TRANSNET SOC LTD

FEASIBILITY STUDY (FEL 3) FOR THE DEEPENING OF BERTHS 203 TO 205

PORT OF DURBAN

DREDGING TURBIDITY AND PHYSICAL IMPACT STUDY

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1.0 EXECUTIVE SUMMARY

This report forms part of a FEL 3 Study (Contract No TCP CON-041-2011-005) that has been undertaken by ZAA Engineering Projects and Naval Architecture (Pty) Ltd (ZAA), relating to the Deepening and Refurbishment of Berths 203 to 205 in the Port of Durban Container Terminal. It has been proposed to extend the cope edge of these berths to enable their deepening, in order to accept Post Panamax container vessels up to 12,000 TEU (fully laden) and 14,000 TEU (partially laden). Refer to Figure 1.

The proposed works require dredging and dumping operations to be performed both inside and outside the Port of Durban. An assessment has been undertaken to determine whether these operations may have an impact on the ecosystem due to increased turbidity (suspended solids) and the associated smothering of seafloor benthos due to settlement. Furthermore, the impact of localized bathymetric changes and resulting wave patterns on beach stability has been assessed.

The dredging design has been optimized to minimize both the impact on the central sandbank and the dredging volumes. Various alternatives that have been considered are shown graphically in Annexure 2. The final selected layout is Option 3-H which resulted from the Ship Navigation Simulation studies. This is very similar to options 3-D, 3-E, 3-F and 3-G, apart from very minor changes in toe slope along the sandbank adjacent to the mooring basin at Pier 2 and an extension of the turning area northwards along Berth O of the T-Jetty. A number of iterations have been performed to optimize the extended sandbank geometry in order to obtain zero loss of marine habitat. These alternatives all minimize the dredging volumes and further offer the opportunity to extend the central sand bank, should this be considered environmentally advantageous (Options 3-D to 3-H). Note that Option 3-D is identical to Option 3-C, except for the extension of the Central Sandbank.

It should also be noted that a substantial separate exercise has been carried out to establish areas within the basin where materials are suitable for reclamation of the central sandbank. This will result in direct transfer of dredged material from basin dredging to the sandbank and thus reduce the amount of material to be dumped out to sea or reclaimed from the borrow site. This report takes the most conservative view and is based on the full volumes being dumped out to sea and subsequently reclaimed.

Details of hydrodynamic simulations to assess the possible extent of turbidity plumes are explained. A numerical model has been set up using the Delft3D suite of tools to simulate the interaction between the following processes:

- Water level variation due to tides
- Flow patterns within the port
- Wind and waves

The approach adopted in the study has been to compare the conditions at and near the seabed before, during and after completion of the works, including:

- Dredging in the harbour and offshore
- Offshore disposal
- Construction of new quay structures and scour protection

Bed shear stresses and suspended solids concentrations have been used to evaluate the hydrodynamic impacts during and after completion of the works, compared with the present conditions.

The results of the study indicate that there will be no significant negative impacts during or after completion of the works, either to the main sandbank within the Port or to the beaches and coastline outside the Port, compared to the status quo.

It is concluded that special dredging equipment or procedures will not be required to reduce turbidity levels. It is anticipated that turbidity levels during and after dredging and dumping will be less than accepted medium to low risk levels. Turbidity monitoring will be undertaken during the dredging and dumping processes to ensure that specified safe limits are not exceeded.

Figure 1 : **Port of Durban Pier 2 : Proposed Deepening of Berths 203 to 205**

(Option 3-H including proposed Central Sandbank Extension)

Figure 2a : **Port of Durban Pier 2 : Proposed Deepening of Berths 203 to 205**
(Option 3-H including proposed Central Sandbank Extension)

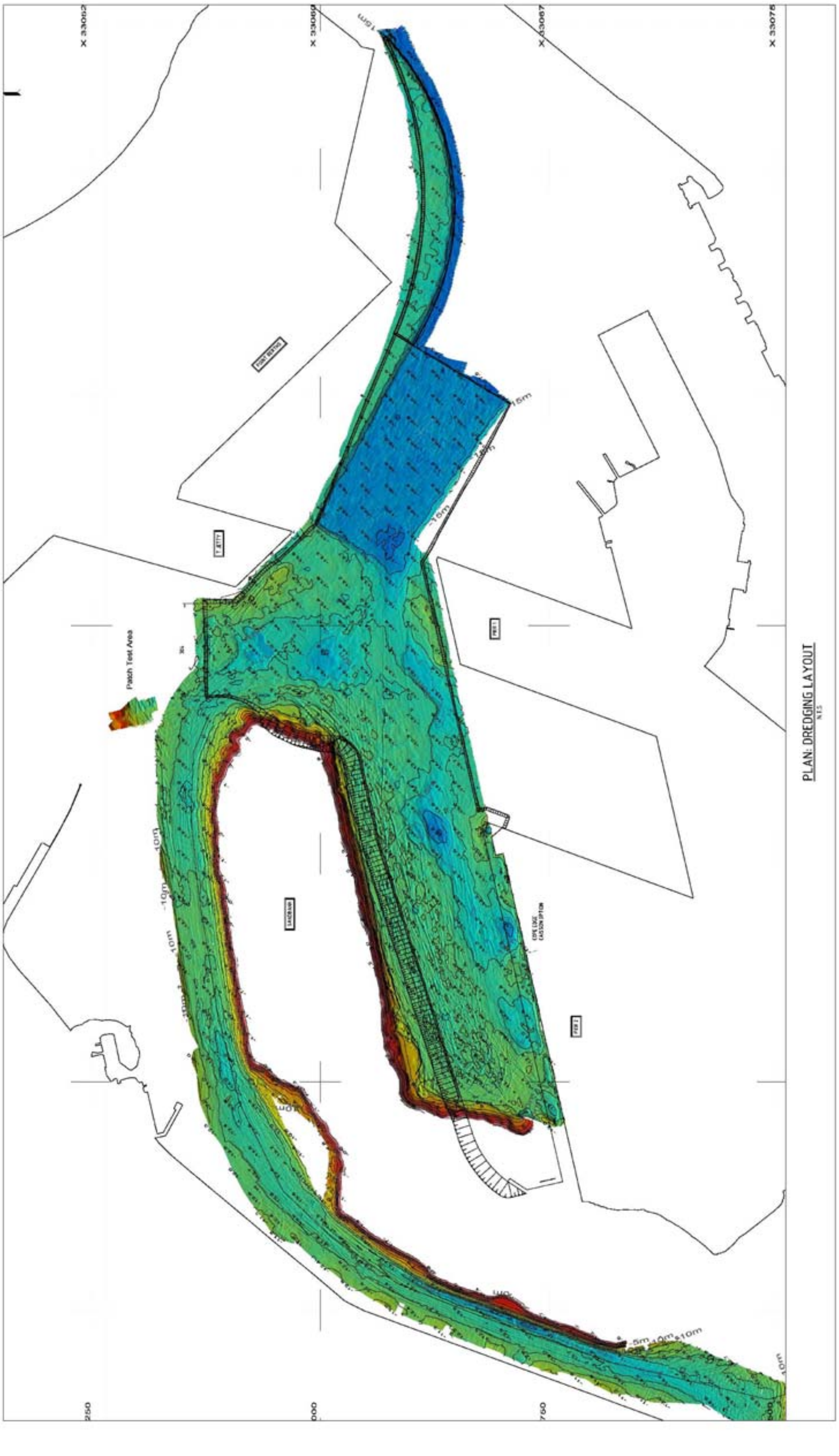


Figure 2b : **Port of Durban Pier 2 : Proposed Deepening of Berths 203 to 205 (Option 3-G including proposed Central Sandbank Extension)**

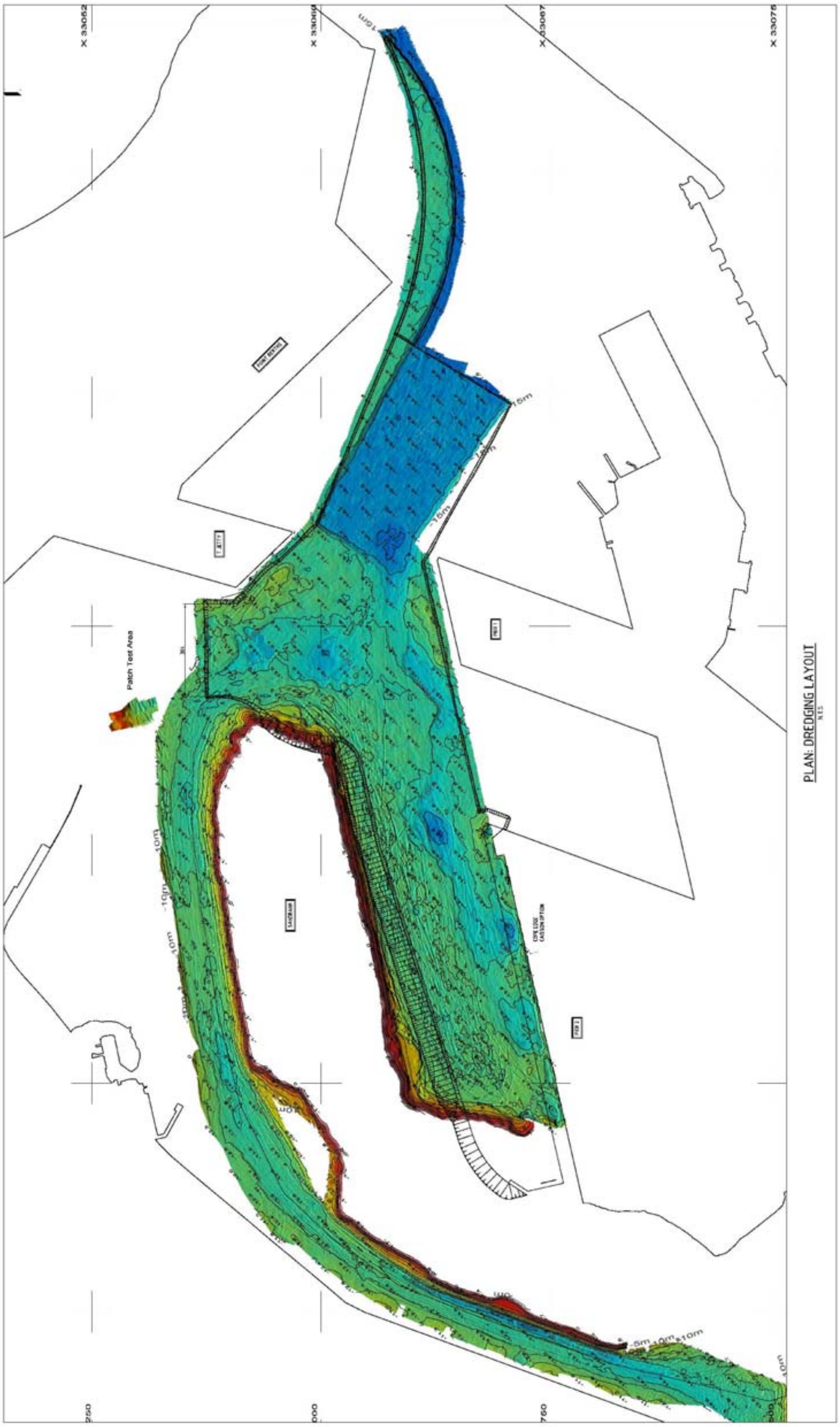


Figure 2c : **Port of Durban Pier 2 : Proposed Deepening of Berths 203 to 205 (Option 3-F including proposed Central Sandbank Extension**

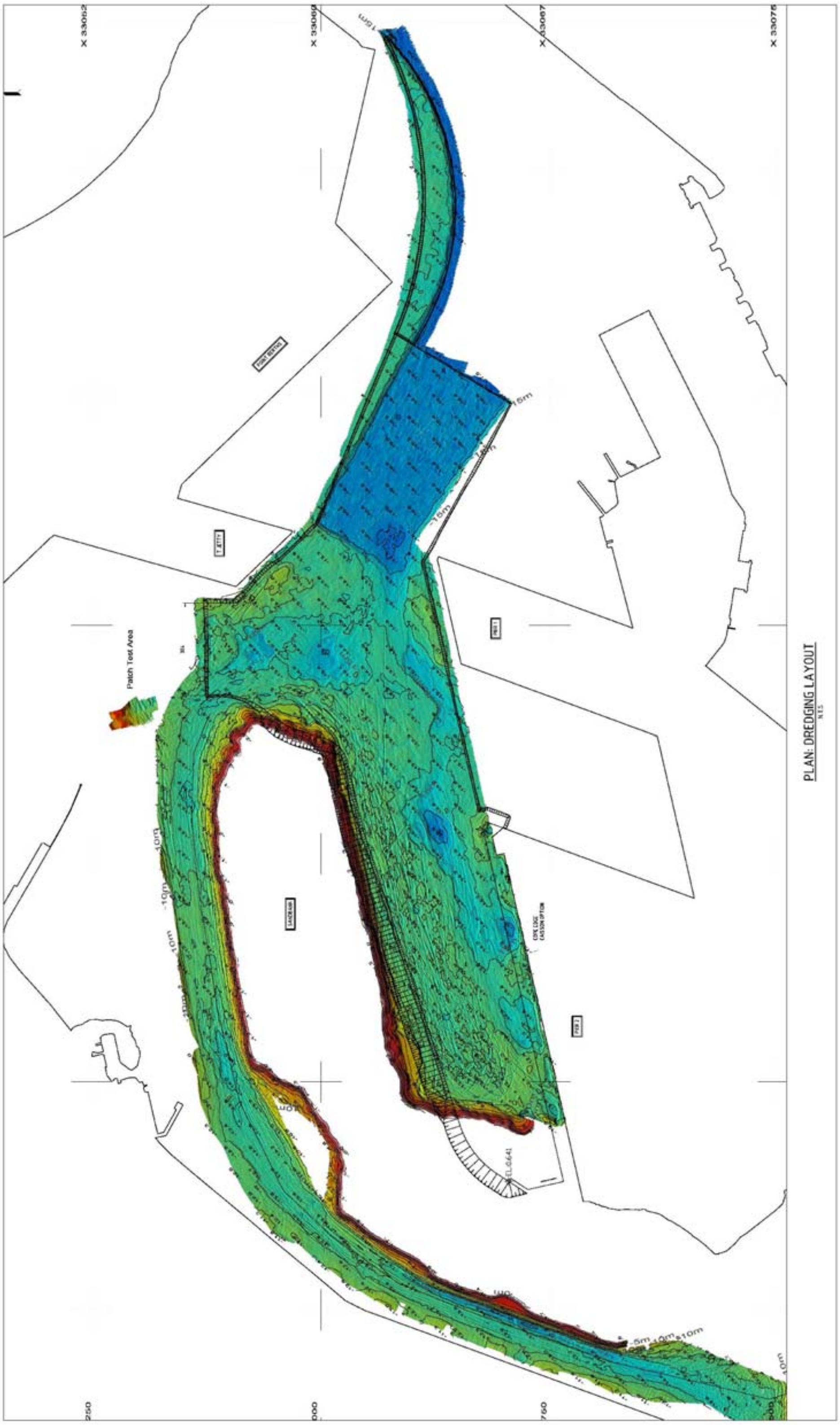


Figure 2d : **Port of Durban Pier 2 : Proposed Deepening of Berths 203 to 205 (Option 3-E including proposed Central Sandbank Extension**

