REPORT

South Bank Quay

Technical Note:
Hydrodynamic and Sediment Plume Modelling

Client: South Tees Development Limited

Reference: PC1084-RHD-ZZ-XX-RP-Z-0001

Status: S0/P01.01

Date: 19 January 2022

HASKONINGDHV UK LTD.

Marlborough House
Marlborough Crescent
Newcastle upon Tyne
NE1 4EE
Maritime & Aviation
VAT registration number: 792428892

+44 191 2111300 **T**
+44 1733 262243 **F**
info.newcastle@uk.rhdhv.com **E**
royalhaskoningdhv.com **W**

Document title:	South Bank Quay
Document short title:	
Reference:	PC1084-RHD-ZZ-XX-RP-Z-0001
Status:	P01.01/S0
Date:	19 January 2022
Project name:	
Project number:	PC1084
Author(s):	Tanja Cooper, Keming Hu
Drafted by:	Tanja Cooper
Checked by:	Keming Hu
Date / initials:	06/01/2021
Approved by:	Nick Cooper
Date / initials:	10/01/2022

Classification
Project related

Disclaimer

No part of these specifications/printed matter may be reproduced and/or published by print, photocopy, microfilm or by any other means, without the prior written permission of HaskoningDHV UK Ltd.; nor may they be used, without such permission, for any purposes other than that for which they were produced. HaskoningDHV UK Ltd. accepts no responsibility or liability for these specifications/printed matter to any party other than the persons by whom it was commissioned and as concluded under that Appointment. The integrated QHSE management system of HaskoningDHV UK Ltd. has been certified in accordance with ISO 9001:2015, ISO 14001:2015 and ISO 45001:2018.

Royal HaskoningDHV

Table of Contents

Table of Tables

Table of Figures

1 Introduction

Royal HaskoningDHV was commissioned by South Tees Development Limited (STDL) to undertake a numerical modelling exercise to inform the Environmental Impact Assessment (EIA) that was prepared as part of the South Bank Quay development project.

The numerical modelling study was reported in **Chapter 6: Hydrodynamics and Sedimentary Processes** of the EIA Report and the accompanying **Appendix 5: Hydrodynamics and Sedimentary Plume Modelling** of the EIA Report and comprised:

- **Hydrodynamic modelling**: An existing 2D North East Regional Tidal Model built in MIKE21-HD was used to provide boundary conditions for an existing 3D Tees Estuary Tidal Model built in MIKE3-HD. The latter model was updated with new bathymetry data and its mesh was refined around the site of the proposed scheme. The model was re-calibrated and then further verified using the acoustic doppler current profiler (ADCP) data newly collected as part of a Metocean Survey undertaken by Partrac in July 2020. The updated and verified 3D model was then used to characterise baseline conditions and predict potential local and estuary-wide changes in hydrodynamics caused by the proposed scheme.

- **Dispersion modelling**: The updated and verified 3D Tees Estuary Tidal Model was used to predict movement of suspended sediment from the proposed dredging and disposal activities by coupling with a sediment plume model built in MIKE3-MT software. The sediment plume model was run for the entire dredging and disposal schedule.

- **Wave modelling**: Since the site is well sheltered from North Sea swell waves, it is locally-generated wind waves that are of more significance to the proposed scheme. To demonstrate this understanding of the baseline wave conditions, an established Tees Bay Wave Model built in MIKE-SW was used to transform extreme offshore waves (1 in 1 year and 1 in 100 year) to the site. In addition, extreme value analysis was undertaken for extreme wind conditions in the Tees Estuary. Locally-generated waves caused by extreme winds were then hindcast using the Tees Bay Wave Model.

Figure 1-1 shows the location of the proposed scheme, as well as the wider study area used for consideration of hydrodynamics and sedimentary processes. The wider study area: (i) extends approximately 18 km offshore to encompass the offshore disposal site Tees Bay C; (ii) covers Hartlepool Headland in the north and Redcar in the south; and (iii) includes the whole of the River Tees up to the Tees Barrage, which is the tidal limit. The proposed scheme at South Bank Wharf is situated approximately 6 km upstream from the mouth of the Tees Estuary.

The previous numerical modelling study covered both Phases 1 and 2 of the South Bank Quay project as a worst case scenario (assuming both phases take place at the same time), although Marine Licence applications were separately made for Phase 1 (MLA/2020/00506) and 2 (MLA/2020/00507). It should be noted that STDL is only seeking to construct Phase 1 of the project during 2022 / 2023. STDL may still construct Phase 2 of the project, however there will be a gap of at least 12 months between Phase 1 and Phase 2.

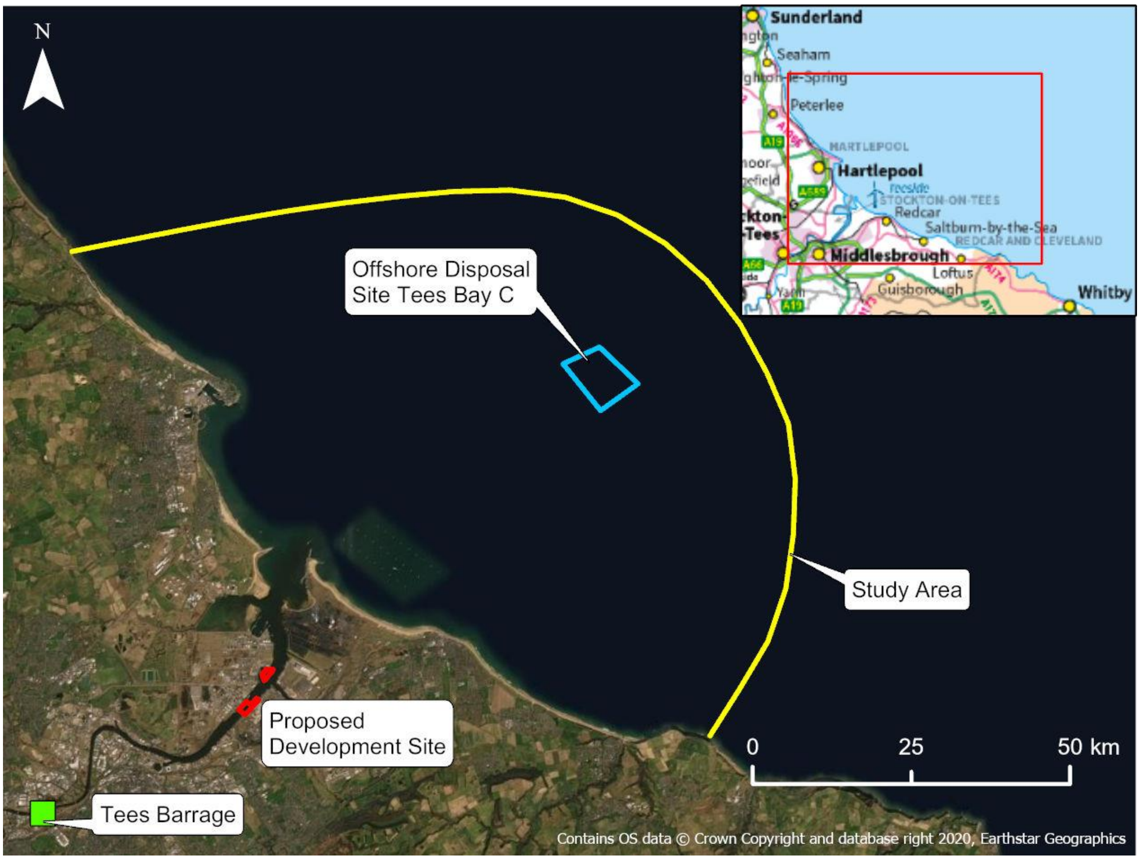

Figure 1-1 Proposed Development Site and Wider Study Area

Following receipt of the Marine Licence for Phase 1 (L/2021/00333/1), STDL is now seeking to vary the originally proposed construction methodology in the following manner. This is required in order to reduce the Phase 1 construction programme so that it can be delivered in adherence to an imposed Marine Licence condition that prohibits dredging in any year from 1st July to 31st August (inclusive) (Condition 5.2.8):

- Change in dredger type from a combination of trailer suction hooper dredger (TSHD) and backhoe dredger (BH) to use of a cutter suction dredger (CSD) by the appointed Contractor – this has the effect of increasing the production rate of dredging (and associated disposal) and changing the potential spill rate of sediment from the dredging process;

- Increasing capacity of the vessel to be used for disposal of dredged material at the offshore disposal site – this has the effect of a reduced number of disposal events, but with each event disposing a greater quantity of material than previously assessed.

- Incorporating into the assessments a better definition of the material type to be dredged based on findings from the Ground Investigation (GI), which has identified more of the 'harder' material and less of the 'softer' material than previously assumed and assessed as a worst case within the ES.

- Incorporating very slight change in the extent of the dredging within the turning area, from a semi-circular to semi-trapezoidal shape.

Royal HaskoningDHV

- Inclusion of currently landside soils (i.e. soils within the riverbank) within the proposed dredging campaign (it should be noted that consultation with the MMO is being undertaken to determine whether this is a feasible approach, however the modelling has conservatively assumed that it will be acceptable to MMO).

The effects of these changes in approach to Phase 1 upon the hydrodynamic and sedimentary regime have been re-assessed using a combination of expert geomorphological assessment (EGA) and sediment plume and disposal modelling. By considering Phase 1 only in the updated assessments, this has the effect of reducing the total volume of material to be dredged and disposed from 1.8 million m^3 (Phase 1 and 2 total) to 1.2 million m^3 (Phase 1 only) and lessening the footprint of the river channel that will be directly affected by dredging (**Figure 1-2**). It should be noted that STDL is still planning on constructing Phase 2 of the South Bank Quay project, however as noted in Section 1, Phase 2 is due to be constructed at least 12 months post construction of Phase 1. No variations to the Phase 2 licence are currently proposed.

