	EC under contract to PTA.	PTA – Regeneration Funds.

Sidescan sonar of trial site and immediate surrounding area. Sweeps across the survey area.	Determination of distribution of CDM. Assessment of reworking of CDM by tides.	EC under contract to PTA.	PTA – Regeneration Funds.
Sediment Profile Imaging along 6 transect lines (station spacing 25 m)	To determine the extent of thin layers of CDM following placement and therefore the extent of cap coverage required. To allow full accounting of all deposited material.	EC under contract to PTA	PTA – Regeneration Funds

4. Monitoring Post- Placement – Short Term (2 weeks)

Monitoring Techniques	**Data Availability/Need**	**Responsibility for action**	**Responsibility for finance**
Bathymetric (multi-beam) survey of the trial site & immediate surrounding (vertical accuracy 20cm or less). Sweeps across the survey area.	Bathymetric data and depth contour maps allowing determination of extent and thickness of the cap immediately following placement. Determination of initial morphology of the CDM and cap mound as a baseline for future surveys.	PTA (except boat hire which will be the responsibility of EC on award of contract where the bathymetric survey can be undertaken in parallel with other surveys).	PTA – Regeneration Funds
Sub-bottom profile, sweeps across the survey area.	Determination of thickness of contaminated material and cap material. Assessment of any consolidation of CDM due to weight of capping material. Comparison with pre-placement data will provide an indication of any consolidation of seabed.	EC under contract to PTA.	PTA – Regeneration Funds.
Side scan sonar of trial site and immediate surrounding area. Sweeps across the survey area.	Determination of distribution of CDM and cap. Assessment of reworking of cap material by tides.	EC under contract to PTA.	PTA – Regeneration Funds.
Boat-mounted downward looking ADCP to measure SPM in water column. Sweeps across the survey area.	Confirmation of return to pre-placement levels, through comparison with background concentrations.	EC under contract to PTA.	PTA – Regeneration Funds.
Water sampling to depth for TBT/DBT and SPM (5 locations: depths of 1m, 20m and 40m: duplicated).	Confirmation of return to pre-placement levels, through comparison with background concentrations. Concentrations from stripping of fresh erosion surfaces by tide/waves and estimates of these losses to water need to be determined.	EC under contract to PTA.	PTA – Regeneration Funds Cefas analytical costs for TBT/DBT from part of licensing cost.

5. Post- Placement –Medium Term (2-3 months)

Monitoring Techniques	Data Availability/Need	Responsibility for action	Responsibility for finance
Surface sediment grab samples for contaminants (TBT/DBT & Heavy Metals) and particle size distribution (psd) taken at seventeen locations.	Contaminant concentration in surface sediments. Comparison with background levels indicates any impact on sediment quality around the trial site. Provides information regarding any changes in particle size distribution also.	EC under contract to PTA (Note Cefas & Mountain Heath will be contracted by EC for sample analysis).	PTA – Regeneration Funds.
Surface sediment grab for in-fauna taken at seventeen locations. Repetitive sampling will be undertaken at eight sampling locations to provide a total of thirty three in-fauna samples. Initially twenty-eight of these samples will be analysed.) – after about 2-3 months	In-fauna types and abundance. Comparison with background data collected pre-trial, will allow an assessment of any initial impact on benthos around the trial site.	EC under contract to PTA (Note Suitable laboratories will be contracted by EC for sample analysis).	PTA – Regeneration Funds.
Beam trawl (2m, 5-10 minute tow) for epi-fauna, taken at five locations in a N-S transect through the disposal site. One sample from each station will be taken for community analyses. One sample from each station will be taken for analysis of TBT in flesh of a target species.	Epi-fauna types and abundance. Comparison with background data collected pre-trial, will allow an assessment of any initial impact on benthos around the trial site. Levels of contaminants in tissue.	EC under contract to PTA (Note; suitable laboratories will be contracted by EC for sample analysis).	PTA – Regeneration Funds.
Underwater TV along three transects.	Film footage demonstrating the integrity of the cap.	EC under contract to PTA	PTA – Regeneration Funds

6. Long-term Post-Placement (Annual or after thresholds for Tier 1 exceeded)

Monitoring Techniques	Data Availability/Need	Responsibility for action	Responsibility for finance
Bathymetric (multi-beam) survey of the trial site & immediate surrounding area (vertical accuracy 20cm or less). Sweeps across the survey area.	Bathymetric data and depth contour plots. Information on any reduction in the thickness of the CDM and cap mound. Combined with sub-bottom profile and side scan sonar data, an assessment can be made as to whether reduction in the thickness of the mound is due to erosion of cap material and /or consolidation.	PTA (except boat hire which will be the responsibility of EC on award of contract where the bathymetric survey can be undertaken in parallel with other surveys).	PTA – Regeneration Funds
Sidescan sonar of the trial site and immediate surrounding area. Sweeps across the survey area.	Information on any transport of the cap material due to Information on loss of integrity of the cap due to hydrodynamic or anthropogenic causes.	EC under contract to PTA.	PTA – Regeneration Funds