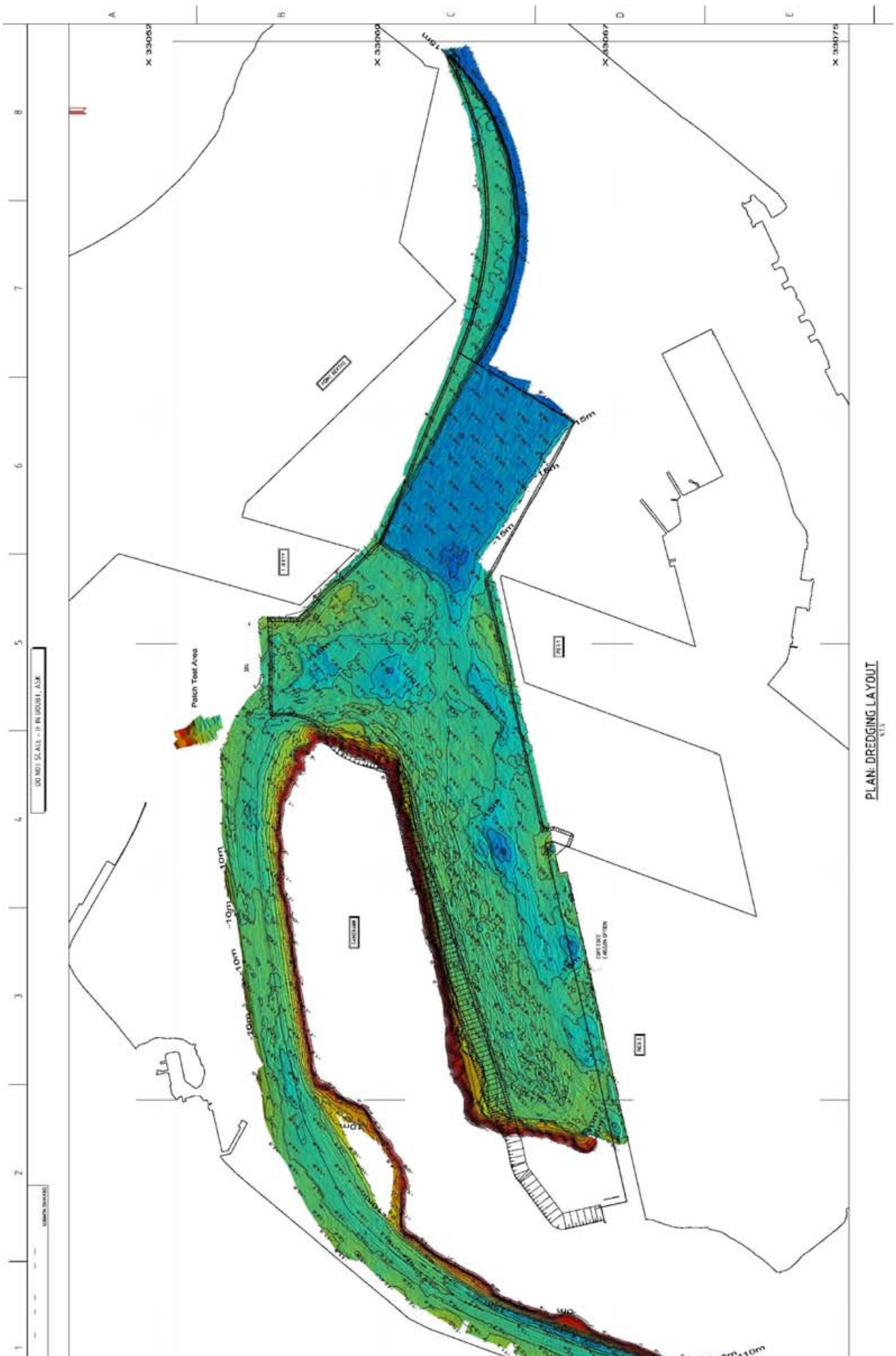


Figure 2e Option 3-D (Central Sandbank Proposed Extension infill shown in Figures 1 and 2g)

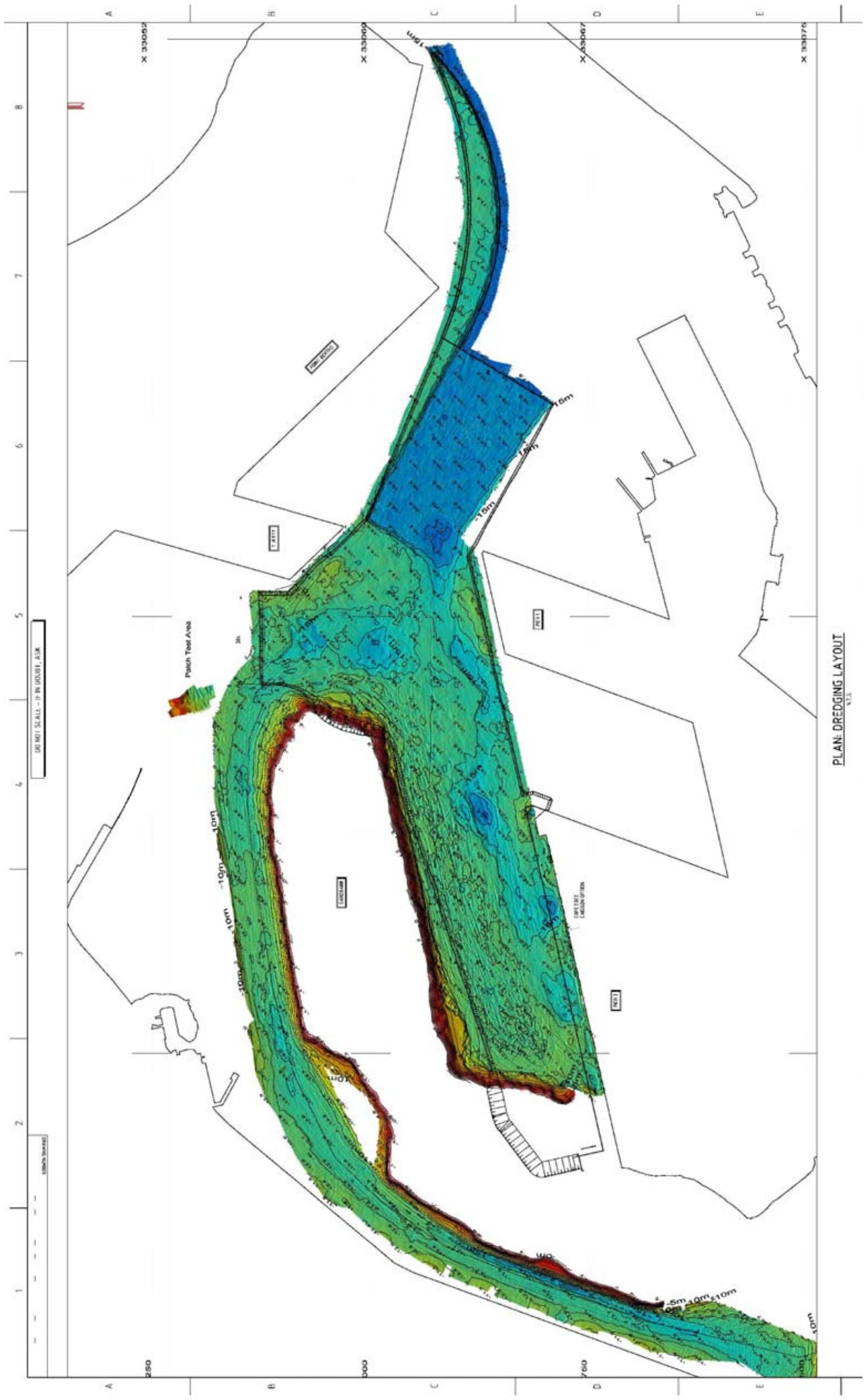


Figure 2f Option 3-C

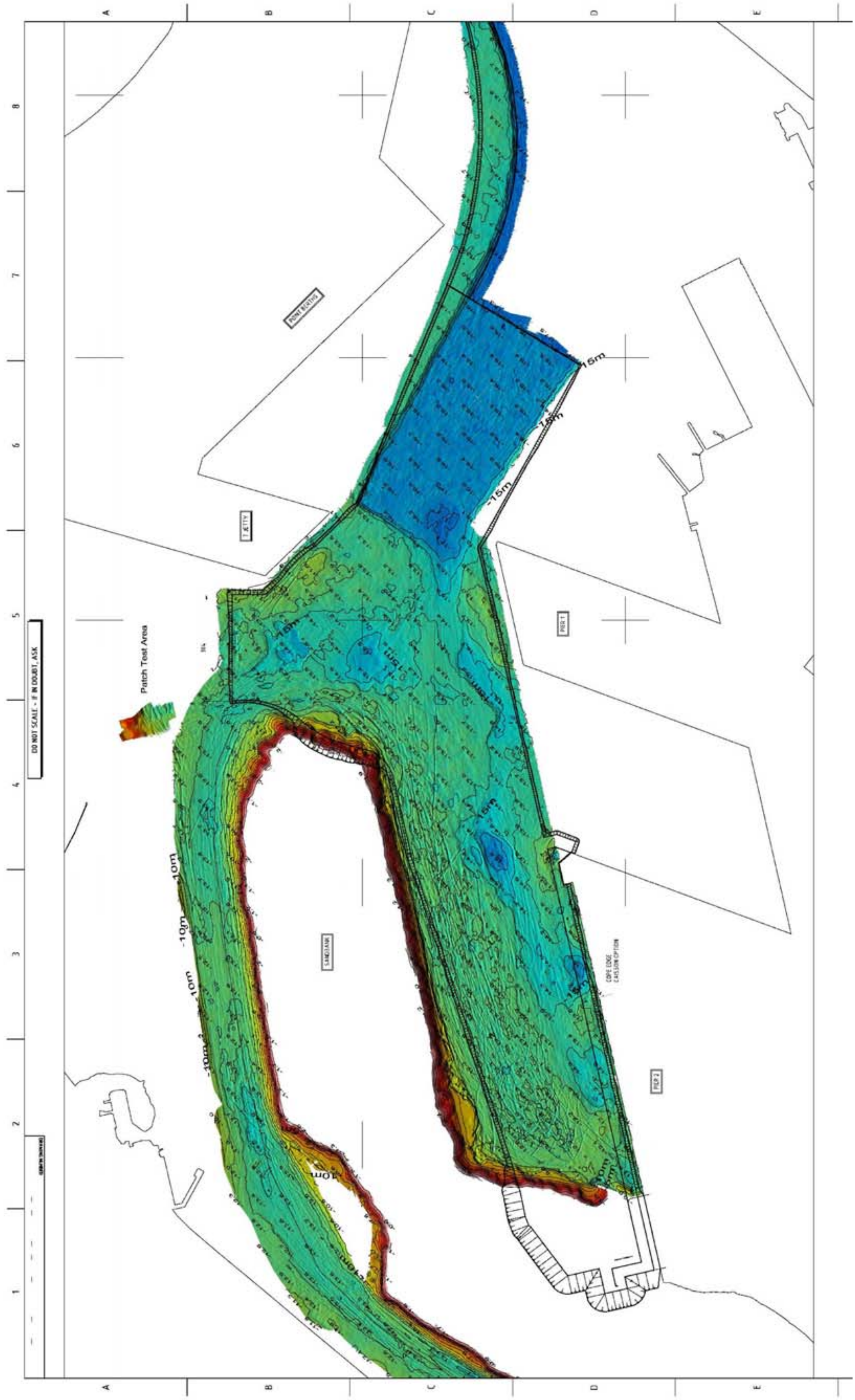


Figure 2g Option 3-B

Figure 2h Option 3-H (Central Sandbank Proposed Extension infill shown in red shading)

2.0 INTRODUCTION

2.1 General

This report forms part of the Work Pack CTR-08 – Turbidity Study, the outcome of which will feed into the Environmental Impact Assessment.

2.2 Scope

The extent of the Scope of Work performed is as follows:

- Definition of physical and numerical parameters related to hydrodynamic and sediment transport models
- Definition of 3D computational grids using latest bathymetric surveys
- Definition of boundary conditions used based on environmental records
- Analysis and interpretation of simulation results
- Deliverables are:
  - Dredging turbidity and physical impact study report
  - Plume dispersion assessment inside and outside port
  - Shoreline stability assessment due to offshore dredging and dumping
  - Main sandbank wave energy and erosion assessment
  - Recommendations regarding chosen dredging operations.

2.3 Reference Documents

This document should be read in conjunction with the following documents:

- Report 1370-RPT-003 (CTR-07) - *Safety of Structures to Dredging*.
- Report 1370-RPT-004 (CTR-13) – *Dredging Design and Survey*.
- Report 1370-RPT-006 – *Assessment of Alternative Design Options*
- Report 1370-RPT-007 (CTR-06) – *Slope Protection Study*

2.4 Bathymetric Surveys within the Port and at the Offshore Disposal Site

A full bathymetric survey has been commissioned and undertaken by Underwater Surveys. The data from this work is of very high quality at a 0,5 m grid and covers Berths 203 to 205, the turning basin as well as the Esplanade Channel, Maydon Channel and the Lot 10 Launching Dock, as shown on UWS Drawing 12-016-ZAA-HBR-BATHY-CD-DCT1370 Chart 1 of 2. It is included in Annexure 1. The offshore borrow area is shown on Chart 2 of the above drawing and in Figure 3 (Existing Disposal Site) of this report. The sand winning site, borrow Area-1, is shown in Figure 4 of this report.

Revised dredging quantities resulting from this survey and the optimized design of the channel and mooring and turning basins have been calculated and summarized in Section 3.

2.5 Optimization of Dredge Quantities

Various ship simulations carried out and reported in Ref. (11) were initially assessed and data from the further programme of simulations carried out by ZAA as part of this project have been examined. The dredging design has been optimized to minimize both the impact on the central sandbank and the dredging quantities. The various alternatives considered are shown in Annexure 2. Option 3-H in Figure 2 has been selected as the preferred alternative as it offers the opportunity of extending the central sandbank and reduces the total loss of sandbank habitat to zero percent.