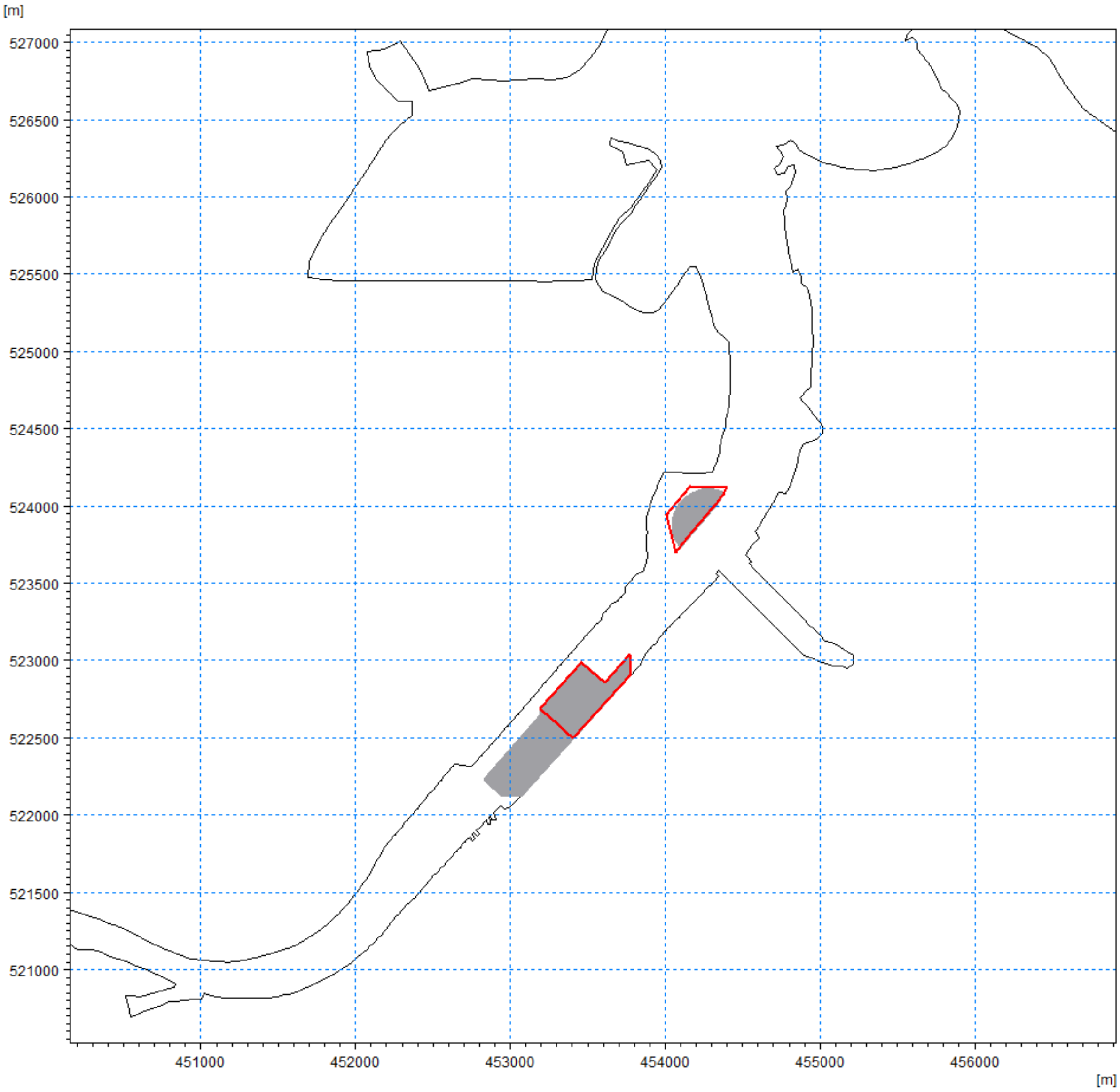

Figure 1-2 Footprint of dredging assessed in the EIA report (grey areas for Phases 1 and 2) and in updated assessments (red boundary for proposed variations to Phase 1 only).

Royal HaskoningDHV

2 Hydrodynamic Regime

The principal findings from the previous numerical hydrodynamic modelling for Phases 1 and 2 of the project were:

- The proposed new quay alignment and capital dredging to deepen the Tees Dock turning area and approach channel and to create a berth pocket will not significantly affect the existing baseline hydrodynamic conditions under any of the three different river flow scenarios considered.

- There will be flow newly occurring in the area of the new quay because it is being set-back from the existing riverbank, but even the peak flows in this area will be low.

- Elsewhere, there will be a general small magnitude reduction in baseline flows varying during different phases of the tidal cycle, but always remaining largely within the reach immediately opposite the new quay. This reduction in baseline flows is caused by both a slight widening of the channel (due to the new quay alignment) and the local deepening of the bed due to the capital dredging.

- The reductions in baseline current speeds in these areas may lead to a slight increase in deposition of sediment. In the main channel the deposition will require periodic dredging to maintain the design depths.

- There is no measurable change caused by the capital dredging at the Tees Dock turning area.

- There are no estuary scale effects on baseline hydrodynamic conditions.

Full details were provided within **Chapter 6: Hydrodynamics and Sedimentary Processes** of the EIA Report and the accompanying **Appendix 5: Hydrodynamics and Sedimentary Plume Modelling** of the EIA Report.

In the updated assessments, proposed project variations to Phase 1 have been considered. Phase 1 would affect a smaller footprint of the river channel compared with the previous assessments for Phases 1 and 2, so any such effects from dredging on the tidal regime during Phase 1 would be lesser than those previously assessed. Also the very slight change in extent of dredging within the turning area from a semi-circular to semi-trapezoidal shape is not deemed at all significant. For these reasons, no updated numerical hydrodynamic modelling has been undertaken.

Royal HaskoningDHV

3 Sediment Regime

3.1 Background

This section of the report describes the updated sediment dispersion modelling exercise for Phase 1 of the South Bank Wharf development project that was undertaken to investigate the suspended sediment transport effects of the proposed dredging of the channel and the berth pocket in front of the new quay wall, as well as the deepening of parts of the Tees Dock turning area. The sediment transport model was built in MIKE3-MT software developed by DHI.

3.2 Sediment Data

Available soil data indicates that it is expected that the dredging material consists of different soil types. A summary of the expected dredging soil types based on the ground investigation data (Definitive Feasibility Study Basis of Design - PC1084-RHD-SB-ZZ-RP-Z-1303) is presented in **Table 3-1**. A distinction is made between soft and hard material because it is expected to influence the choice of dredging equipment to be deployed.

Table 3-1: Soil Types to be dredged

Soft/hard soil type	Stratum	Top to bottom levels (mCD)	Description
Soft soil material	Tidal Flat Deposits	+2 to -2	Loose to medium dense grey brown very clayey slightly gravelly SAND
Hard soil material	Mercia Mudstone Group	-11 and deeper	Red brown highly weathered MUDSTONE weak with occasional deposits of gypsum
Hard soil material	Glacial Till	-2 to -11	Stiff (locally firm) red brown sandy gravelly CLAY of low plasticity. Gravel is fine to coarse subangular and consists of sandstone, quartzite and mudstone

Based on the ground investigation data, for the sediment dispersion modelling, the following particle size distribution of the two soil types has been adopted as shown in **Table 3-2**.

Table 3-2: Particle size distribution for dredged soil types

Sediment Category	Sediment Size (mm)	Soft material	Hard material
Silt/Clay	0.031	70%	20%
Fine Sand	0.13	10%	5%
Medium Sand	0.3	5%	-
Coarse Sand	1.3	5%	-
Gravel/Cobble	2	10%	75%

3.3 Dispersion Model Setup

The sediment dispersion model built in MIKE3-MT is coupled with the 3D hydrodynamic model built in MIKE3-HD. The computational mesh of MIKE3-MT is identical to the MIKE3-HD mesh described in Section 4 of this report.

The dredging layout for Phase 1 is shown in **Figure 3-1**. The river channel in front of the South Bank Wharf as well as part of the Tees Dock turning area will be dredged to a level of -11mCD. The berth pocket in front of the new quay has a design bed level of -13.6mCD, but the dredge volumes considered in the dispersion model include an extra two metres of dredge material down to a bed level of -15.6mCD to allow for a rock blanket to be installed in the berth pocket.

The sediment dispersion model has been run for a three-month period to cover the full duration of the dredging schedule. Due to the uncertainty of the time when the dredging will take place, the worst scenario in terms of the tides has been chosen, and the model has been run for the period of March to May in which spring tides are slightly higher.

The sediment dispersion model has been setup with four layers in order to differentiate between suspended sediment concentrations (SSC) throughout the water column, e.g. near the sea bed and near the water surface.

In order to simulate the sediment dispersion close to natural conditions, wave disturbance effect has been included in the MIKE3-MT model. Wave condition of 1m and 4.9 sec (Tz) has been chosen in the model settings.

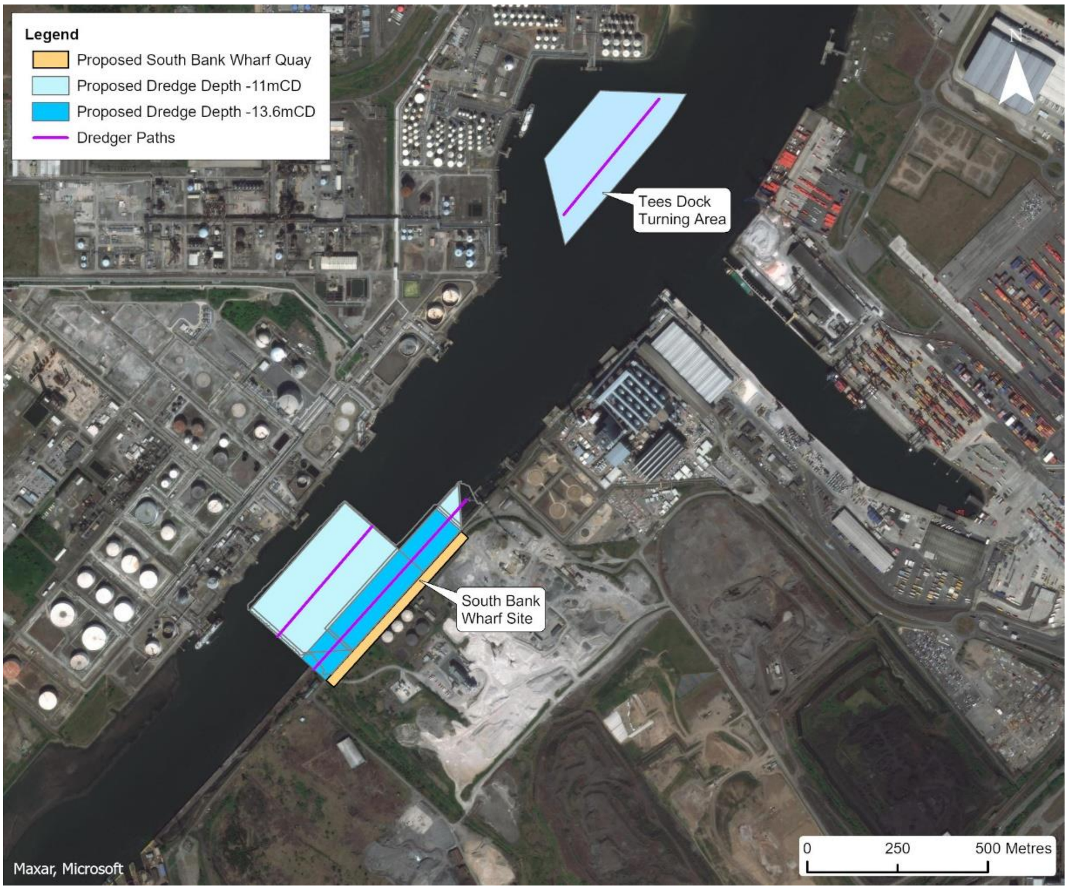

Figure 3-1 Dredging Layout

3.4 Dredging Methodology and Schedule

The dredging method, dredging schedule and details of the sediment release settings for the sediment plume dispersion model are described in this section.

Royal HaskoningDHV

3.4.1 Dredging Method

The sediment will be dredged using a Cutter Suction Dredger (CSD).

All dredged material will be taken to the Tees Bay C offshore disposal site which is approximately 18km (or 10 nautical miles) away from the South Bank Wharf site. This is shown in **Figure 3-2**.

Figure 3-2 South Bank Wharf Dredge Site and Tees Bay C Offshore Disposal Site

Royal HaskoningDHV

3.4.2 Dredging Schedule

The dredging schedule and quantity for the CSD are described in **Table 3-3**. The dredging will begin with the CSD removing the soft soil material and hard material respectively from the berth pocket, then removing both soil materials from the channel before moving on to removing both materials in the turning area.