Sub-bottom profiles across the trial site. Sweeps across the survey area.	Information on any reduction in thickness of the cap. Estimation of consolidation of seabed, CDM and cap materials. Assessment of any changes in the physical nature of the cap. For example the production of a cap surface armoured with a later of coarse material due to the winnowing out of finer materials by normal tidal currents and waves.	EC under contract to PTA.	PTA – Regeneration Funds
Sediment Profile Imaging (SPI), along 3 transects, station spacing 15m.	Information on depth of bio-turbation on cap surface. Assessment of any erosion of cap.	EC under contract to PTA.	PTA – Regeneration Funds
Surface sediment grab samples for contaminants (TBT/DBT & Heavy Metals) and particle size distribution (psd) taken at seventeen locations.	Concentrations of contaminants in surface sediments around the trial site and at the cap surface. Comparison with baseline levels (pre-placement) will provide information on any loss of contaminants from CDM to the cap and surrounding area.	EC under contract to PTA (Note; suitable laboratories will be contracted by EC for sample analysis).	PTA – Regeneration Funds
Surface sediment grab samples in-fauna taken at seventeen locations. Repetitive sampling will be undertaken at eight sampling stations to provide a total of thirty three in-fauna samples. Initially twenty-eight of these samples will be analysed.	Benthos types and abundance. Comparison with baseline data will provide: An assessment of any long-term impacts on benthos around the trial site. Information on –re-colonisation/recovery of benthos around the trial site. The level of colonisation (and associated bio-turbation) of cap surface.	EC under contract to PTA (Note; suitable laboratories will be contracted by EC for sample analysis).	PTA – Regeneration Funds.
Beam trawl (2m beam, 5-10 minute tow) for epi-fauna, taken at five locations in a N-S transect through the disposal site. One sample from each station will be taken for community analyses. One sample from each station will be taken for analysis of TBT in flesh of a target species.	Epi-fauna types and abundance. Tissue contaminant analysis. Comparison with background data collected pre-trial, will allow an assessment of any impact on benthos around the trial site.	EC under contract to PTA (Note; suitable laboratories will be contracted by EC for sample analysis).	PTA – Regeneration Funds.
Underwater TV – along three transects.	Film footage demonstrating the integrity of the cap.	EC under contract to PTA.	PTA – Regeneration Funds.

9. Tier Two Post Placement Monitoring

Monitoring Techniques	Information provided	Responsible for action	Responsible for finance
Bathymetric survey (multi beam) of the trial site and immediate surrounding area (vertical accuracy 20 cm or less). Sweeps across the survey area	Bathymetric data and depth contour plots. Information on any reduction in the thickness of the CDM and cap mound. Combined with sub-bottom profile and side scan sonar data, an assessment can be made as to whether reduction in the thickness of the mound is due to erosion of cap material and or consolidation.	PTA (except boat hire which will be the responsibility of EC on award of contract where the bathymetric survey can be undertaken in parallel with other surveys)	PTA – Regeneration Funds.
Sidescan sonar of the trial site and immediate surrounding area	Information on any transport of the cap material due to tidal or wave induced processes. Information on loss of integrity of the cap due to hydrodynamic or anthropogenic causes.	EC under contract to PTA.	PTA – Regeneration Funds.
Sub-bottom profiles across the trial site. Sweeps across the survey area.	Information on any reduction in thickness of the cap. Estimation of consolidation of seabed, CDM and cap materials. Assessment of any changes in the physical nature of the cap. For example the production of a cap surface armoured with a layer of coarse material due to the winnowing out of finer material by normal tidal currents and waves.	EC under contract to PTA.	PTA – Regeneration Funds.
Sediment Profile Imaging (SPI) – transect across site	Information on depth of bio-turbation on cap surface. Assessment of any erosion of cap.	EC under contract to PTA.	PTA – Regeneration Funds.
Sediment cores for contaminant testing and particle size distribution, taken at thirteen locations within the trial site. Sub-samples collected from cores at three depths (Surface, middle, bottom).	Assessment of contaminant levels and layering of sediments outside the trial site and over the cap, to determine if there is significant movement of CDM and cap material from the trial site. Assessment of contaminant levels in cap to determine if there is significant migration of contaminants from the CDM to the cap. Measurement of the thickness of cap and CDM layers to determine if there is significant erosion of the cap.	EC under contract to PTA (Note; Cefas & Mountain Heath will be contracted by EC for sample analysis.	PTA-Regeneration Funds.
Surface sediment grab samples for contaminants (TBT/DBT & Heavy Metals) and particle size distribution (psd) taken at 5 locations on the N-S transect.	Concentration of contaminants along a N-S transect extending to just beyond tidal re-charge. To determine if contaminants from the trial site are travelling with the prevailing southerly current.	EC under contract to PTA (Note; Cefas & Mountain Heath will be contracted by EC for sample analysis.	PTA-Regeneration Funds.

Surface sediment grab for in-fauna taken at seventeen locations. Repetitive sampling will be undertaken at eight sampling stations to provided a total of thirty three in-fauna samples. Initially twenty-eight of these samples will be analysed.	Benthos types and abundance. Data will provide: An assessment of any long-term impacts on benthos around the trial site. Information on re-colonisation/recovery of benthos around the trial site. The level of colonisation (and associated bio-turbation) of cap surface. Assessment of impacts on benthos on a N-S transect.	EC under contract to PTA (Note: suitable laboratories will be contracted by EC for sample analysis)	PTA regeneration fund
Beam trawl (2m beam, 5-10 minutes tow) for epifaunal, taken at five locations in a N-S transect through the disposal site. One sample from each station will be taken for community analyses. One sample from each station will be taken for analysis of TBT in flesh of a target species.	Epi-fauna types and abundance Tissue contaminant analysis. Comparison with background data collected pre-trial, will allow an assessment of any impact on benthos around the trial site.	EC under contract to PTA (Note: suitable laboratories will be contracted by EC for sample analysis.	PTS – Regeneration Funds.
Underwater TV along three transects.	Film footage demonstrating the integrity of the cap.	EC under contract to PTA	PTA-regeneration funds.

REFERENCES

USACE, 1998. *Guidance for Sub-aqueous Dredged Material Capping*, Technical Report DOER-1.