2.6 Offshore Disposal Site

The dredged spoil will be dumped at the existing licensed offshore disposal site (Figure 3). This is approximately 5 km offshore at its center point and is about 3,5 km x 2,75 km in extent. The seabed in this area varies from -50 m to -100 m PCD water depth. A proposed new disposal site also shown in Figure 3 has not been approved.

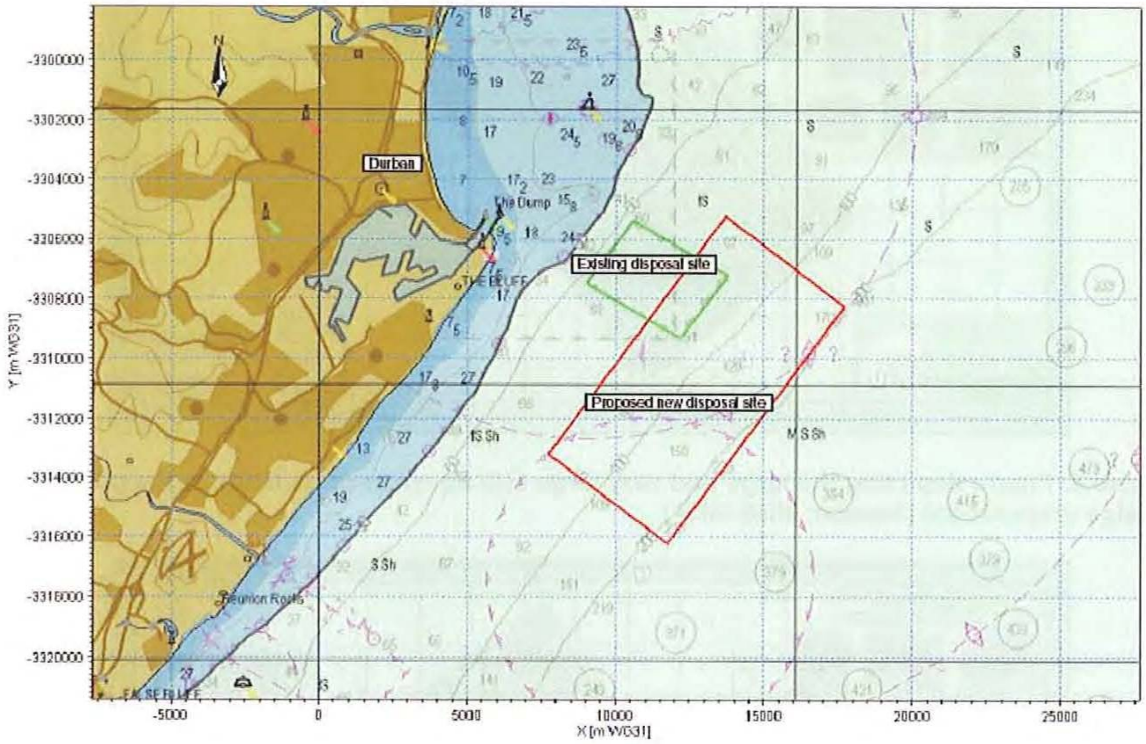


Figure 3 – Existing Dredge Spoil Disposal Site
(Note that the site shown as 'Proposed new disposal site' has not been approved)

2.7 Offshore Sand Winning (Borrow) Site

The current licensed offshore borrow sites are shown in Figure 4. Area-1 (Northern Portion) is the selected area for this project.

The material from the borrow site will be used for backfill behind the new quay wall. The volume that will be dredged is approximately 1 100 000 m^3.

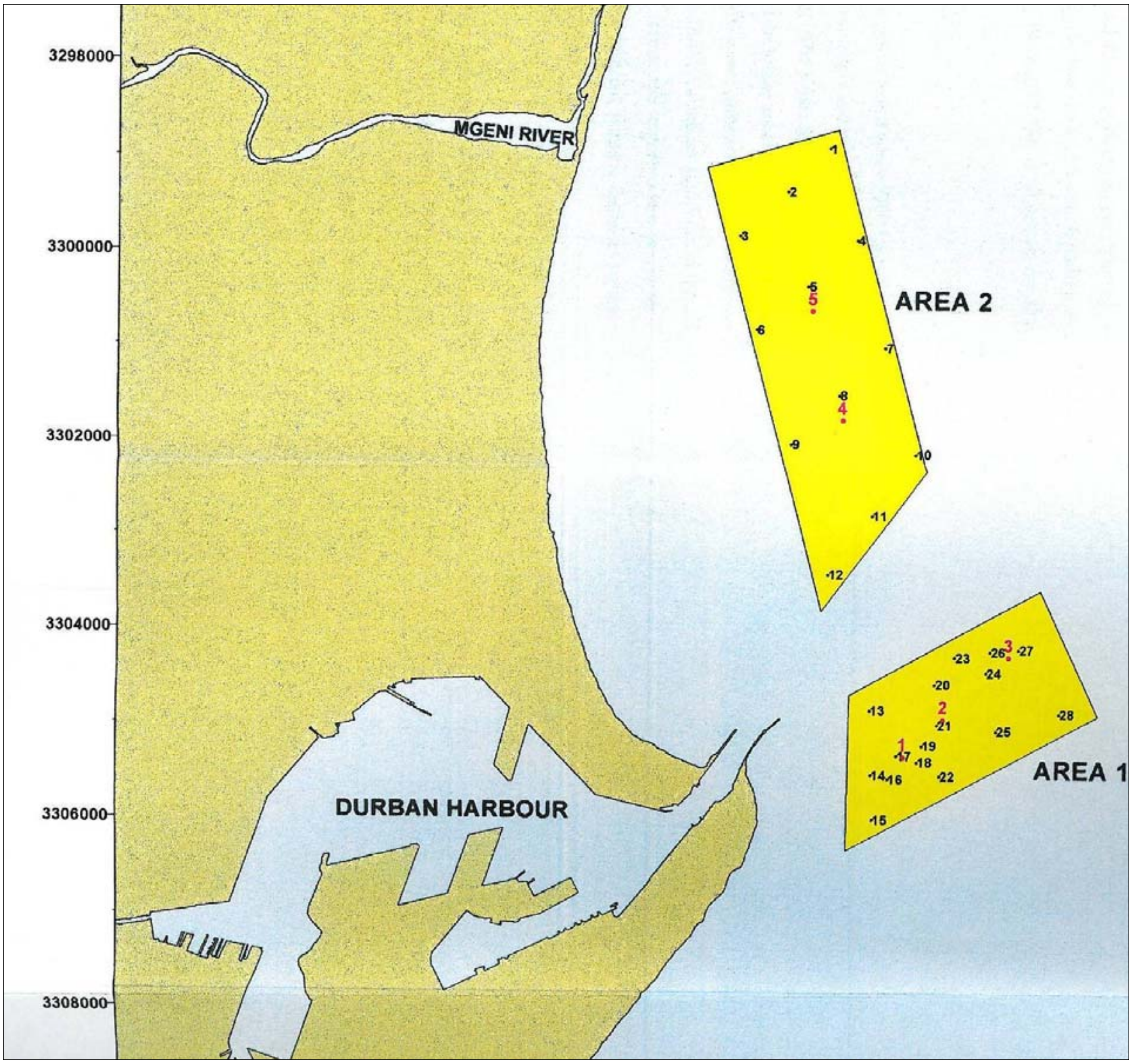


Figure 4 – Offshore Borrow Area-1 Location

3.0 PROJECT DESCRIPTION

3.1 General

ZAA Engineering Projects and Naval Architecture (Pty) Ltd has been appointed under Contract No TCP CON-041-2011-005 to carry out a Feasibility Study for the Deepening of Berths 203 to 205 in the Port of Durban. It has been proposed to deepen container Berths 203, 204 and 205 in order to accommodate Post Panamax vessels up to 12000 TEU (fully laden) and 14000 TEU (partially laden). For this study it is assumed that these berths would be extended seaward by approximately 50m, with an increase in berth depth to -16.5mCDP (Chart Datum Port).

3.2 Dredging Extent and Quantities

Dredge quantities derived from the existing bathymetric data is as follows (Refer Drawing 1370-DWG-1700)

TABLE 1: DREDGING QUANTITIES

Area	Depth	Location	Total m^3	Clay m^3	Sand m^3
1a	-17.0 m	Entrance Channel Widening	237 900	1 600	236 300
2a	-16.5 m	Basin: Pier 1, Pier 2 & T-Jetty	4,028,418	622,051	3,406,367
		Totals	4,266,318	623,651	3,642,667

3.3 Dredging-Offshore Dumping Operations

Details of dredger types are given in *ZAA 1370-RPT-004 Dredging Design and Survey*. To summarize, it has been assumed that dredging will be carried out by Trailing Suction Hopper Dredgers (TSHD) with hopper capacities that may vary from 2 700 m^3 to 6 200 m^3, or a combination of TSHD and Cutter Suction Dredgers (CSD).

Based on an assumed average dredging rate of 90 000m^3/week and 90% efficiency, the average dredging rate has been calculated at 0.165 m^3/s. However, the peak dredging rate has been assumed to occur using a 6 200 m^3 hopper filled in 60 minutes, giving a peak rate of 1.722 m^3/s. The dredging-dumping cycle is scheduled to work on a period of approximately four to five hours. Two scenarios have therefore been modeled to provide an envelope of probable turbidity:

- Continuous dredging at an average rate 0.165 m^3/s
- Intermittent peak dredging for one hour on a four hour cycle at a rate 1.722 m^3/s.

Offshore dredging-dumping operations consist of sand dredging at the borrow site and dumping of dredged silt, sand and clay material at the nearby disposal site. Dumping has been modeled at the disposal site at intervals of four hours, lasting an average of 15 minutes.

The following parameters have been applied for the dredging and dumping operations:

Dredger types:	Trailing Suction Hopper and Cutter suction dredger
Average dredging rate:	0.165 m^3/s
Peak dredging rate:	1.722 m^3/s
Hopper Capacity	2700 m^3 to 6200 m^3
Average Dumping time:	15 minutes
Dredging-Dumping Cycle time:	4 hours

4.0 ENVIRONMENTAL CONSIDERATIONS

4.1 Shoreline Stability Impacts Due to Changes in Wave Energy

Increased beach erosion may be associated with interruptions in the natural sediment transport regime and wave focusing for instance, due to local changes in the bathymetry. Much like installing an artificial reef system to improve surf conditions, dumping large volumes of dredged sediment offshore may result in larger than normal waves under certain wind or current conditions. It has been estimated that the level of the offshore dredge disposal site may increase by up to 0.5m. One of the main purposes of this study is to ascertain whether any significant impact would result because of this change in the bathymetry.

Similarly, it has been approximated that the increase in depth over the entire borrow site could be kept to around 0.2m if dredged uniformly. This change has been applied together with the raising at the disposal site during the post construction scenarios.

A number of observation points have been set up in the hydrodynamic model at which bottom shear stresses are monitored. Comparing pre- and post -construction scenarios, an increase in calculated bottom shear stresses would indicate obvious increase in erosion. The presence of any long shore current ensures removal of suspended solids, resulting in possible build-up elsewhere.

It is however accepted that a “stable” beach profile may vary from time to time. This is a factor to keep in mind during interpretation of simulation results. Significant variations should be assessed for possible further investigation.

The main sandbank in the Port of Durban is considered an environmentally sensitive area and is particularly scrutinized. The sandbank is a highly dynamic structure within the Port and would be sensitive to abrupt changes in flow patterns around it causing it to quickly adjust its shape. Care is to be taken that current patterns are not excessively disrupted causing the sandbank to migrate into shipping lanes and increasing maintenance dredging requirements.

4.2 Turbidity Due to Dredging and Dumping

Turbidity refers to the optical properties of water. Total Suspended Solids (TSS) is a major quantity affecting turbidity. TSS is a measurement of the dry weight mass of non-dissolved solids suspended in water and may be organic or inorganic.

Sedimentation rates above the norm, within ecologically sensitive or rich areas endanger the benthos (seafloor inhabitants) by covering them at a rate higher than they are able to adapt naturally to, literally smothering many forms of life. Fine suspended particles may also damage sensitive gill structures of organisms or interfere with particle feeding.

Significant and sustained turbidity also leads to reduction of light penetration, negatively affecting those organisms relying on light either for photo-synthesis or sight.

Excessive release of suspended solids within the Port may cause water depth reductions in navigation channels due to settlement in areas of low flow velocity.

Through monitoring and assessing the movement and dispersion of sediments plumes, conclusions may be drawn as to the severity and possible impacts on the environment.

Mitigating severe turbidity and TSS issues may be in the form of implementing special dredging technologies, timing dredging operations with tides or other environmental variables, or limiting operations during certain periods such as spawning seasons to protect marine life.

It is noted that coral reefs and oyster beds are particularly sensitive to turbidity and the presence of these features require special attention.

In previous studies by Steffani et al (2003), proposed guidelines for suspended solids in the vicinity of ecologically sensitive areas are given as follows:

- Low risk: < 20mg/l (<0.02kg/m³)
- Medium risk, permissible for short periods: 20-80mg/l (0.02-0.08kg/m³)
- Unacceptable risk, requiring mitigation: >80mg/l (>0.08kg/m³)

It should be noted that these guidelines were applicable to the coastline of the southwestern Cape, but they are assumed to be equally appropriate for the study area. According to South African Marine Water Quality Guidelines, suspended sediment concentrations should be less than 20 mg/litre for a low risk scenario with respect to feeding of oysters and Department of Water Affairs (1995, Ref (11)) reported that prawns prefer 2 to 14 mg / litre.

5.0 NUMERICAL MODEL AND SIMULATION

5.1 Introduction

The Delft3D suite of hydrodynamic and sediment transport calculation tools have been used to model and simulate various scenarios around the Port of Durban.

Numerical models of coastal processes contain concepts regarding hydraulics, waves, currents and sediment transport that are captured in mathematical formulations. At best, these models may aid to quantify certain processes and help in understanding the complex interaction between different processes.

The purpose of this model is not to create a virtual reality by including every possible process and detail. Rather, a “realistic analogue” of the problem is created where only chosen processes and their effects are investigated in relative isolation.

Coastal processes such as the ones active around the entrance of the Port of Durban are notoriously complex to model. Inshore currents oppose the southward flowing Agulhas current in the form of an eddy that meanders, causing irregular current reversal along the coast. An alternative approach is to use actual tidal input combined with realistic wind and wave parameters in a model large enough to find its own equilibrium.

Figures 5 to 7 indicate the extent of the model grid.