A total of 1.2 million m^3 of bed material will be dredged over a period of nine weeks. The simulation covers the entire dredging period and the movement of dredger and transport barges were tracked for the processes of dredging, sailing, disposal and downtime for bad weather, refuelling, and equipment maintenance. **Figure 3-3** shows the sediment release schedules for the dredger at the South Bank Quay site and Tees Dock turning area (i.e. the Phase 1 dredge footprint), whilst and **Figure 3-4** shows the sediment release schedules for the transport barge at the offshore disposal site.

The disposal schedule will follow the same pattern as the dredging schedule in that the barge filled by the CSD will sail to the offshore disposal site once its full capacity has been reached.

Table 3-3: Dredging Schedule Overview

	South Bank Wharf Berth Pocket		South Bank Wharf Channel		Tees Dock Turning Area	
	Soft material	**Hard material**	**Soft material**	**Hard material**	**Soft material**	**Hard material**
Vessel load (m^3)	2000	5000	2000	5000	2000	5000
Loading (Dredge) time (minutes)	50	160	50	160	50	160
Sailing time empty (minutes)	80	80	80	80	80	80
Connection time (minutes)	20	20	20	20	20	20
Sailing time loaded (minutes)	90	90	90	90	90	90
Disconnection time (minutes)	20	20	20	20	20	20
Discharging time (minutes)	10	10	10	10	10	10
Operational to service hours (%)	68.45%	68.45%	68.45%	68.45%	68.45%	68.45%
Total dredging cycle time (minutes)	270	380	270	380	270	380
Effective operation hours per week	100	100	100	100	100	100
Number of trips to offshore disposal site per week	22.2	15.8	22.2	15.8	22.2	15.8
Cycle production (m3/week)	133,333	150,000	133,333	150,000	133,333	150,000
Dredging volume (m3)	305,369	460,054	147,136	106,304	142,465	73,171
Dredging time (weeks)	2.3	3.1	1.1	0.7	1.1	0.5

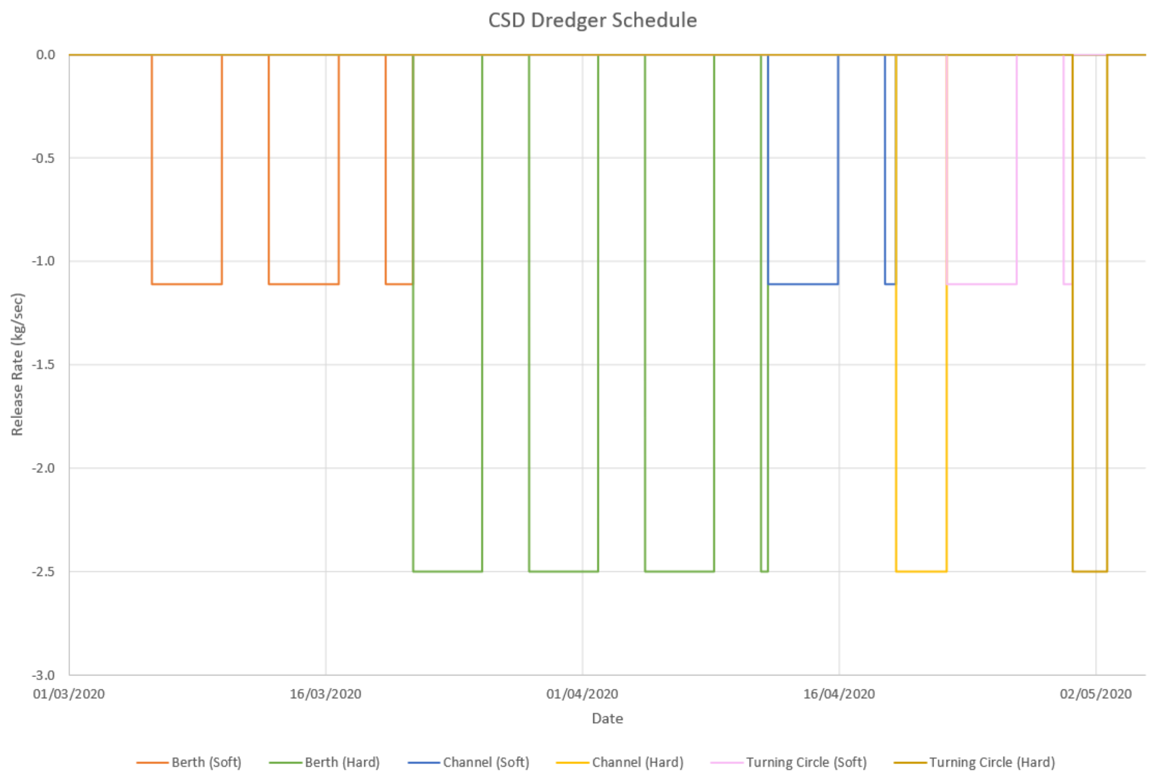

Figure 3-3 Sediment release schedule for dredger

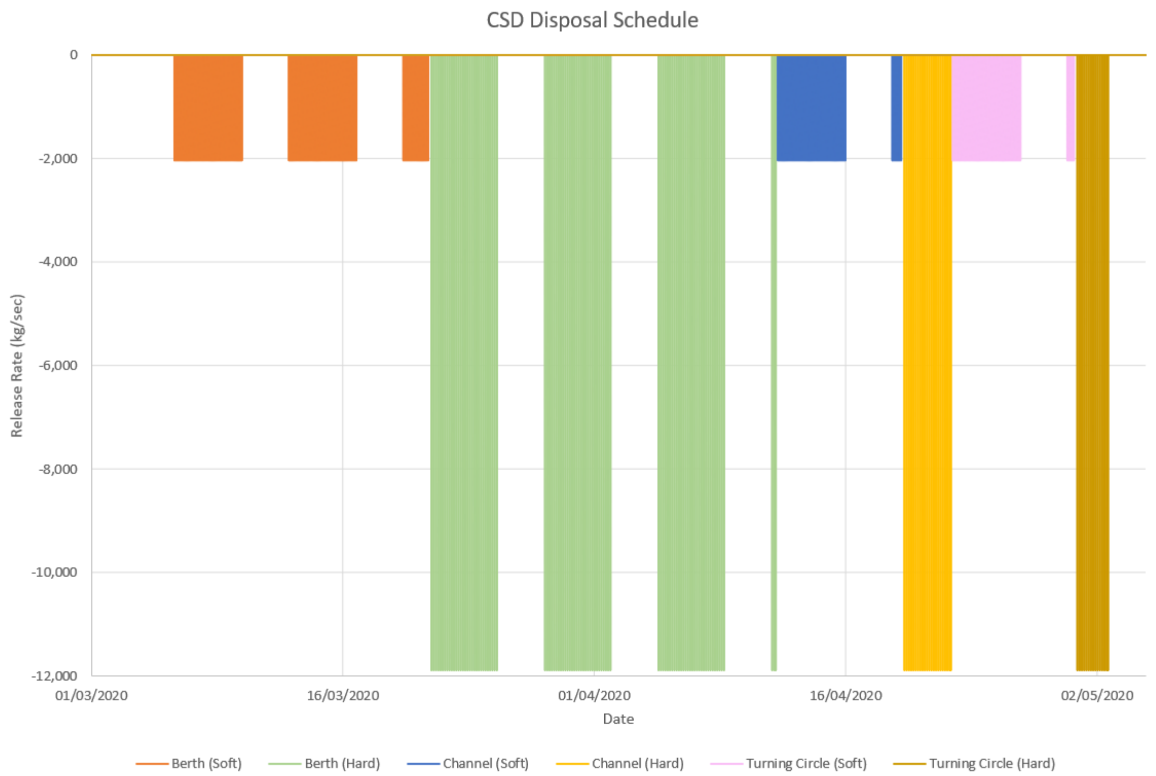

Figure 3-4 Sediment release schedule at offshore disposal site

Royal HaskoningDHV

3.4.3 Sediment Release Assumptions

The following assumptions have been made for the simulation of sediment plumes arising from dredging and offshore disposal.

The CSD will operate at full capacity, with two barges being deployed for transport of the dredged soil material to the disposal site. The dredger will release material from along a single line along each of the channel, the berth pocket and part of the Tees Dock turning area. This adopted method for material release is a conservative approach for worst case plume effect. The dredger will actually move around the dredging areas along multiple lines which means the sediment release will be more dispersed and thus the sediment concentration will be less than simulated.

At the offshore disposal site, two release scenarios have been considered. The first involves the barges releasing all material at a single point in the centre of the disposal site. This adopted method for material release is a conservative approach for worst case plume effect. Recognising that the barges could actually discharge their loads anywhere within the disposal site a second scenario was adopted where the model randomly generated a release point within the disposal site for each visit.

3.4.4 Sediment Property Representation

The five sediment fractions, critical bed shear stresses and fall velocities used in the sediment dispersion model to represent bed sediments are shown in **Table 3-4**. The critical bed shear stress and fall velocities were calculated using the SandCalc software developed by HR Wallingford.

Table 3-4: Sediment settling velocity and critical bed shear stress

Sediment Grading Type	Sediment Size (mm)	Settling Velocity (m/s)	Critical Shear Stress (N/m^2)
Silt/Clay	0.031	0.000554	0.0847
Fine Sand	0.13	0.00935	0.1548
Medium Sand	0.3	0.0372	0.2025
Coarse Sand	1.3	0.135	0.657
Gravel/Cobble	2	0.1734	1.166

3.5 CSD Dredging and Disposal Cycle

This section describes the CSD dredge and disposal cycle for the two different soil types. The sediment release rate, sediment loss rate and discharge sediment rate are the same for each of the dredge areas, namely berth pocket, channel and turning area. They differ in dredge and disposal duration due to the different volume of material that is being removed.

3.5.1 Soft surface layer

The CSD dredger will dredge the soft surface layer material above a level of -2mCD by operating continuously filling a barge, with two barges being in operation sailing back and forth to the offshore disposal site. The dredger disperses sediment into the water column at a sediment release rate of 1.11 kg/s. The sediment loss rate (the so-called ‘S-factor’) is taken as 6 kg/m^3 for the CSD which follows the CIRIA Guidance (2000).

Royal HaskoningDHV

The CSD will dredge for 50 minutes to load one barge, the barge will then sail for 90 minutes to the disposal site, discharge for 10 minutes with a discharge sediment rate of 2038.333 kg/s. The barge will then take 80 minutes to sail back to site. Disconnecting and re-connecting the barge from and to the CSD will take 40 minutes in total. The total time of one dredge and disposal cycle takes 270 minutes.

The CSD works on 68.45% operational working hours, which allows for downtime due to bad weather, refuelling, and equipment maintenance.

The CSD dredge and disposal cycle for the soft material will take 2.29 weeks for 305,369 m^3 in the berth, 1.1 weeks for 147,136 m^3 in the channel and 1.07 weeks for 142,465 m^3 in the turning area.

3.5.2 Hard surface layer

The CSD dredger will dredge the hard material below a level of -2mCD by operating continuously filling a barge, with two barges being in operation sailing back and forth to the offshore disposal site. The dredger disperses sediment into the water column at a sediment release rate of 2.5 kg/s. The sediment loss rate (the so-called ‘S-factor’) is taken as 6 kg/m^3 for the CSD which follows the CIRIA Guidance (2000).

The CSD will dredge for 160 minutes to load one barge, the barge will then sail for 90 minutes to the disposal site, discharge for 10 minutes with a discharge sediment rate of 11,891.67 kg/s. The barge will then take 80 minutes to sail back to site. Disconnecting and re-connecting the barge from and to the CSD will take 40 minutes in total. The total time of one dredge and disposal cycle takes 380 minutes.