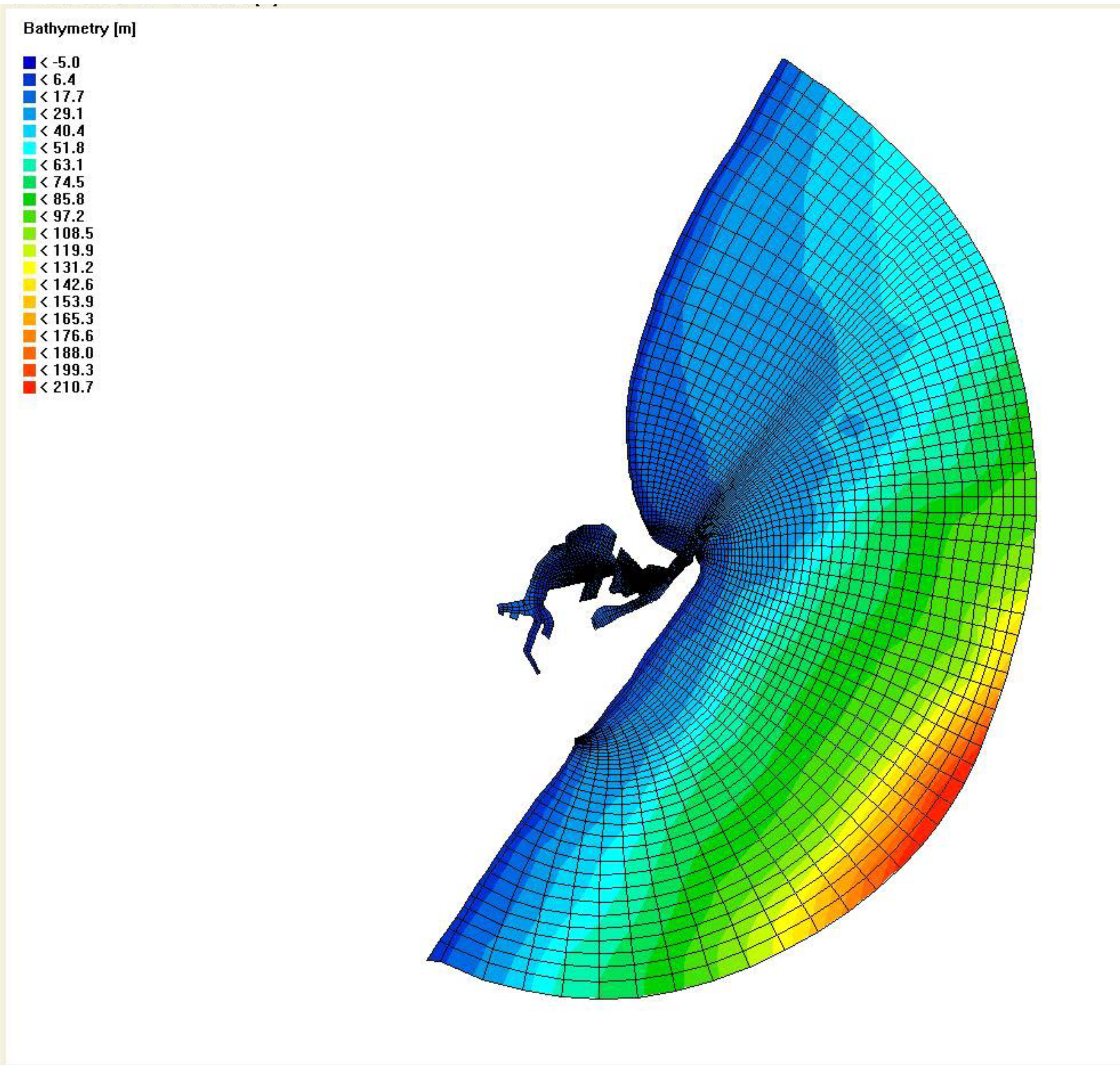


Figure 5: Overall Grid Showing Bathymetry and Boundary.

5.2 Modelling Approach and Assumptions

A comparative simulation approach has been adopted for this study. The seabed states before and after the proposed construction and dredging works are subject to identical wind and wave scenarios. Bed shear stress and suspended solids concentration are the principal components used for evaluating hydrodynamic impacts at predetermined observation points.

The approach adopted is based on Ref (12). Critical bed shear stresses have been assessed in terms of levels reported in Refs (13) and (14).

Certain assumptions have been made during the definition of input parameters, in the absence of detailed analyses on sediment samples and seabed processes. Estimated particle settling velocities, critical shear stresses, erosion and bottom friction parameters are used based on various previous studies performed in Durban and Richards Bay and Refs (13) and (14). A precedent for such assumptions has been set in these studies and they are considered acceptable for use in a comparative study at feasibility level.

5.3 Model Description

Hydrodynamic simulations have been performed using the Delft3D suite of tools. A single curvilinear grid has been employed by both Delft3D-FLOW and Delft3D-WAVE in a series of coupled analyses to account for tidal, wind and wave effects.

The modeled computational grid is curvilinear and orthogonal in horizontal space, with five layers in the vertical space from free surface to seabed.

Time periods considered include three (3) day periods either side of a spring high/low and a neap high/low tidal cycle. Tidal forcing at the model boundary has been input as time series corresponding to the month of January 2010. Wind and wave scatter diagrams constructed from hindcast data has been used to set up a number of scenarios representing the prevalent conditions.

It can be seen from records that the prevalent wave condition is a south southeasterly swell of around 2m in height and a period of 9 seconds. Values of 3 m and 10 seconds have been applied in the simulations. Two predominant wind directions, north northeast and south southwest, are applied.

During the pre-construction scenarios, discharges are activated to simulate the release of dredging plumes near Berth 205 and at the borrow site (sand winning for backfill works). During the post construction scenarios, dumping at the disposal site is simulated by four (4) hourly discharges of dredged material, assuming certain fractions descend directly to the sea bottom and others are lost in suspension.

5.4 Input Parameters

5.4.1 Bathymetry

Bathymetry input has been based on various survey datasets obtained from the Harbour Mouth Widening Project (PRDW), recently commissioned Underwater Surveys data, and the South African Naval Hydrographic Charts.

Bathymetry for the pre-construction scenarios is based on the current state while the post-construction scenario bathymetry has been modified to include deepening of the container Berths 203 to 205, turning circle in the approaches to those berths and a widening of the existing access channel. Offshore changes to the bathymetry for the post-construction scenario include deepening of the borrow site by 0.2m and raising of the disposal site by 0.5m.

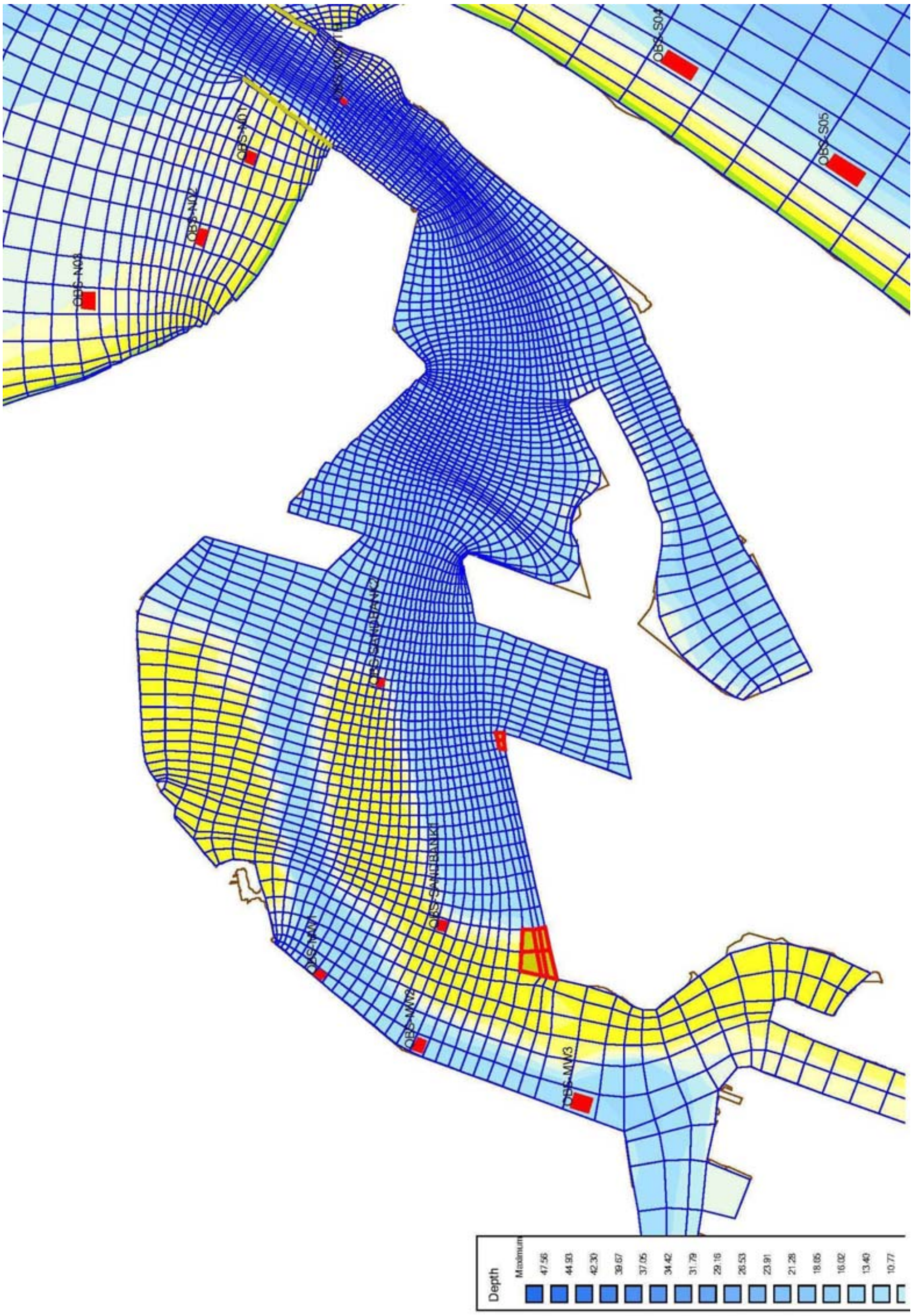


Figure 6: Detail of Harbour Grid and Bathymetry for Pre Construction Scenarios

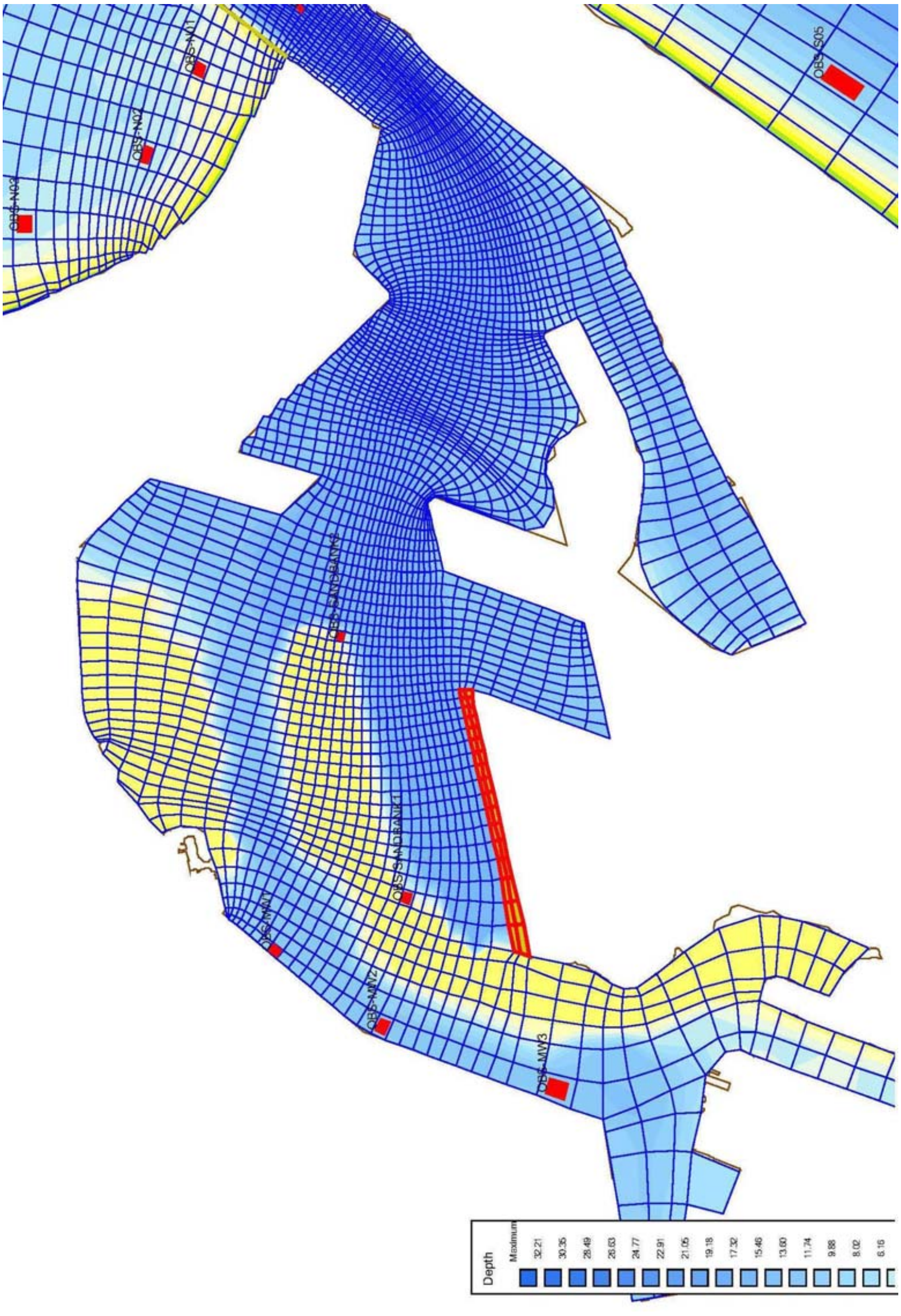


Figure 7a: Detail of Harbour Grid and Bathymetry for Post Construction Scenarios (Option 3-B)