The CSD works on 68.45% operational working hours, which allows for downtime due to bad weather, refuelling, and equipment maintenance.

The CSD dredge and disposal cycle for the hard material will take 3.07 weeks for 460,054 m^3 in the berth, 0.71 weeks for 106,304 m^3 in the channel and 0.49 weeks for 73,171 m^3 in the turning area.

3.6 Results of Dispersion Model

3.6.1 Background

Results from the updated sediment dispersion modelling for proposed variations to the Phase 1 project are discussed in turn for the river dredging and offshore disposal activities. Note that all modelling plots in the following sections show the elevations in SSC or sediment deposition due to these activities above baseline levels.

For SSC and sediment deposition, maximum ‘zone of influence’ plots are presented in following sections. These show the maximum values and spatial extents of enhancement in SSC or deposition on the bed from any stage of the river dredging or offshore disposal operations during the relevant phase of the dredging programme. It is important to note that this type of figure does not represent a plume or deposition that would occur instantaneously at any one point in time. Rather, this type of figure shows the maximum areas of the river channel or offshore area that will become affected by a plume or deposition at some point during the nine weeks of dredging or disposal activities (in some areas this will be on a single occasion, in other areas it will be on multiple occasions) and the maximum magnitude of change that will be experienced at that point.

To provide context, plots are first presented for the results arising under the previously assessed conditions for the original Phase 1 and Phase 2 of the South Bank Quay project (reproduced from the EIA Report) and then the equivalent plot is presented for conditions arising under the proposed project variations to Phase 1 only.

3.6.2 River Dredging

The combined maximum ‘zone of influence’ from all stages of the dredging activities associated with the previously assessed Phases 1 and 2 of the project has been plotted in **Error! Reference source not found.** for the near-bed layer and Error! Reference source not found. for the near-surface layer. These figures can be compared against the updated modelling results for the proposed project variation (covering Phase 1 only of the dredging) in Error! Reference source not found. (near-bed layer) and Figure 3-8 (near-surface layer).

For the previously assessed Phases 1 and 2 of the project (**Figure 3-5** and **Figure 3-6**), near-surface effects are generally slightly lower than near-bed effects, and during the dredging, all plume effects are confined to within the river reaches that extend between Middleborough Dock/Transporter Bridge at the upstream end and the Oil Terminal on the north bank at the downstream end. Furthermore, all plumes associated with dredging of the berthing pocket and river channel in the vicinity of the new quay are confined to the right bank (south of centre line) portion of the channel’s width, whilst all plumes associated with dredging of the turning area are confined to the left bank (north of centre line) portion of the channel’s width in the reaches that they respectively affect. No plume effects (and by implication no deposition effects) of a significant level above background values will occur beyond these reaches.

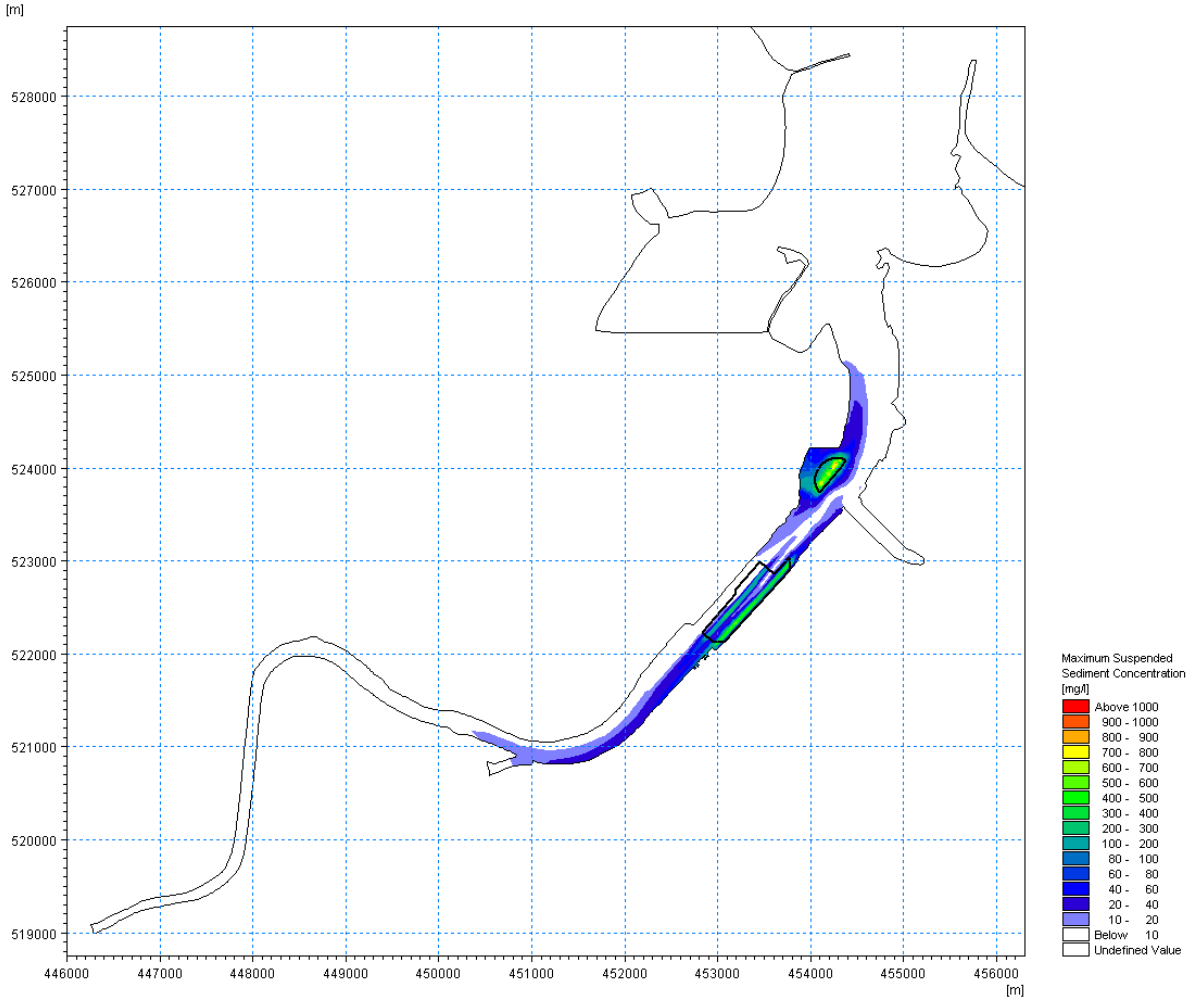

Figure 3-5 Maximum enhanced suspended sediment concentrations (near-bed layer) arising from dredging activities under the previously assessed project [Phases 1 and 2, reproduced from EIA Report]

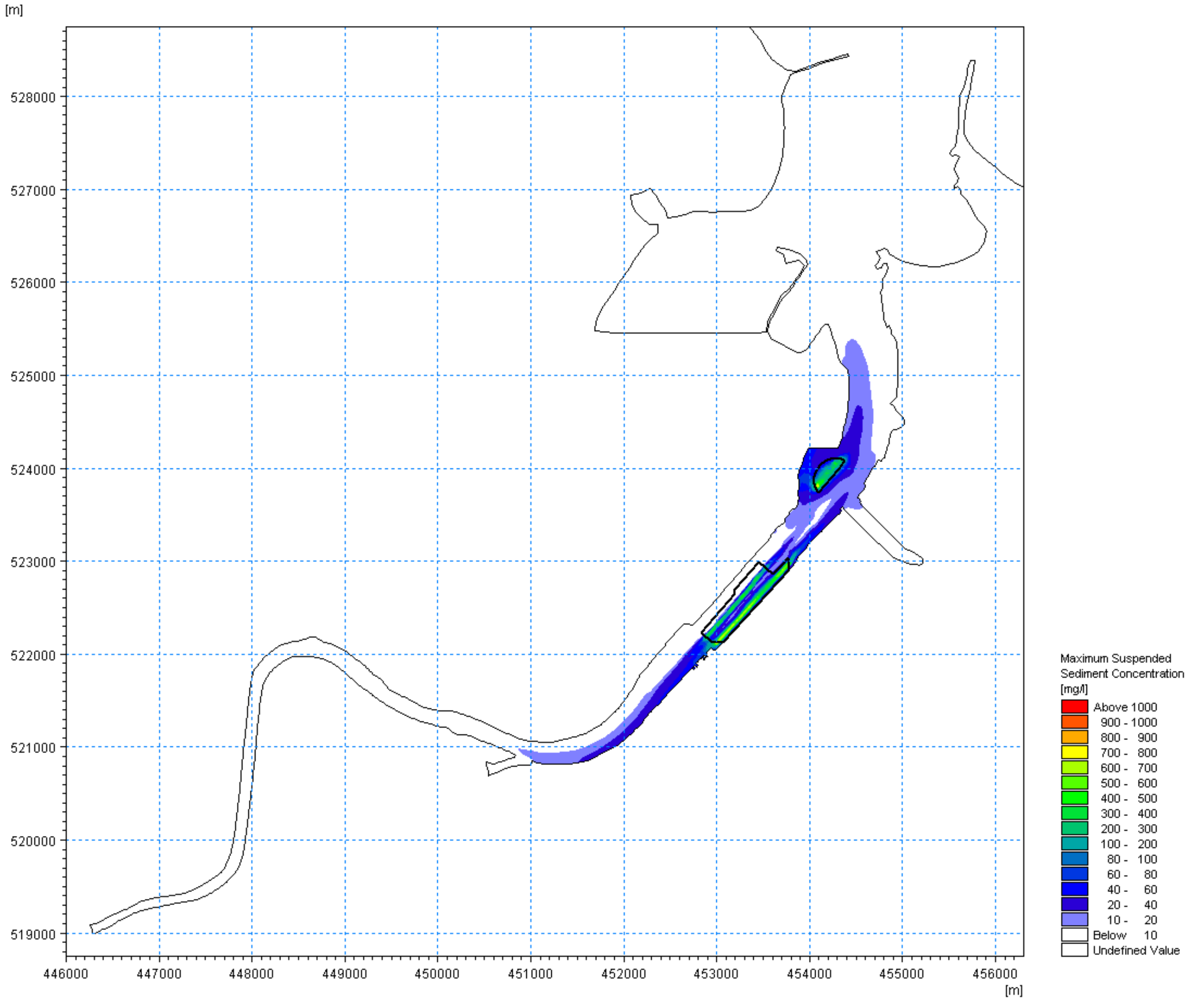

*Figure 3-6 Maximum enhanced suspended sediment concentrations (near-surface layer)*arising from dredging activities under the previously assessed project [Phases 1 and 2, reproduced from EIA Report]

For the proposed project variations, (**Error! Reference source not found.** and **Figure 3-8**) the updated modelling results for Phase 1 only show that both the magnitude and spatial extent of the arising maximum 'zone of influence' are considerably less than that previously assessed for Phases 1 and 2, for both the near-bed and near-surface layers of the water column. This is predominantly due to the lesser volume of material being dredged, the shorter overall dredging programme, the smaller area within which dredging will be undertaken, and the different spill rates of the CSD compared to that previously assessed for the TSHD and BH dredgers.

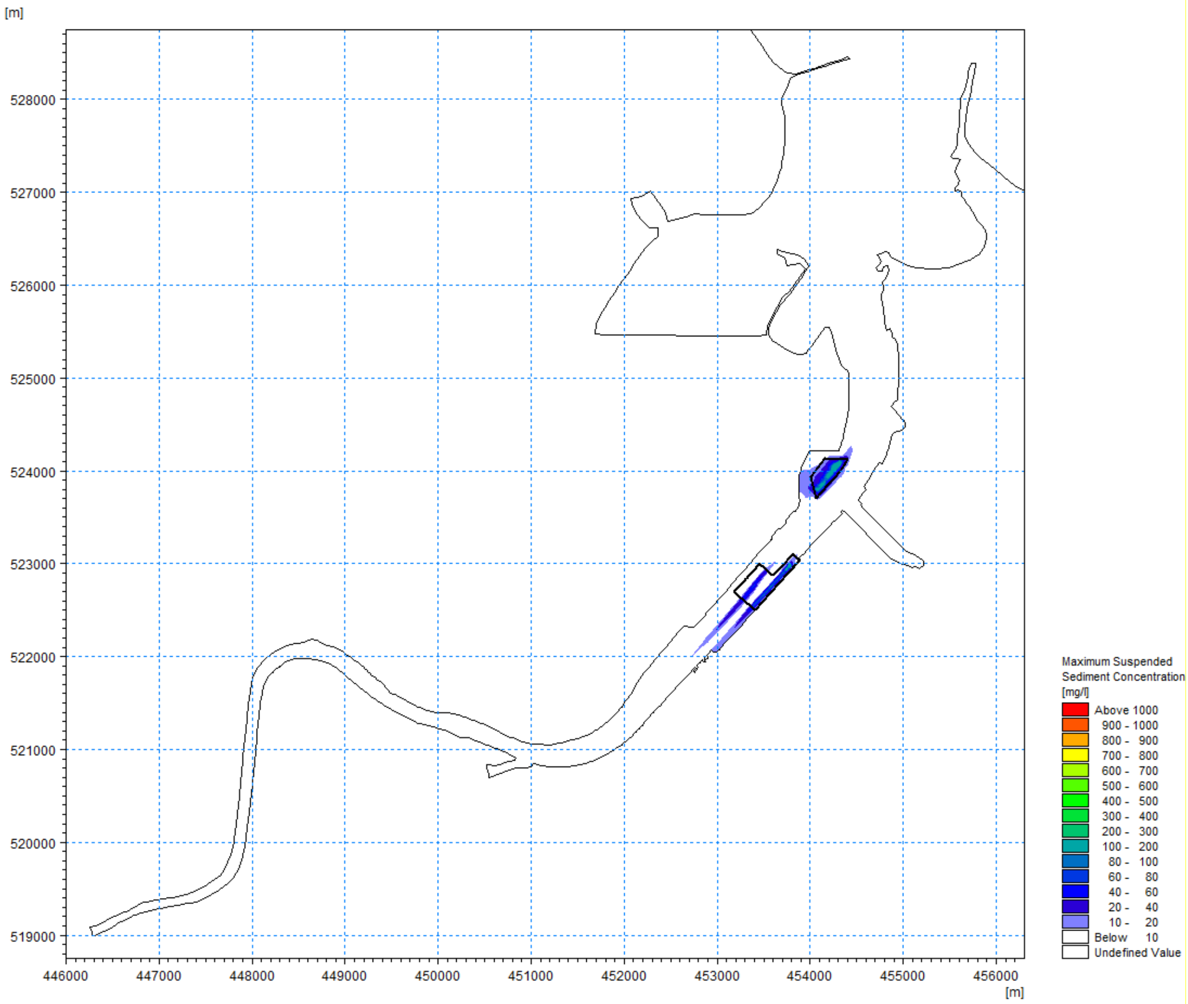

Figure 3-7 Maximum enhanced suspended sediment concentrations (near-bed layer) arising from dredging activities under the proposed project variation to Phase 1 [updated modelling]

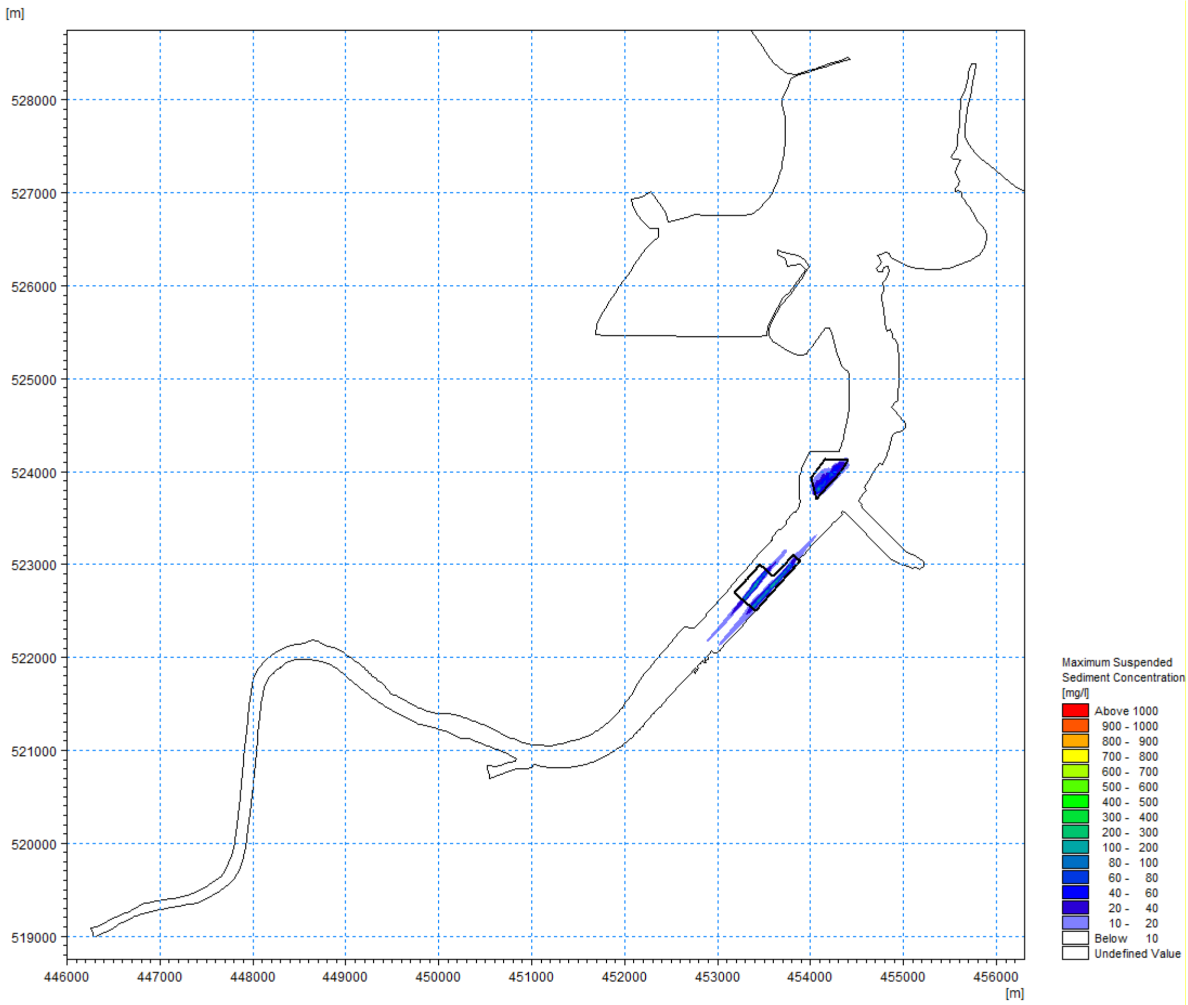

Figure 3-8 Maximum enhanced suspended sediment concentrations (near-surface layer) arising from dredging activities under the proposed project variation to Phase 1 [updated modelling]

For the previously assessed Phases 1 and 2 of the project, **Figure 3-9** shows the maximum changes in river bed thickness caused by the deposition of sediment from the plumes created by river dredging. It can be seen that much of the sediment falls to the bed within the dredged areas (from where it will be re-dredged to achieve the necessary bed depths), whilst the deposition that occurs in other parts of the river is much lower, typically less than 5cm, within the same area of river that is affected by the zone of influence from the sediment plumes.

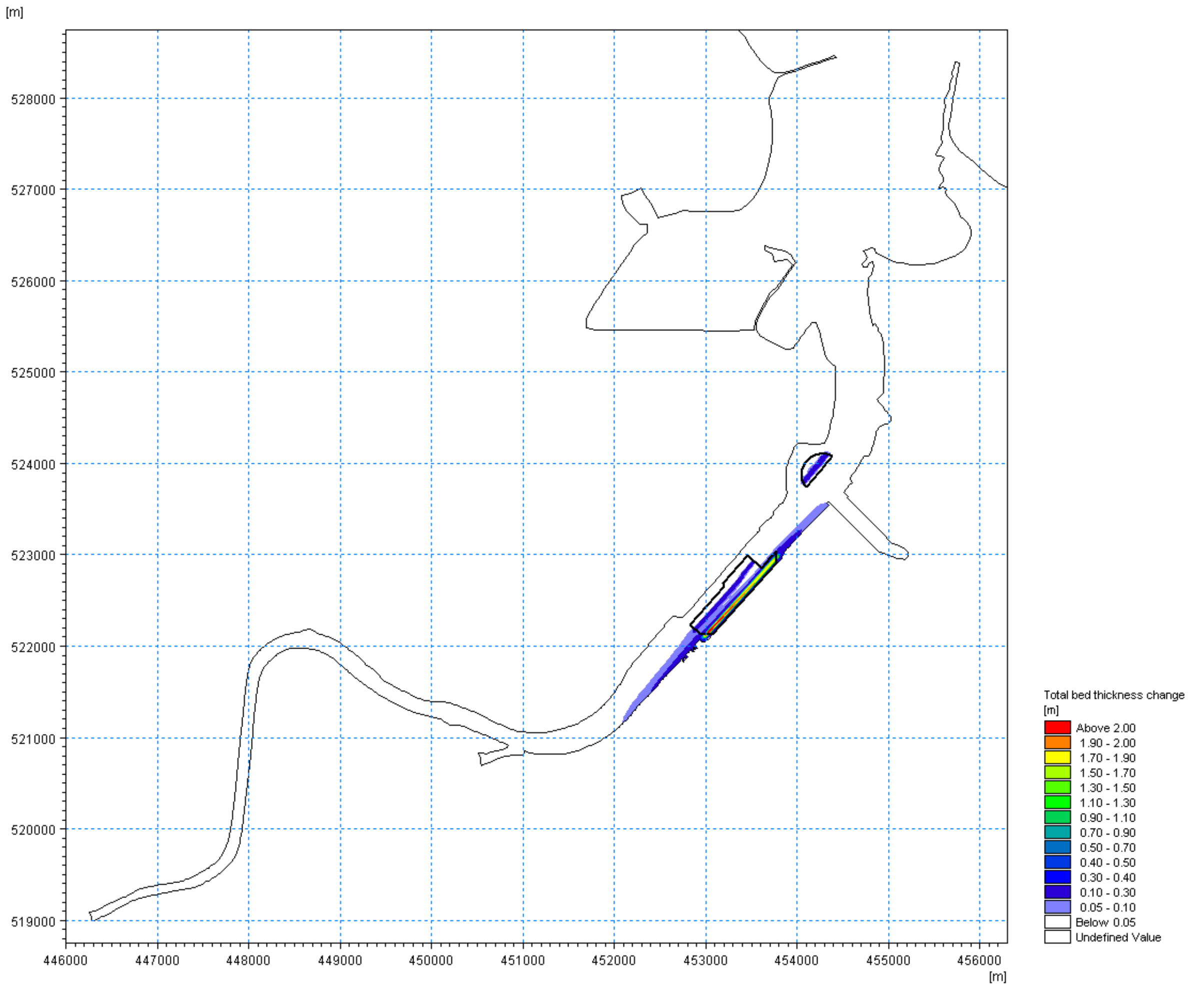

Figure 3-9 Maximum river bed thickness change due to sediment deposition arising from dredging activities under the previously assessed project [Phases 1 and 2, reproduced from EIA Report]

For the proposed project variations, the updated modelling results for Phase 1 only (**Figure 3-10**) show that both the magnitude and spatial extent of the arising maximum river bed thickness change are considerably less than that previously assessed for Phases 1 and 2 of the project. In particular, the changes are confined to within the footprint of the dredged areas, from where the re-deposited sediment will be dredged and removed.