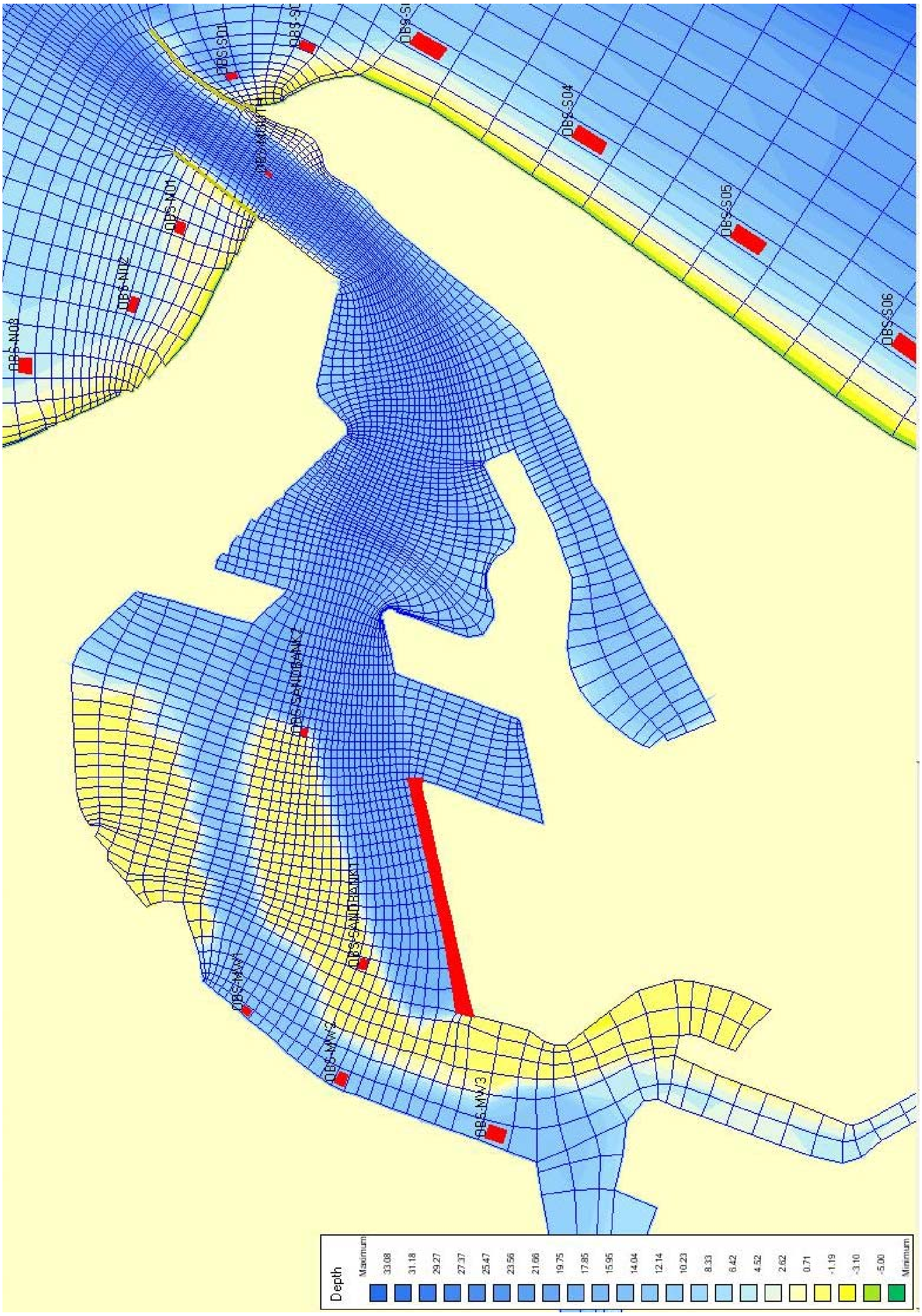


Figure 7b: Detail of Harbour Grid and Bathymetry for Post Construction Scenarios (Option 3-D)

5.4.2 Sediments

The fractions of material lost to suspension during dredging and dumping operations are summarized in the following table. These have been conservatively based on losses expected from cutter suction dredgers.

TABLE 2: DREDGE AND DUMP RATES AND CONCENTRATIONS

Operation	Rate (m^3/s)	Fraction lost to suspension (kg/m^3)	Time
Dredging (average)	0.165	14	Continuous
Dredging (peak)	1.722	14	60 minutes : 4 hour cycle
Dumping Offshore	6.9	95	15 minutes

The fraction of material lost to suspension during dredging has been estimated at 4kg/m³ of dredged material. An additional 10kg/m³ has been assumed to go into suspension due to overflow of the hopper, bringing the total to 14 kg/m³ dry material lost to suspension. For an average dredge rate of 0.165 m³/s, the average sediment loading is calculated as 2.31kg/s. For a peak dredge rate of 1.722 kg/m³ the peak sediment loading is 24 kg/m³.

Based on the discharge time of 15 minutes for a 6200m³ hopper and assuming a maximum dry density of dredged material to be in the order of 1600 to 1800 kg/m³, and a fraction of 5% lost to suspension during dumping (Kirby and Land, 1991), the weight of dry material lost to suspension is estimated conservatively as 95 kg/m³, upper bound. The associated discharge rate is 6200m³ / 756s = 6.9 m³/s.

Sediment loading has been estimated according to Kirby and Land, 1991 and Pennekamp and Quaak, 1998.

Other physical parameters for the cohesive sediment are summarized as follows:

Specific Gravity	2.7
Settling Velocity	0.6 mm/s
Reference Density for Hindered Settling	1600 kg/m³
Critical Bed Shear Stress for Sedimentation	0.2 N/m²
Critical Bed Shear Stress for Erosion	Set at a high value for these calculations to prevent erosion interfering with suspended sediment modeling of dredging activities.

Refer to Figure 8 below for positions of dredge discharge position off Berth 205, "DREDGE" and dump discharge offshore at location marked "DUMP2"

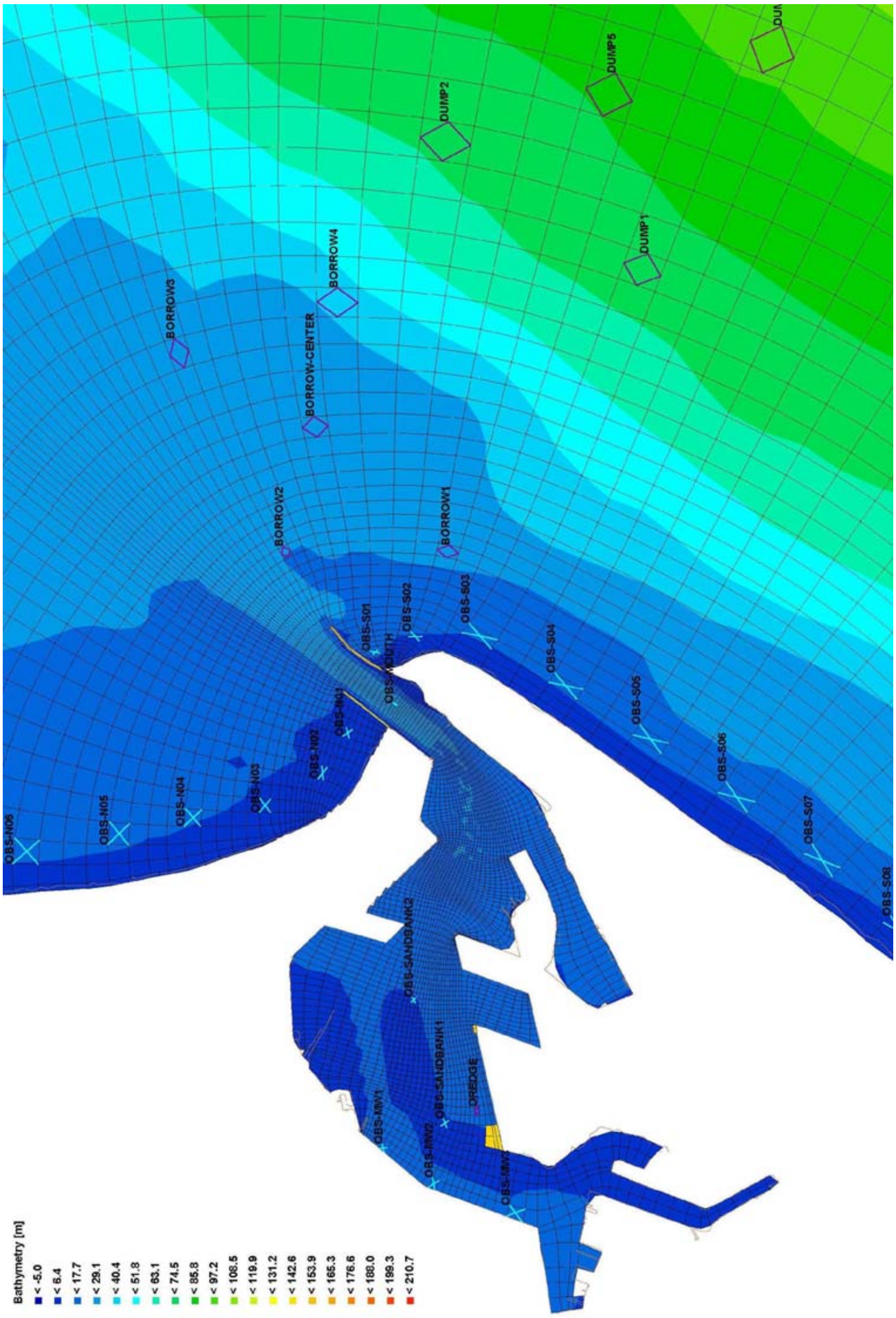


Figure 8: Grid Detail Indicating Dredge and Dump Locations and Monitoring Positions

5.4.3 Boundary Conditions

A single open boundary has been defined in the FLOW model, at which water level is varied according to tidal data from the month of January 2010. Due to the large distance between the end points of this boundary, the tidal levels are varied slightly along the length to account for tidal variance along the coast. The difference in tidal levels has been interpolated from the tidal difference between Durban and Richards Bay to the North. Figures 9 and 10 provide plots of tidal levels used for neap and spring tide scenarios. Time on the horizontal axis is given in minutes, starting at the reference time of 00:00 on 01 January 2010.

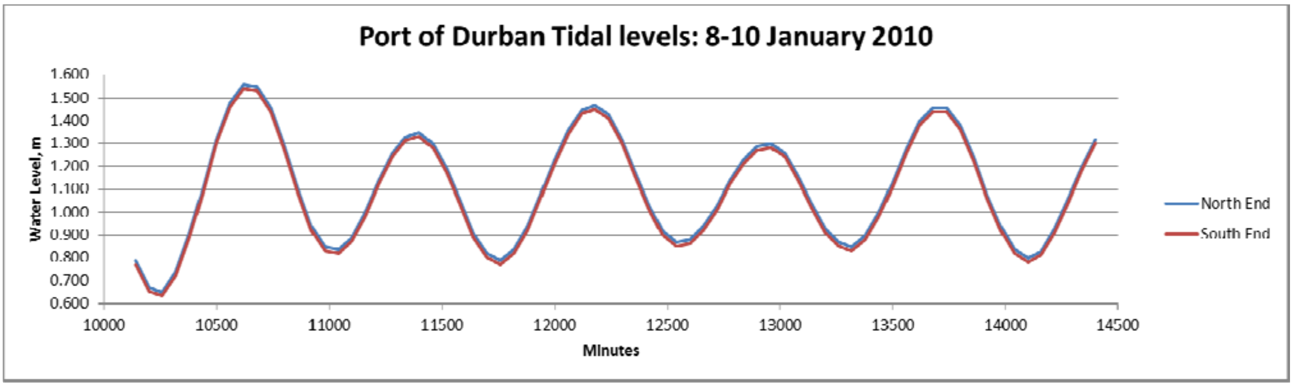


Figure 9: Tidal Level Input for Neap Tide Scenarios

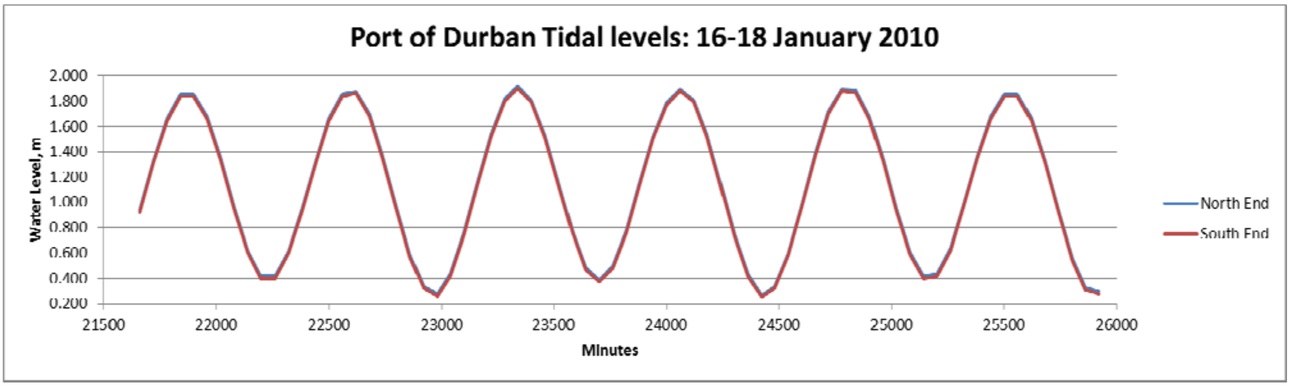


Figure 10: Tidal Level Input for Spring Tide Scenarios

5.5 Wind and Swell input

The National Centre for Environmental Prediction (NCEP) hind cast wind and wave data for the period 1997 to 2010 has been used for this study. Wind speed and direction are input as a uniform vector over all grid cells in the FLOW model. This data is shared with the WAVE model through the coupling process. Table 3 provides details on annual wind occurrence data. A mean wind speed of 20m/s has been chosen for all scenarios with directions either 202.5° (SSW) or 22.5° (NNE).