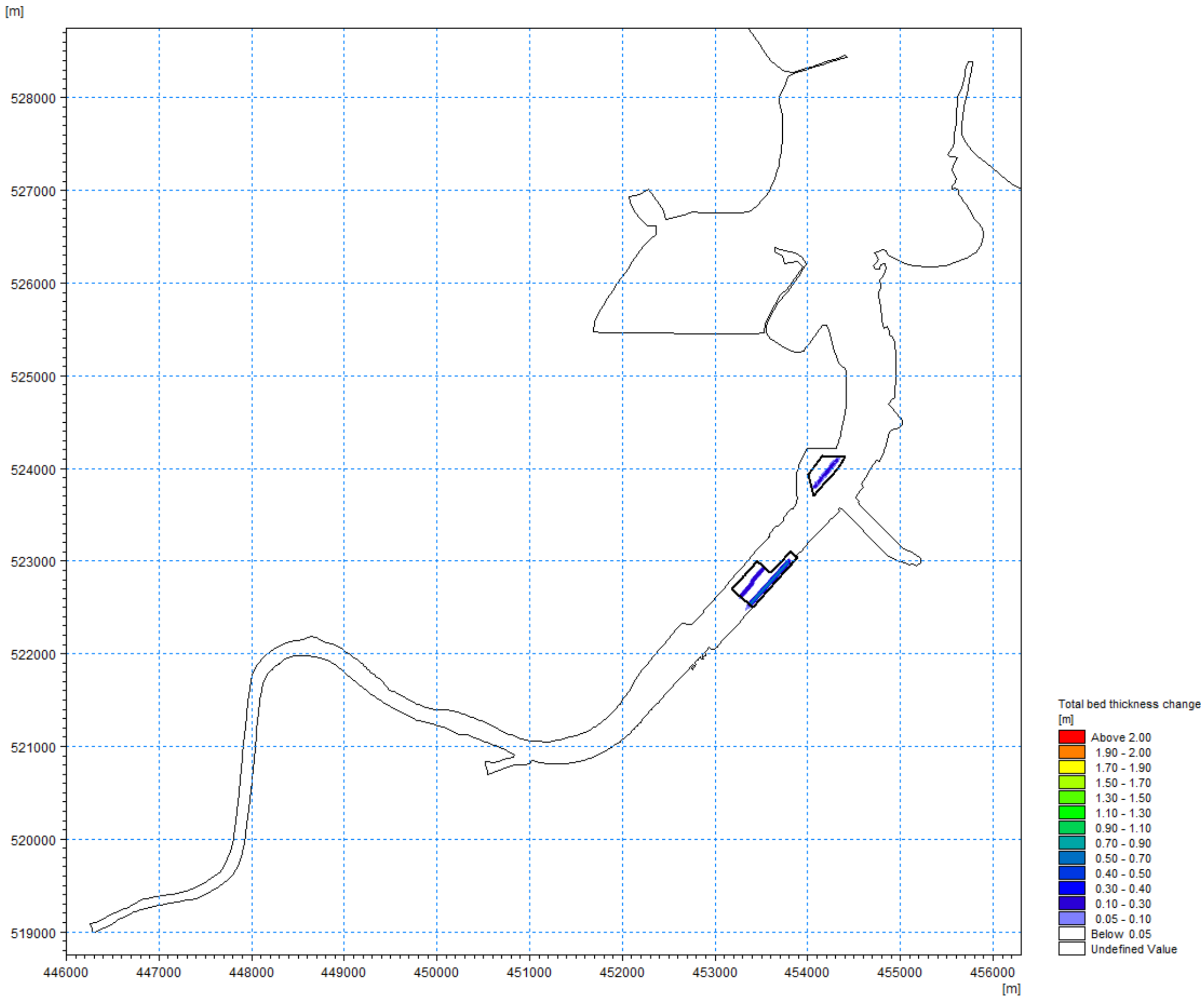

Figure 3-10 Maximum river bed thickness change due to sediment deposition arising from dredging activities under the proposed project variation to Phase 1 [updated modelling]

3.6.3 Offshore Disposal Site

The offshore disposal site is located within a water depth of around 43.5m, approximately 18km from the proposed development site and around 12km from the mouth of the river at its nearest point. The site is licensed for the disposal of dredged sediment and is routinely monitored as part of a national programme. Therefore, plumes arising from disposal activities and subsequent sediment deposition is unlikely to be of concern within the licensed area, or in immediately adjacent sea bed areas.

For the previously assessed Phases 1 and 2 of the project, the maximum 'zone of influence' from disposal associated with the dredging programme has been plotted in **Figure 3-11** for the near-bed layer of the water column. It should be noted that this represents a worst case whereby all disposal activities have occurred in the model at a single release point and the potential for coalescence of subsequent depositional plumes is greatest. It can be seen that SSC values are elevated by the greatest amount at the release point (by up to several thousand mg/l), reducing to more typically a few hundred mg/l within a few km of the upstream and downstream boundaries. At the extremities of the plume extent, there are wide zones of relatively low SSC values (<100mg/l). It should be noted that in reality, subsequent disposals will be at different parts of the release site and so the zone of influence is likely to be slightly broader in width and shorter in length than shown in the worst case.

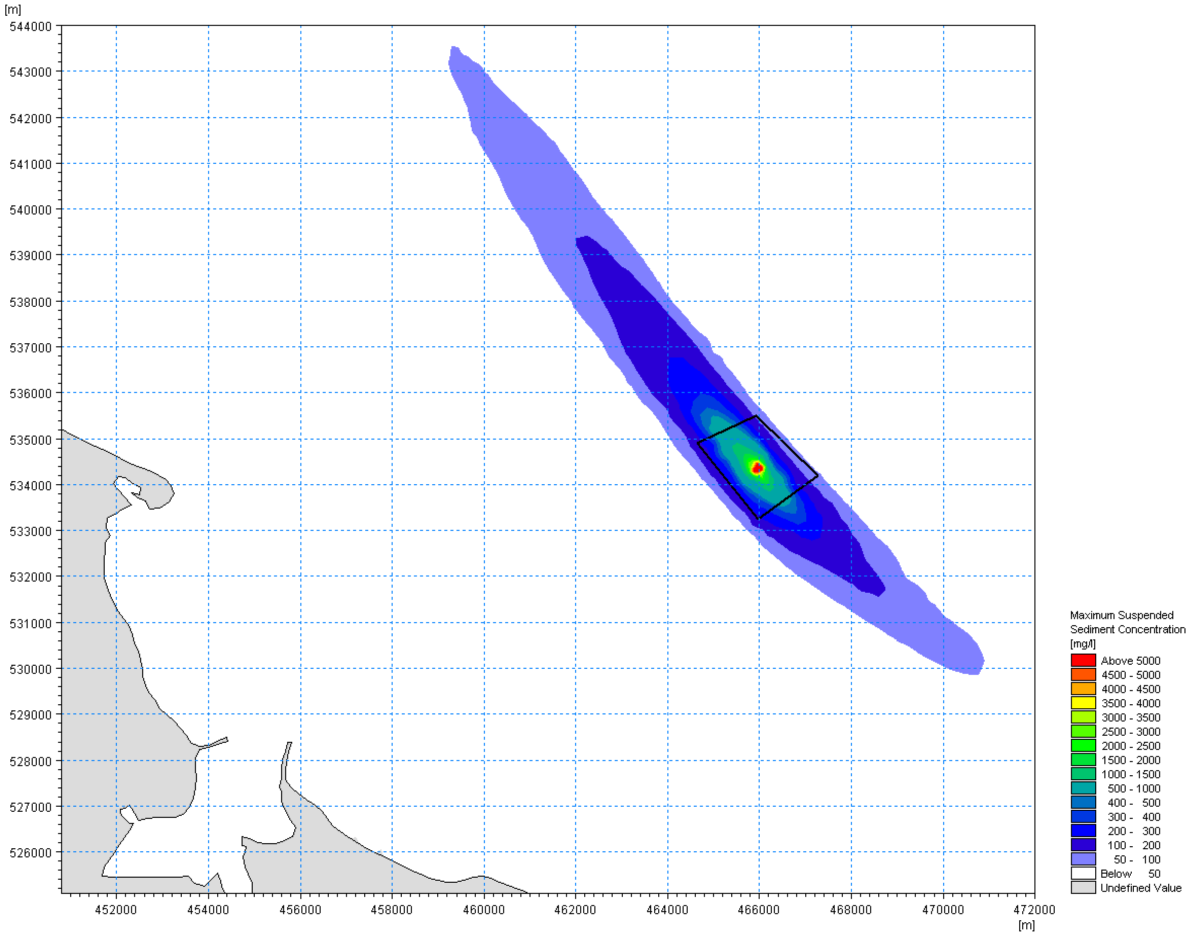

Figure 3-11 Maximum enhanced suspended sediment concentrations (near-bed layer) arising from disposal activities under the previously assessed project with all sediment release at the centre of the disposal site [Phases 1 and 2, reproduced from EIA Report]

For the proposed project variations to Phase 1 only, two scenarios have been modelled. For the first scenario, **Figure 3-12Error! Reference source not found.**shows the maximum 'zone of influence' for the near-bed layer of the water column from all disposals being made at a single central point. This scenario is directly comparable to that modelled for Phase 1 and 2 combined and shown in **Figure 3-11**. In keeping with the results for the river dredging, the updated modelling results show that both the magnitude and spatial extent of the arising maximum 'zone of influence' are considerably lesser than that arising from the previously assessed Phases 1 and 2 of the project. This is predominantly due to the lesser volume of material overall being disposed, the shorter overall disposal programme, a greater proportion of hard material which settles down through the water column quicker, and, for soft material, the barge contains a large quantity of water from the CSD. This means the discharge quantity of soft material by a barge is slightly smaller than previously by TSHD, even though the barge capacity is greater.