TABLE 3 ANNUAL WIND PERCENTAGE OCCURRENCE DATA (m/s) (FOR THE PERIOD 1997 - 2010 AT LATITUDE 30 S , LONGITUDE 31.25 E)

Wind Velocity (+10m CD	WIND DIRECTION (FROM)																SUM
m/s	S-SSW	SSW-SW	SW-WSW	WSW-W	W-WNW	WNW-NW	NW-NNW	NNW-N	N-NNE	NNE-NE	NE-ENE	ENE-E	E-ESE	ESE-SE	SE-SSE	SSE-S	
0 - 5	2.932	2.997	3.204	2.900	2.568	2.551	2.868	3.174	2.898	2.104	1.476	1.175	1.037	1.272	1.888	2.415	**37.459**
5 - 10	7.620	11.180	7.109	1.801	0.665	0.752	1.358	3.684	8.549	5.355	1.089	0.271	0.222	0.296	0.500	1.932	**52.383**
10 - 15	0.586	2.040	0.759	0.025	0.015	0.012	0.044	0.298	2.642	2.846	0.266	0.027	0.002		0.015	0.020	**9.597**
15 - 20	0.005	0.047	0.010			0.002	0.002	0.007	0.168	0.229	0.062	0.010					**0.542**
20 - 25								0.002	0.007	0.005	0.002						**0.016**
	11.143	**16.264**	**11.082**	**4.726**	**3.248**	**3.317**	**4.272**	**7.165**	**14.264**	**10.539**	**2.895**	**1.483**	**1.261**	**1.568**	**2.403**	**4.367**	**99.997**

TABLE 4 DURBAN HARBOUR OFFSHORE SIGNIFICANT WAVE HEIGHT (M) PERCENTAGE OCCURRENCE DATA (FOR PERIOD 1997-2010 AT LATITUDE 30 S , LONGITUDE 31.25 E)
DIRECTION FROM

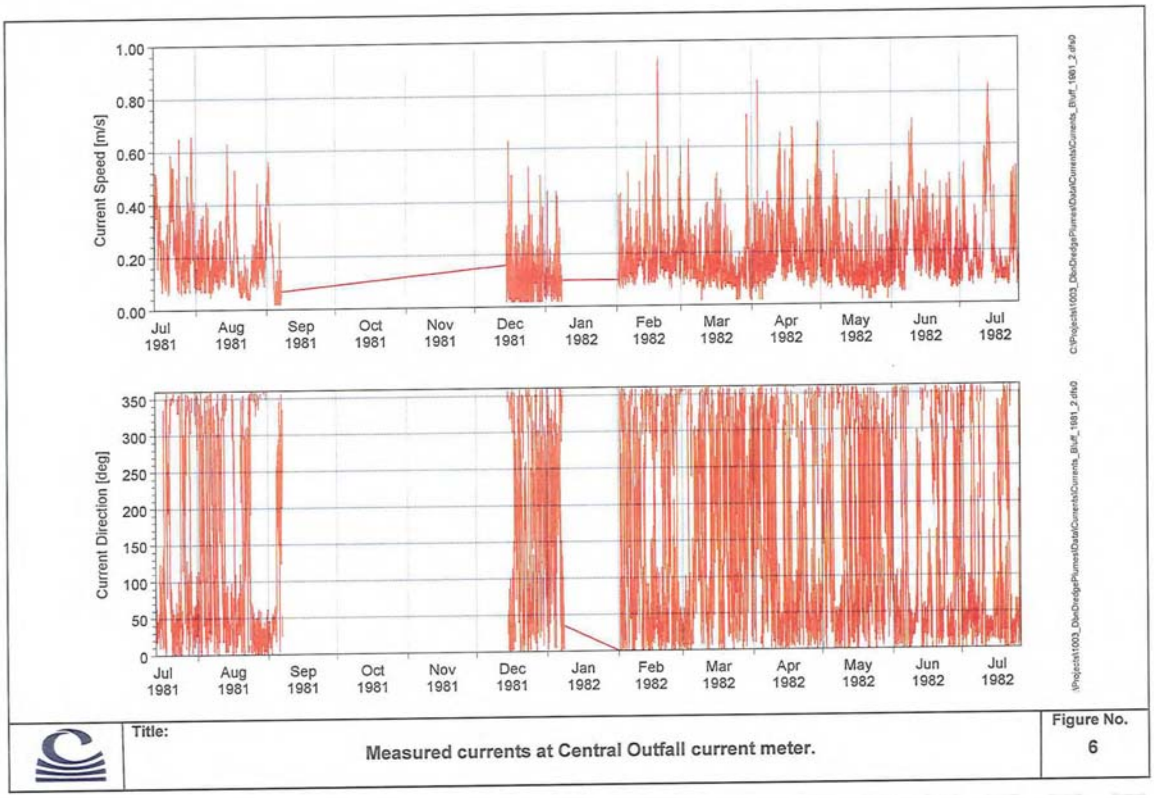
Significant Wave Height Hs (m)	N-NNE	NNE-NE	NE-ENE	ENE-E	E-ESE	ESE-SE	SE-SSE	SSE-S	S-SSW	SSW-SW	SW-WSW	WSW-W	W-WNW	WNW-NW	NW-NNW	NNW-N	SUM
0.0 - 0.5				0.002													**0.002**
0.5 - 1.0	0.010	0.044	0.057	0.113	0.261	0.165	0.128	0.069	0.172	0.180			0.002				**1.201**
1.0 - 1.5	0.071	0.690	2.161	4.051	6.222	2.526	1.801	1.811	3.437	3.171	0.015		0.015	0.002	0.005	0.027	**26.005**
1.5 - 2.0	0.049	0.754	4.191	5.086	9.147	3.122	3.019	3.307	8.343	4.908	0.012	0.007			0.002	0.002	**41.949**
2.0 - 2.5	0.015	0.140	0.998	1.372	3.248	1.355	1.321	1.892	6.042	2.395	0.015						**18.793**
2.5 - 3.0		0.022	0.138	0.256	0.646	0.461	0.562	0.747	3.287	1.178	0.005						**7.302**
3.0 - 3.5			0.010	0.081	0.207	0.153	0.227	0.315	1.094	0.690							**2.777**
3.5 - 4.0				0.007	0.049	0.081	0.057	0.138	0.540	0.308							**1.180**
4.0 - 4.5					0.025	0.002	0.030	0.079	0.232	0.101							**0.469**
5.0 - 5.5					0.017	0.010	0.012	0.020	0.103	0.037							**0.199**
5.5 - 6.0							0.007	0.010	0.049	0.012							**0.078**
6.0 - 6.5							0.002	0.005	0.015								**0.022**
6.5 - 7.0								0.002									**0.002**
7.0-7.5								0.002	0.002								**0.004**
SUM	**0.145**	**1.650**	**7.555**	**10.968**	**19.822**	**7.875**	**7.166**	**8.397**	**23.316**	**12.980**	**0.047**	**0.007**	**0.017**	**0.002**	**0.007**	**0.029**	**99.983**

TABLE 5 ANNUAL OMNI DIRECTIONAL WAVE PERCENTAGE OCCURRENCE DATA (AT LATITUDE 30 S , LONGITUDE 31.25 E)

OMNI DIRECTIONAL WAVE DATA AT HARBOUR AREA

Significant Wave Height Hs (m)		**SPECTRAL PEAK PERIOD Tp(s)**											**sum**
		0 to 2	**2 to 4**	**4 to 6**	**6 to 8**	**8 to10**	**10 to 12**	**12 to 14**	**14 to 16**	**16 to 18**	**18 to 20**	**20 to 22**	
		1	**3**	**5**	**7**	**9**	**11**	**13**	**15**	**17**	**19**	**21**	
0-0.5	**0.25**		0.002										**0.002**
0.5-1	**0.75**		0.022	0.177	0.342	0.257	0.231	0.142	0.027				**1.198**
1-1.5	**1.25**		0.491	2.811	7.623	7.732	4.249	2.387	0.653	0.059			**26.005**
1.5-2	**1.75**		0.185	5.687	10.944	12.907	6.022	4.498	1.538	0.160	0.007		**41.948**
2-2.5	**2.25**			1.786	5.094	5.128	3.578	2.210	0.867	0.126	0.005		**18.794**
2.5-3	**2.75**			0.117	2.316	1.783	1.486	1.009	0.483	0.104			**7.298**
3-3.5	**3.25**				0.560	0.955	0.746	0.330	0.128	0.054	0.005		**2.778**
3.5-4	**3.75**				0.073	0.582	0.310	0.137	0.060	0.017			**1.179**
4-4.5	**4.25**				0.009	0.177	0.169	0.096	0.015				**0.466**
4.5-5	**4.75**					0.046	0.093	0.052	0.007				**0.198**
5-5.5	**5.25**						0.041	0.009	0.022	0.005			**0.077**
5.5-6	**5.75**						0.010	0.012					**0.022**
6-6.5	**6.25**							0.002					**0.002**
6.5-7	**6.75**							0.004					**0.004**
7-7.5	**7.25**							0.009					**0.009**
7.5-8	**7.75**												
	sum		**0.700**	**10.578**	**26.961**	**29.567**	**16.935**	**10.888**	**3.800**	**0.525**	**0.017**		**99.980**

Measured currents at the Central Outfall current meter (July 1981 to July 1982) are shown in Figure 10b below which includes Figures 6 and 8 from Ref. (11). These have been used to check that the computed current velocities and directions are of a similar order and direction to those measured in 1981/1982.



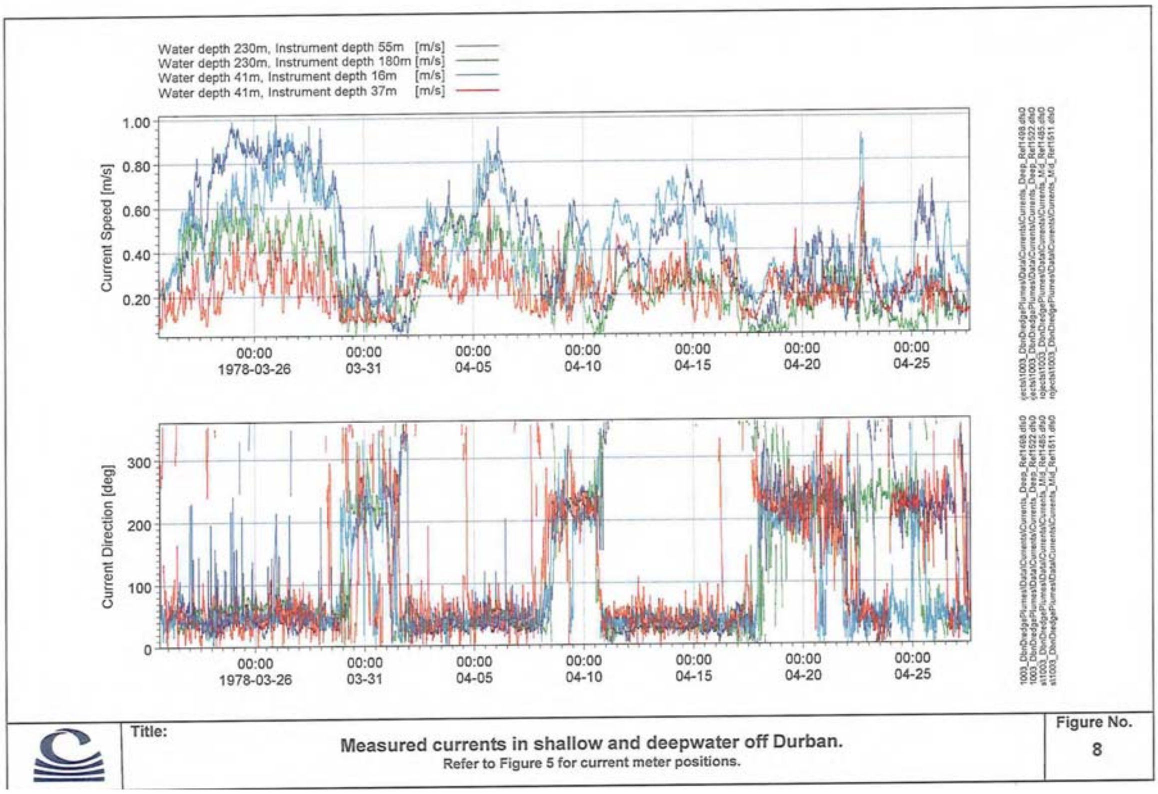


Figure 10b Measured Currents from Ref (11) : Figures 6 and 8

5.6 Scenarios

A total of eight scenarios have been simulated to represent each combination of tide, wind and wave state. Dredge discharge inside the port is simulated during the pre-construction scenarios, while offshore dumping is simulated during the post-construction scenarios. Table 5 provides details of these scenarios.

TABLE 5: SIMULATION SCENARIO DETAILS

runid	OPERATION	Tidal Cycle	Wind		Wave		
Pre Construction Scenarios			Speed (m/s)	Direction (°)	Hs (m)	Period (s)	Direction (°)
pre-n1	Dredging at B205, 24-7	Neap	20	202.5	3	10	146.25
pre-n2	Dredging at B205, 24-7	Neap	20	22.5	3	10	146.25
pre-s1	Dredging at B205, 24-7	Spring	20	202.5	3	10	146.25
pre-s2	Dredging at B205, 24-7	Spring	20	22.5	3	10	146.25
Post Construction Scenarios							
post-n1	Dumping at disposal site	Neap	20	202.5	3	10	146.25
post-n2	Dumping at disposal site	Neap	20	22.5	3	10	146.25
post-s1	Dumping at disposal site	Spring	20	202.5	3	10	146.25
post-s2	Dumping at disposal site	Spring	20	22.5	3	10	146.25

5.7 Results and Discussion

5.7.1 Main Sandbank Bed Shear Stresses

Values for bed shear stress have been monitored at two observation points on the main sandbank. For each environmental condition, the pre- and post-scenario results have been plotted on a graph (blue lines for pre- and red lines used for post-construction scenarios). These graphs are given below as figures 11 to 18. It can be seen that for Option 3-B there is generally minimal change in bed shear stress on the sandbank due to the changes in bathymetry. A similar response is anticipated for Option 3-C.

However, for Option 3-D there is an increase in bed shear stress in the case of the completed works. This is because the water is shallower at the observation points. The new sand fill will be vibro-compacted at placement. It is specified that, for the fill so placed, the critical bed shear stress will be of the order of 2 to 2.5 N/m^2 (Refs (13) and (14)). These bed shear stresses are of similar magnitude to stresses already being experienced by the central sandbank (see for example Figures 11c and 13c).

Referring to Figure 1, it is apparent that local erosion on the top of the sandbank has taken place due to ebb and flow of the tides, as well as wind and ship driven waves. The newly placed fill is expected to erode in a similar local fashion.

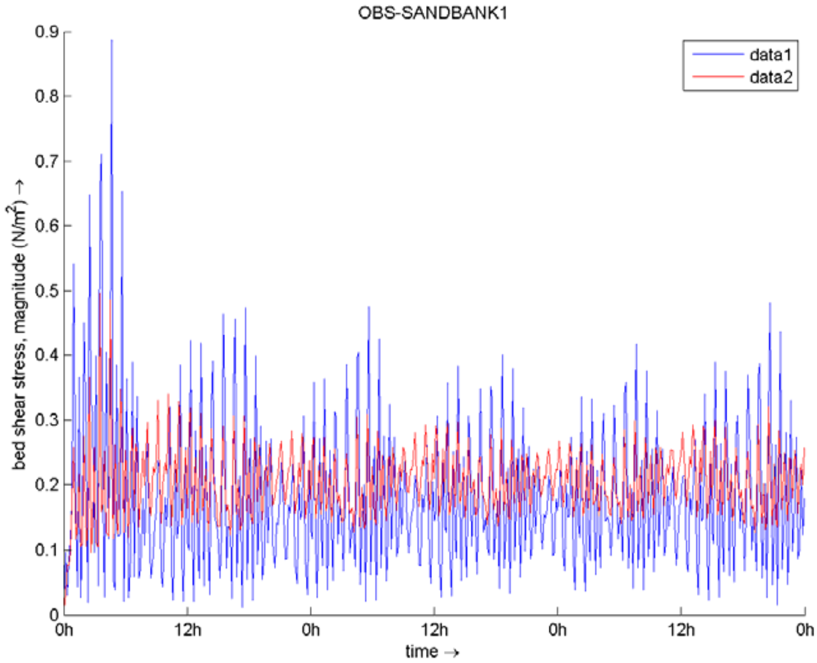


Figure 11a: Bed Shear Stress at OBS-SANDBANK1-N1 Scenarios (Blue=PRE, Red=POST, Option 3-B)

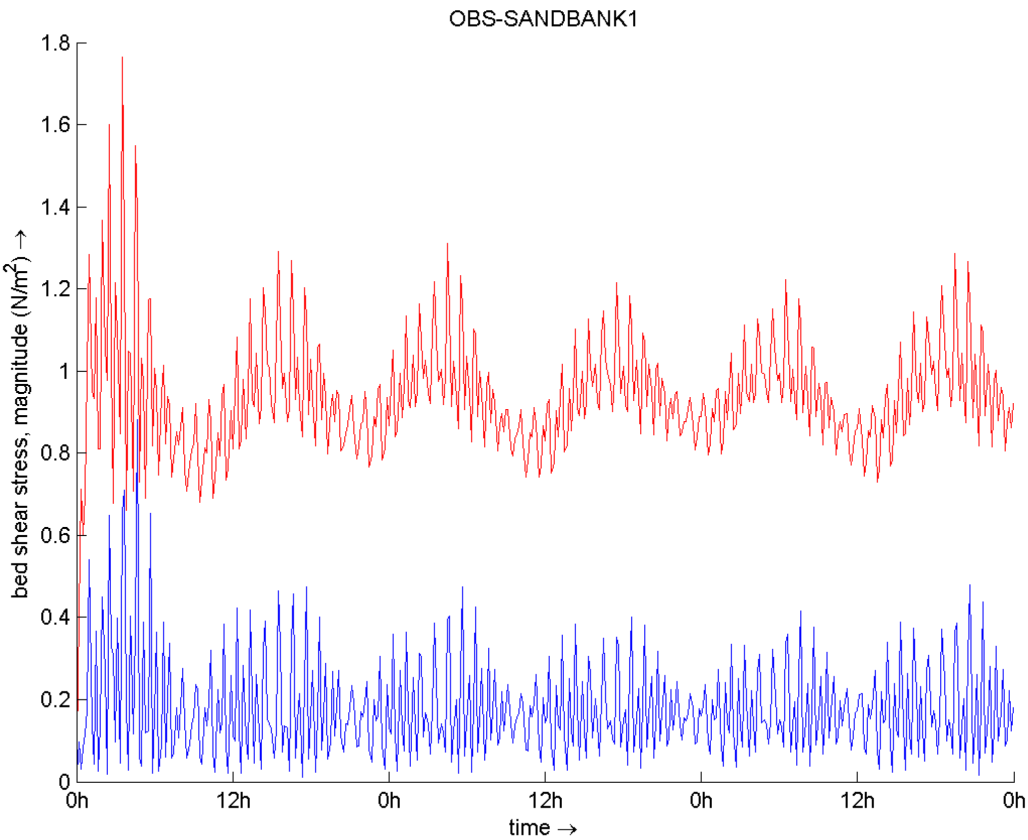


Figure 11b: Bed Shear Stress at OBS-SANDBANK1-N1 Scenarios (Blue=PRE, Red=POST, Option 3-D)

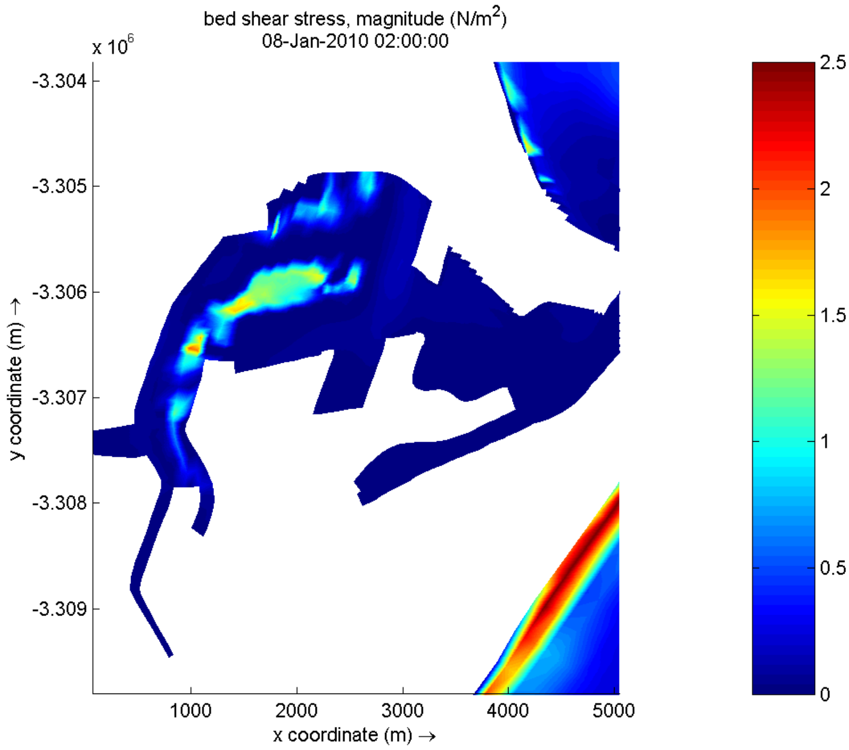


Figure 11c: Typical Maximum Bed Shear Stress at OBS-SANDBANK1-N1 Scenarios (PRE-DREDGING)

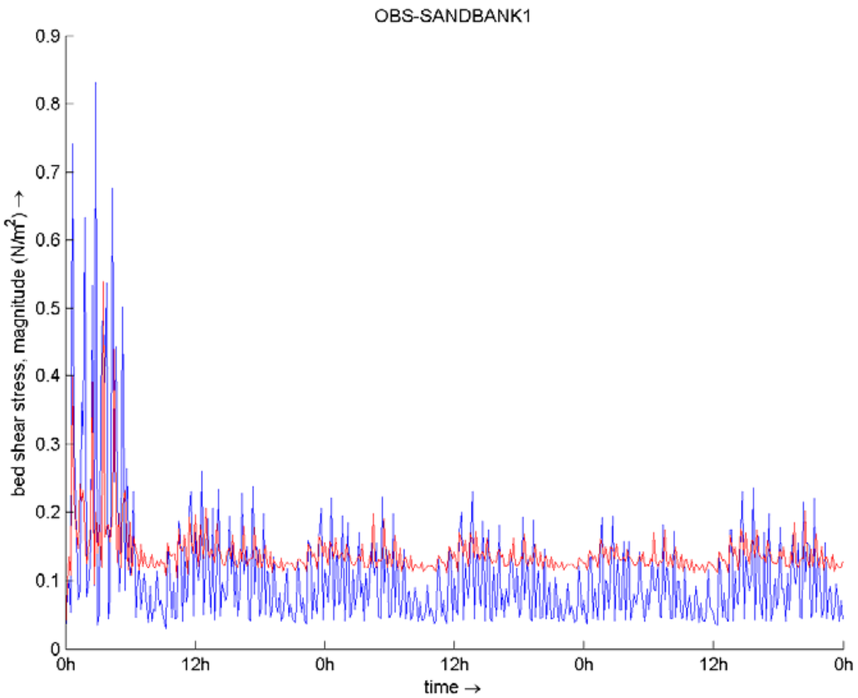


Figure 12a: Bed Shear Stress at OBS-SANDBANK1-N2 Scenarios (Blue=PRE, Red=POST, Option 3-B)

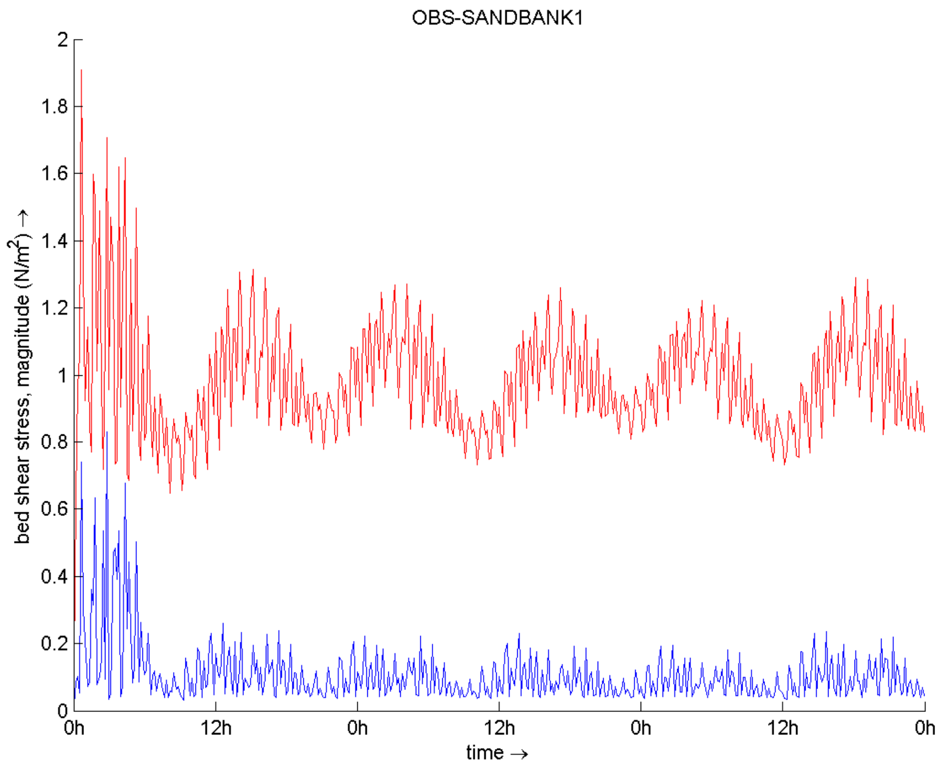


Figure 12b: Bed Shear Stress at OBS-SANDBANK1-N2 Scenarios (Blue=PRE, Red=POST, Option 3-D)

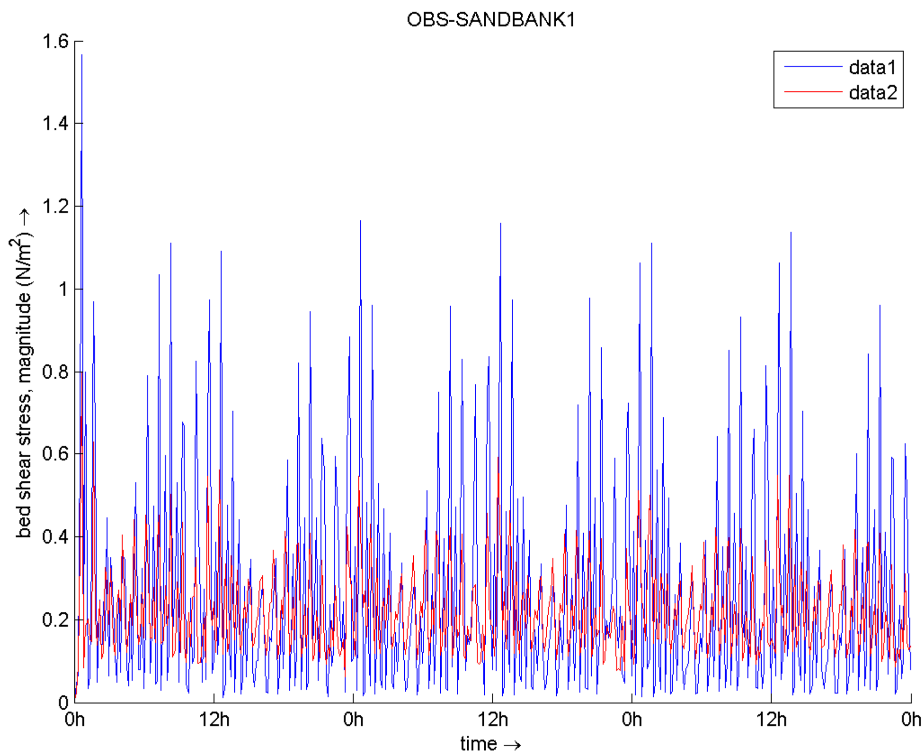


Figure 13a: Bed Shear Stress at OBS-SANDBANK1-S1 Scenarios (Blue=PRE, Red=POST, Option 3-B)

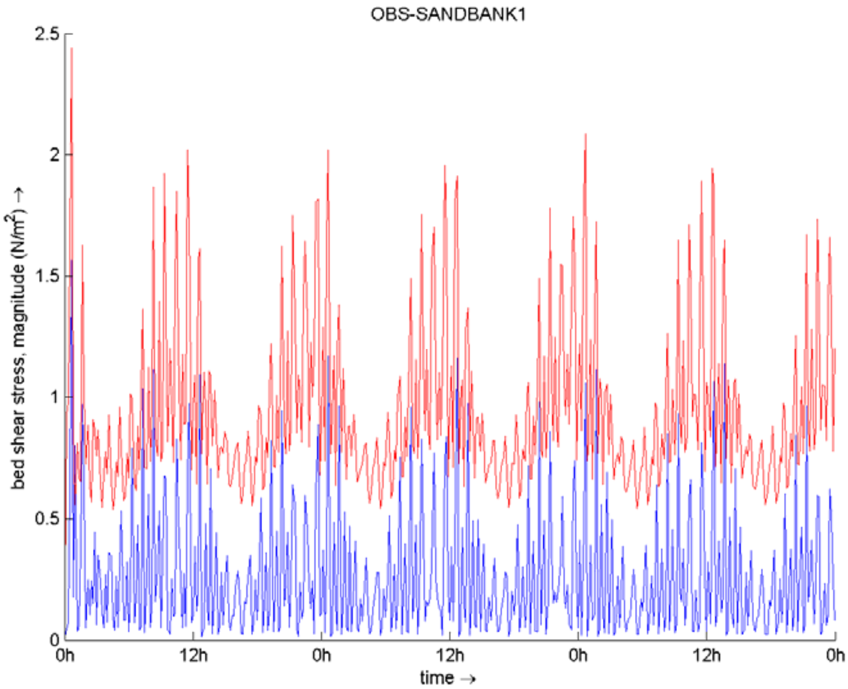


Figure 13b: Bed Shear Stress at OBS-SANDBANK1-S1 Scenarios (Blue=PRE, Red=POST, Option 3-D)