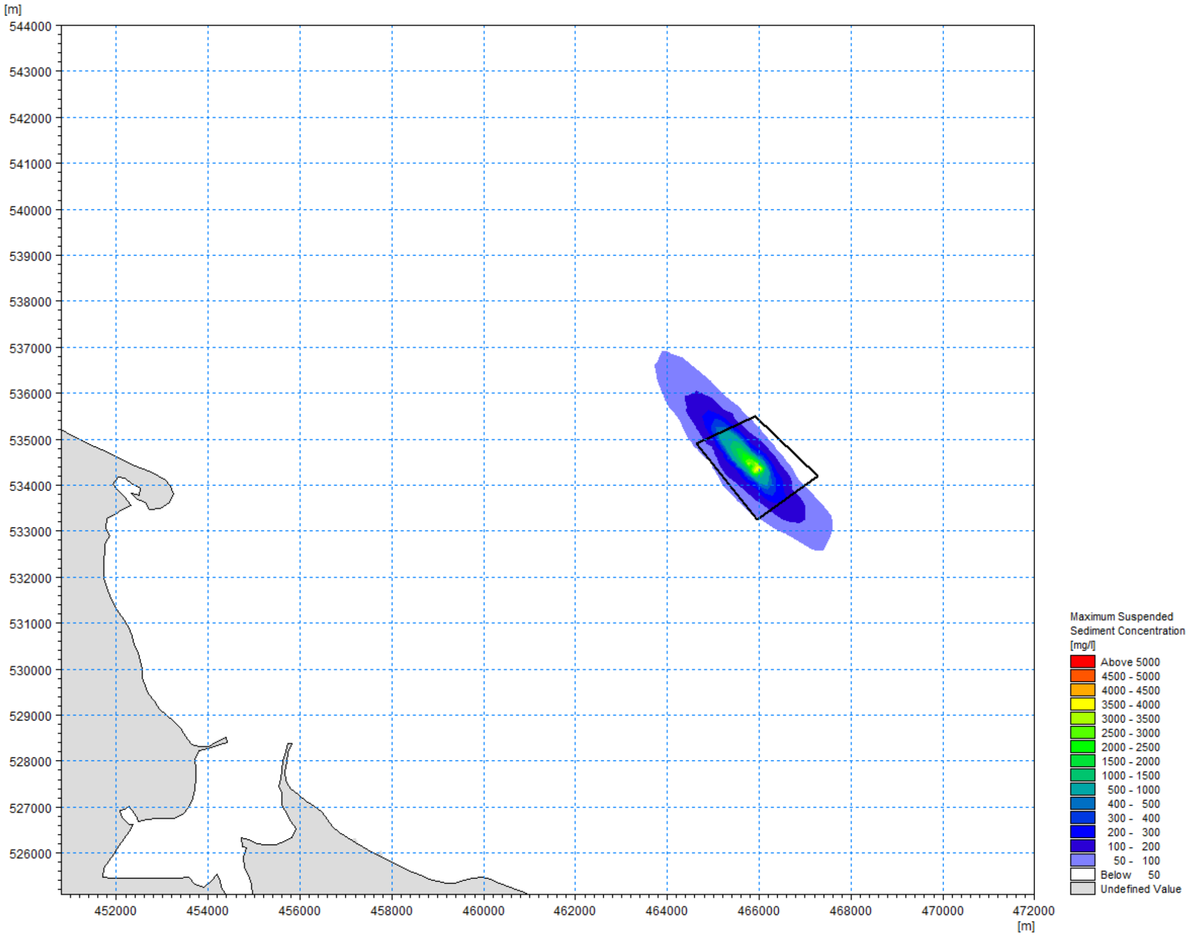

Figure 3-12 Maximum enhanced suspended sediment concentrations (near-bed layer) arising from disposal activities under the proposed project variation to Phase 1 with all sediment release at the centre of the disposal site [updated modelling]

Recognising that in reality it is unlikely all material will be deposited at a single point within the disposal site, a second scenario was modelled for Phase 1 only where the barges could discharge their loads anywhere within the disposal site, using a randomly generated release point within the disposal site for each visit. **Figure 3-13** shows the maximum 'zone of influence' for the near-bed layer of the water column from disposals being made under this random scenario. This produces a squatter, broader maximum 'zone of influence', with higher concentrations retained within the disposal site and lower concentrations spreading beyond its boundaries. Note that the occasional highest values (red zones) occur at times when a disposal activity coincides with high or low water, when tidal currents are slack.

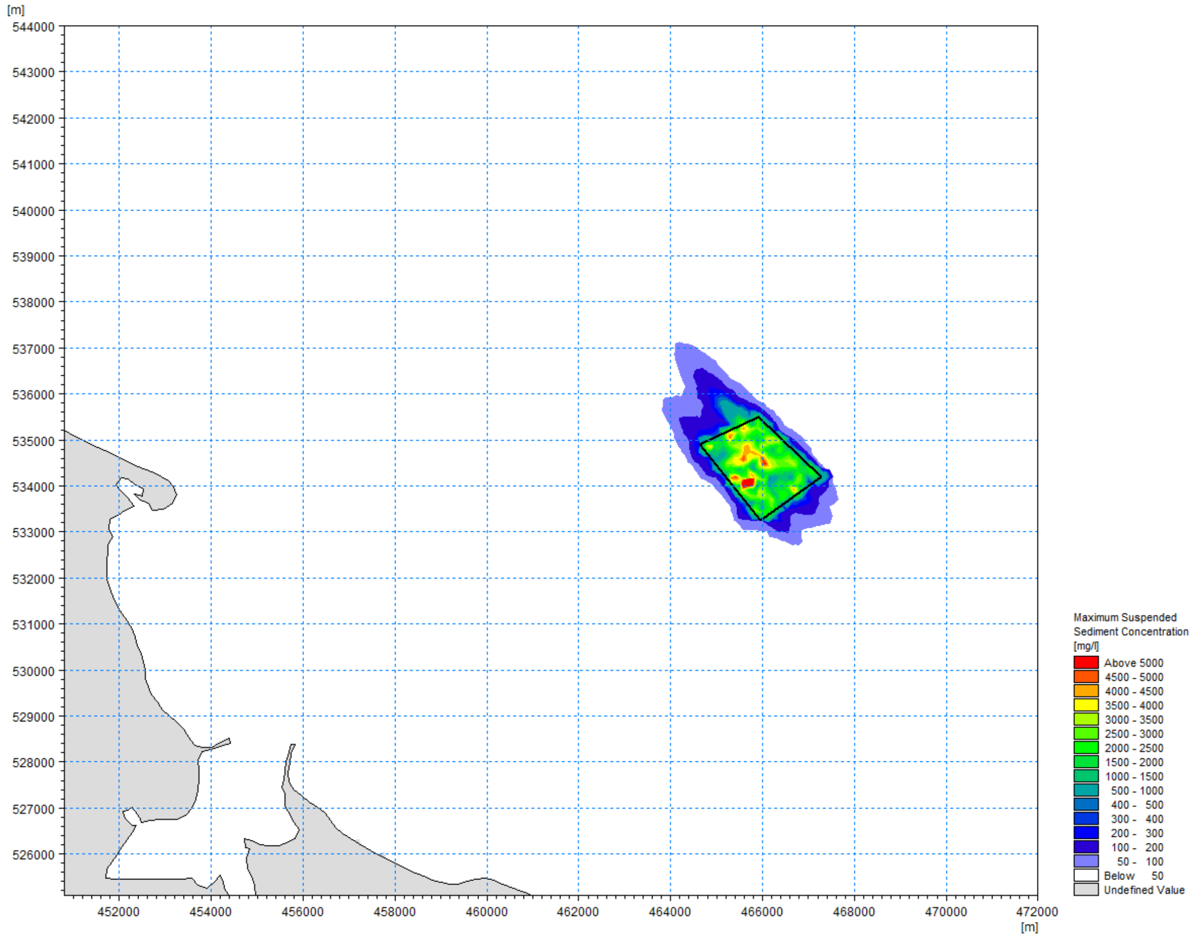

Figure 3-13 Maximum enhanced suspended sediment concentrations (near-bed layer) arising from disposal activities under the proposed project variation to Phase 1 with sediment release at random points within the disposal site [updated modelling]

Royal HaskoningDHV

For the previously assessed Phases 1 and 2 of the project, Error! Reference source not found.**Figure 3-14** shows the maximum changes in sea bed thickness caused by deposition of material from the sediment plume for the worst case considered (all material released at a single central point). It can be seen that much of the sediment falls to the bed within the disposal area, forming a mound on the sea bed. Deposition to the west and east of the disposal site is negligible, whilst to the south and north covers a similar zone to the sediment plume. In reality, disposals will be at different points within the licensed area, and so such a pronounced mound will not form and deposition on the sea bed to the north and south of the site will be much lower than this worst case.

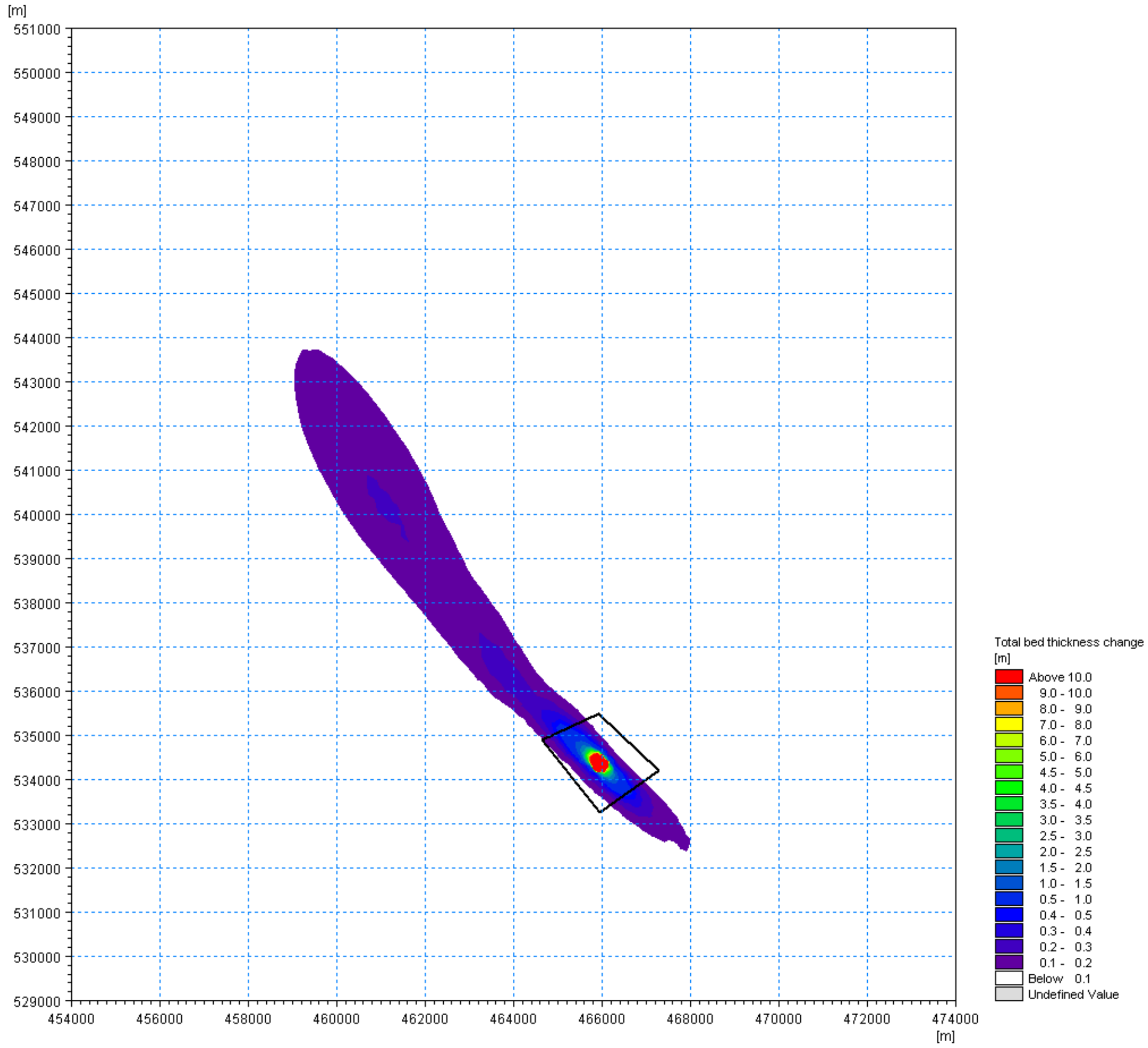

Figure 3-14 Maximum sea bed thickness change due to sediment deposition arising from disposal activities under the previously assessed project with all sediment release at the centre of the disposal site [Phases 1 and 2, reproduced from EIA Report]

For the first scenario modelled for the proposed project variations to Phase 1 only, Error! Reference source not found.Figure 3-15 shows the maximum sea bed thickness change from all disposals being made at a single central point. This scenario is directly comparable to that modelled for Phases 1 and 2 of the project and shown in **Figure 3-14**. In keeping with the results for the plume dispersion, the updated modelling results show that both the magnitude and spatial extent of the arising maximum 'zone of influence' for the proposed project variations to Phase 1 only are considerably less than that previously assessed for Phases 1 and 2 of the project, barely extending beyond the disposal site's boundaries.

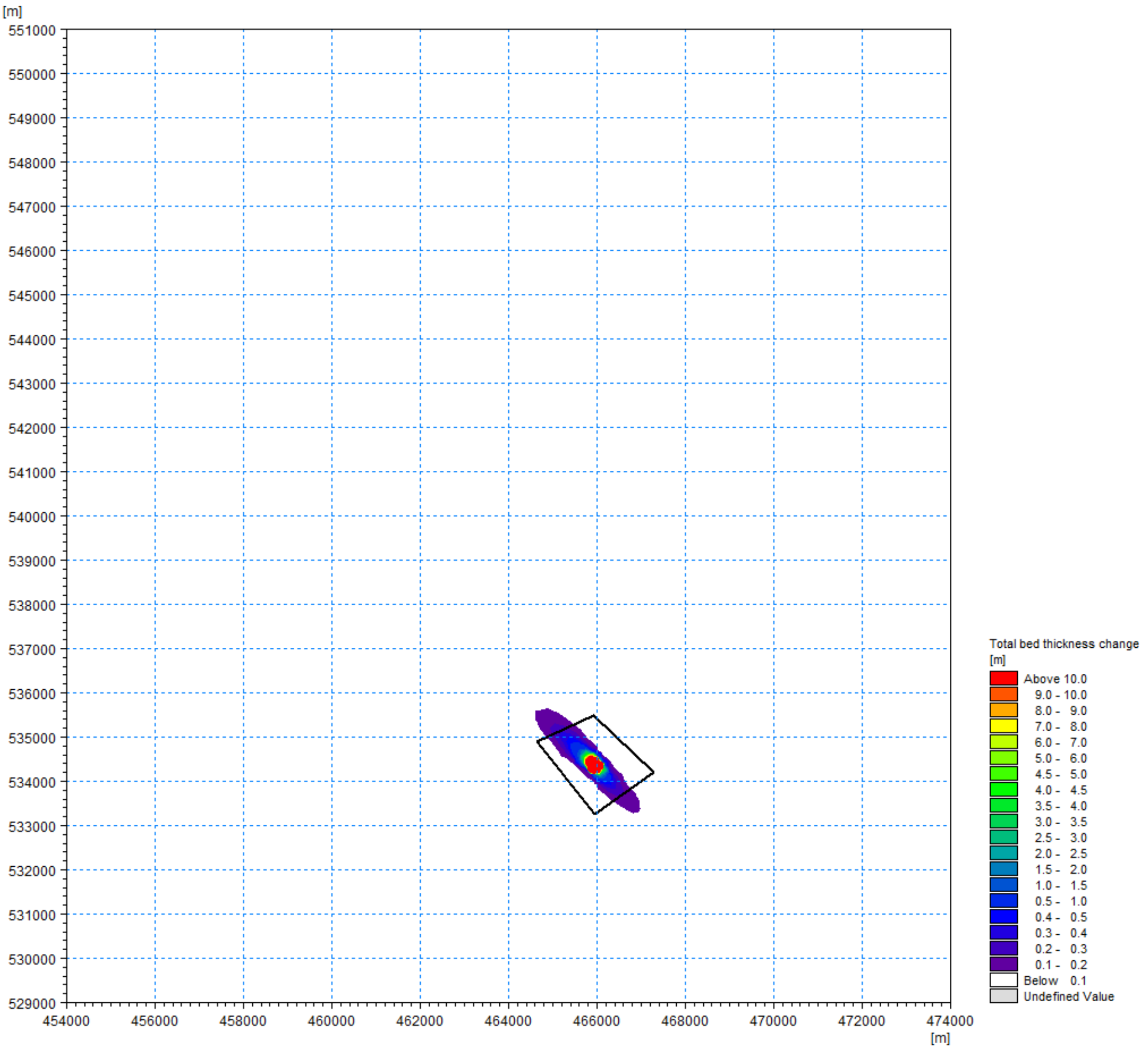

Figure 3-15 Maximum sea bed thickness change due to sediment deposition arising from disposal activities under the proposed project variation to Phase 1 with all sediment release at the centre of the disposal site [updated modelling]

For the second scenario modelled for the proposed project variations to Phase 1 only, **Figure 3-16** shows the maximum sea bed thickness change from random disposals within the offshore site. This produces a squatter, broader maximum effect, with modest change within and little change beyond the disposal site's boundaries.

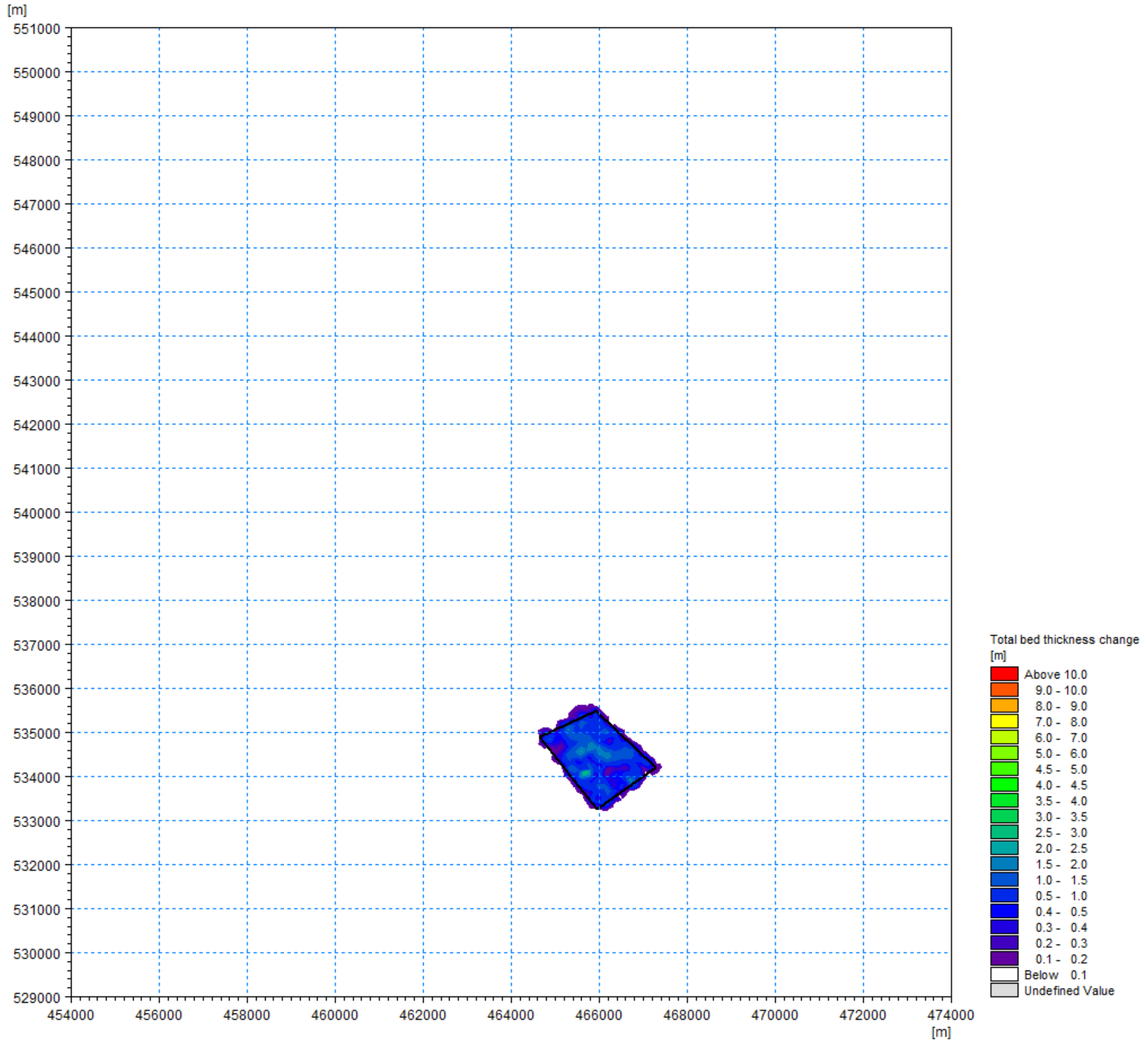

Figure 3-16 Maximum sea bed thickness change due to sediment deposition arising from disposal activities under the proposed project variation to Phase 1 with sediment release at random points within the disposal site [updated modelling]

3.7 Conclusion

The river dredging and offshore disposal activities associated with the proposed project variations will both cause plumes of sediment to form close to the release points of material into the water column. These plumes will disperse under wave and current action and all sediment particles suspended in the water column will ultimately settle to the river or sea bed, causing deposition. However, both the spatial extent and magnitude of effects under the proposed project variations to Phase 1 only are less than those previously assessed for Phases 1 and 2 of the project.

4 Wave Regime

The principal findings from the previous numerical wave modelling for Phase 1 and Phase 2 were:

- The South Bank Quay site is well sheltered from North Sea swell waves;
- Locally-generated waves under extreme wind are of more significance, reaching a height of 0.3m to 0.4m for a 1 in 1 year return period and 0.5m to 0.7m for a 1 in 100 year return period;
- There is no significant predicted effect from the project on local wind-generated waves at the site.

Full details were provided within **Chapter 6: Hydrodynamics and Sedimentary Processes** of the EIA Report and the accompanying **Appendix 5: Hydrodynamics and Sedimentary Plume Modelling** of the EIA Report.

In the updated assessments, proposed project variations to Phase 1 have been considered. Phase 1 would affect a smaller footprint of the river channel compared with the previous assessments for Phases 1 and 2 combined, so any such effects from dredging on the tidal regime during Phase 1 would be lesser than those previously assessed. Also the very slight change in extent of dredging within the turning area from a semi-circular to semi-trapezoidal shape is not deemed at all significant. For these reasons, no updated numerical wave modelling has been undertaken.