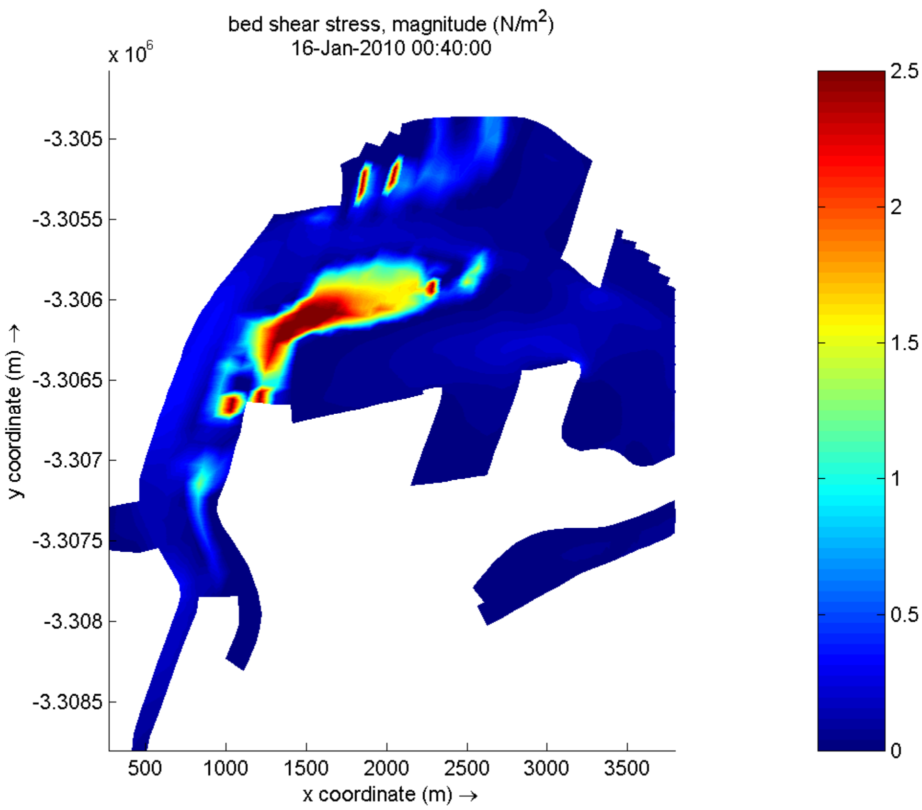


Figure 13c: Typical Maximum Bed Shear Stress at OBS-SANDBANK1-S1 Scenarios (PRE-DREDGING)

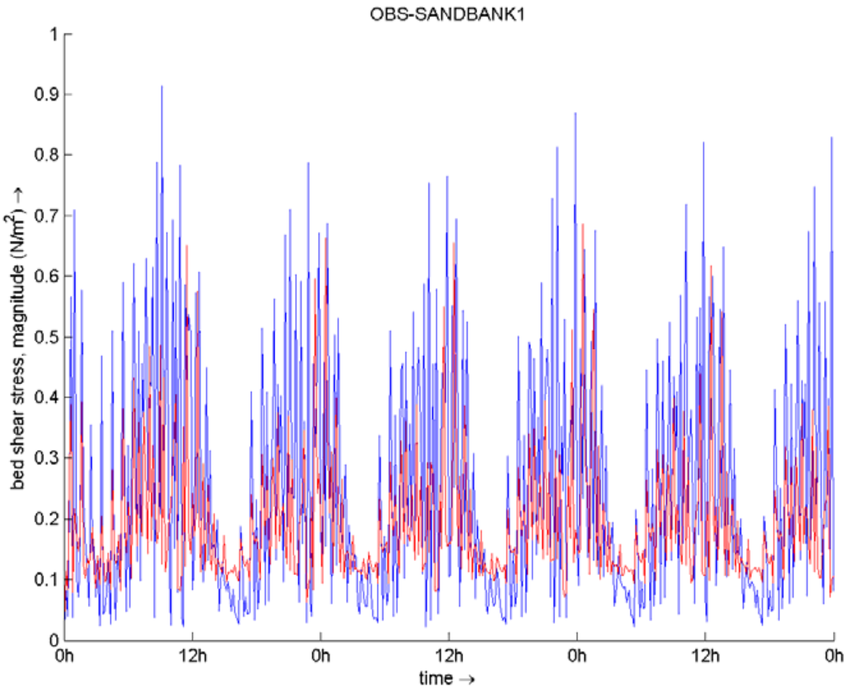


Figure 14a: Bed Shear Stress at OBS-SANDBANK1-S2 Scenarios (Blue=PRE, Red=POST, Option 3-B)

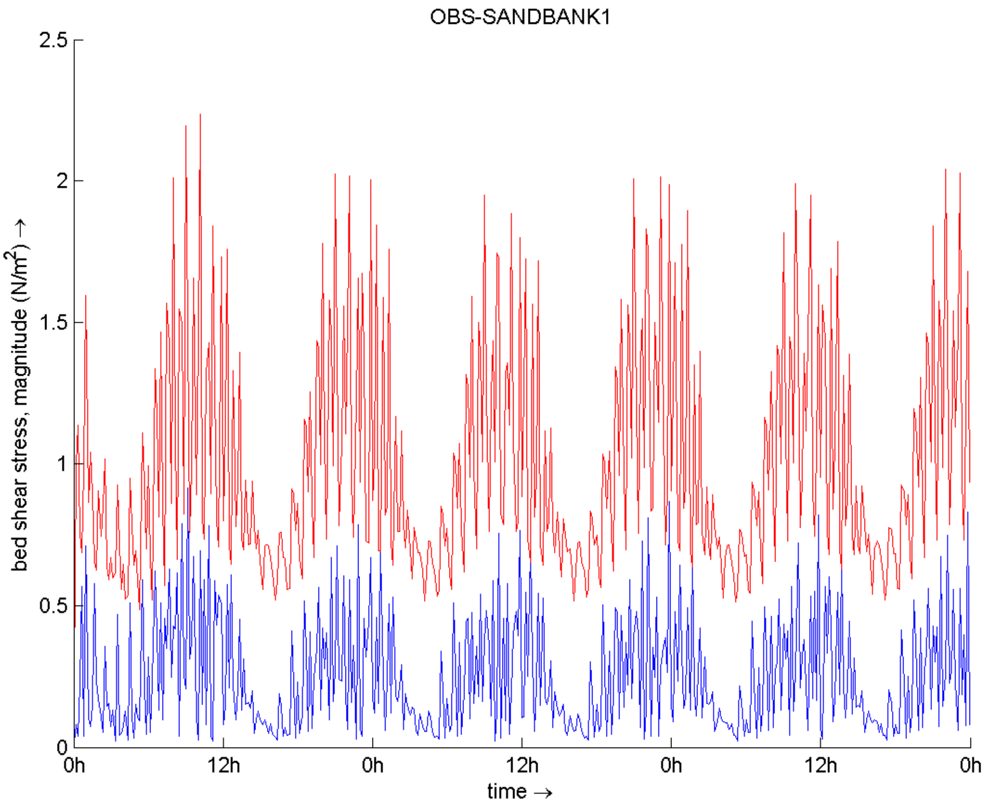


Figure 14b: Bed Shear Stress at OBS-SANDBANK1-S2 Scenarios (Blue=PRE, Red=POST, Option 3-D)

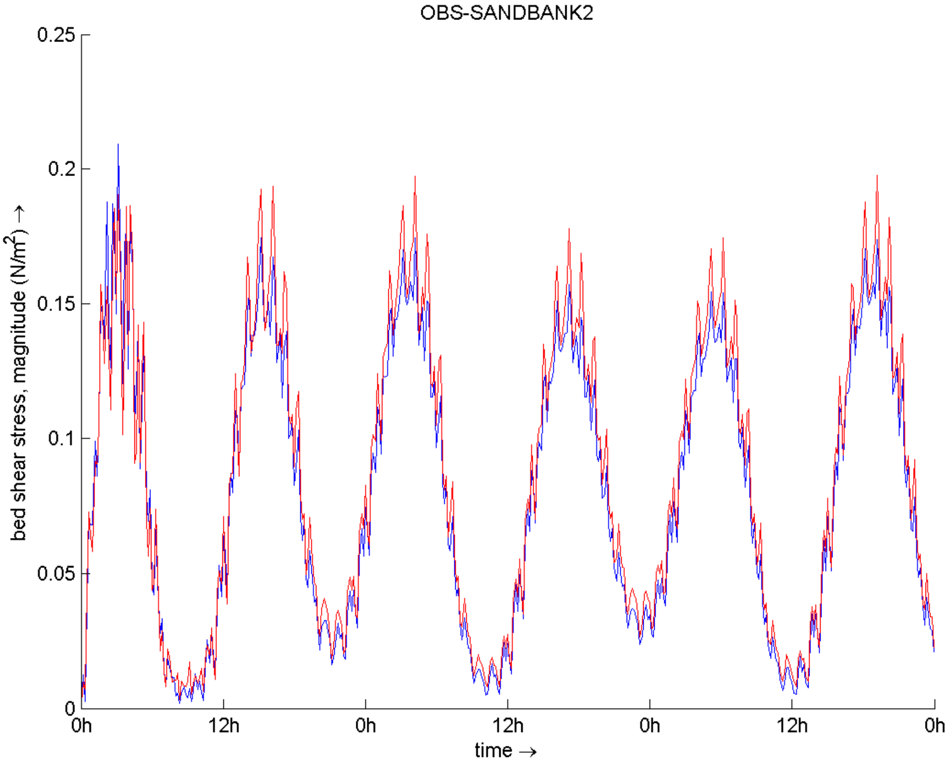


Figure 15a: Bed Shear Stress at OBS-SANDBANK2-N1 Scenarios (Blue=PRE, Red=POST, Option 3-B)

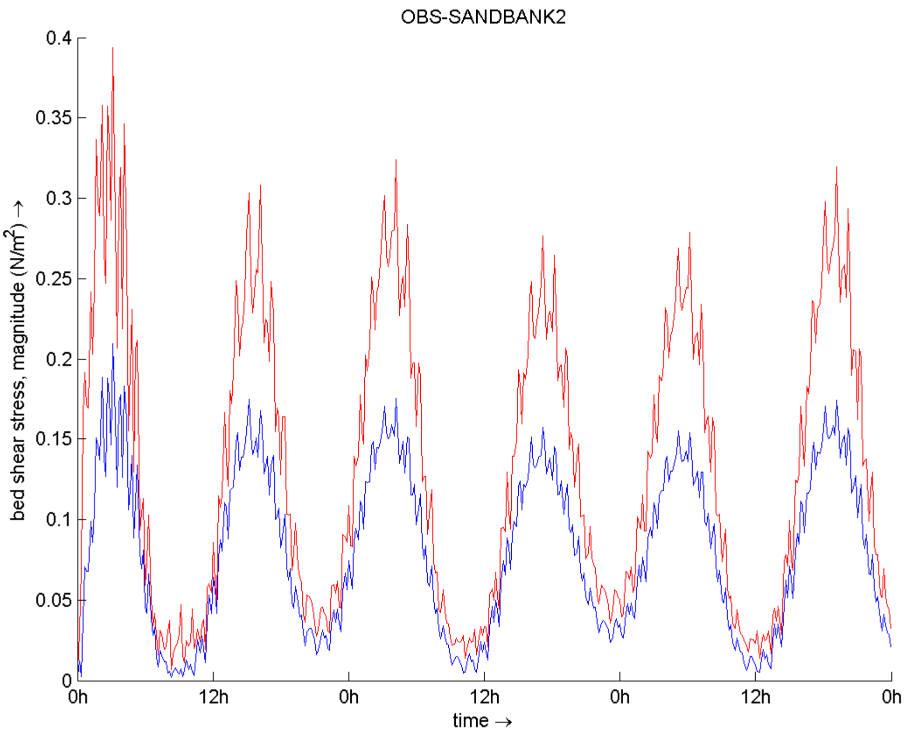


Figure 15b: Bed Shear Stress at OBS-SANDBANK2-N1 Scenarios (Blue=PRE, Red=POST, Option 3-D)

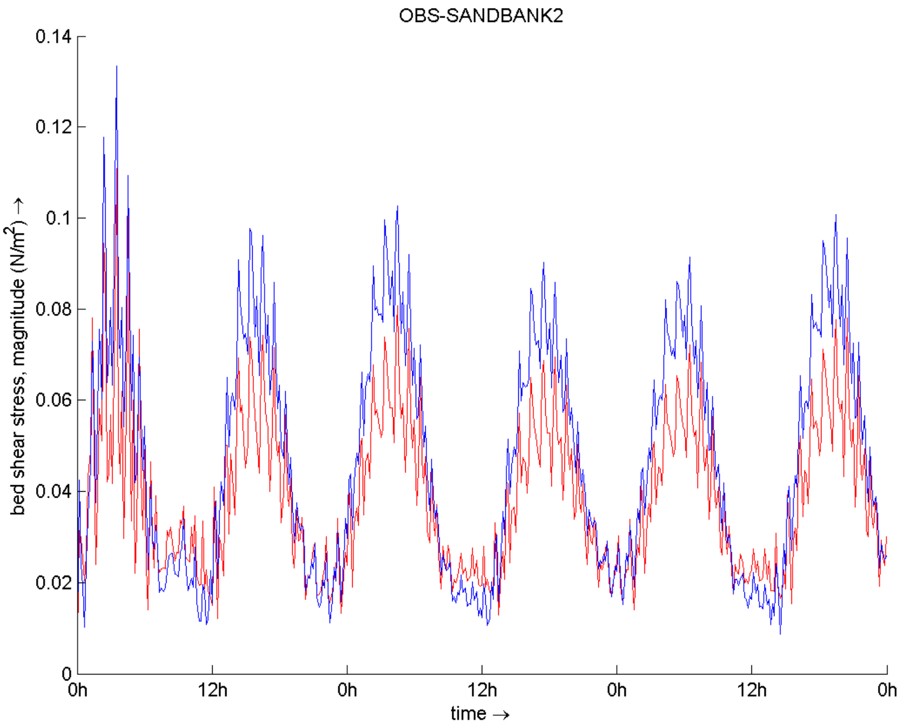


Figure 16a: Bed Shear Stress at OBS-SANDBANK2-N2 Scenarios (Blue=PRE, Red=POST, Option 3-B)

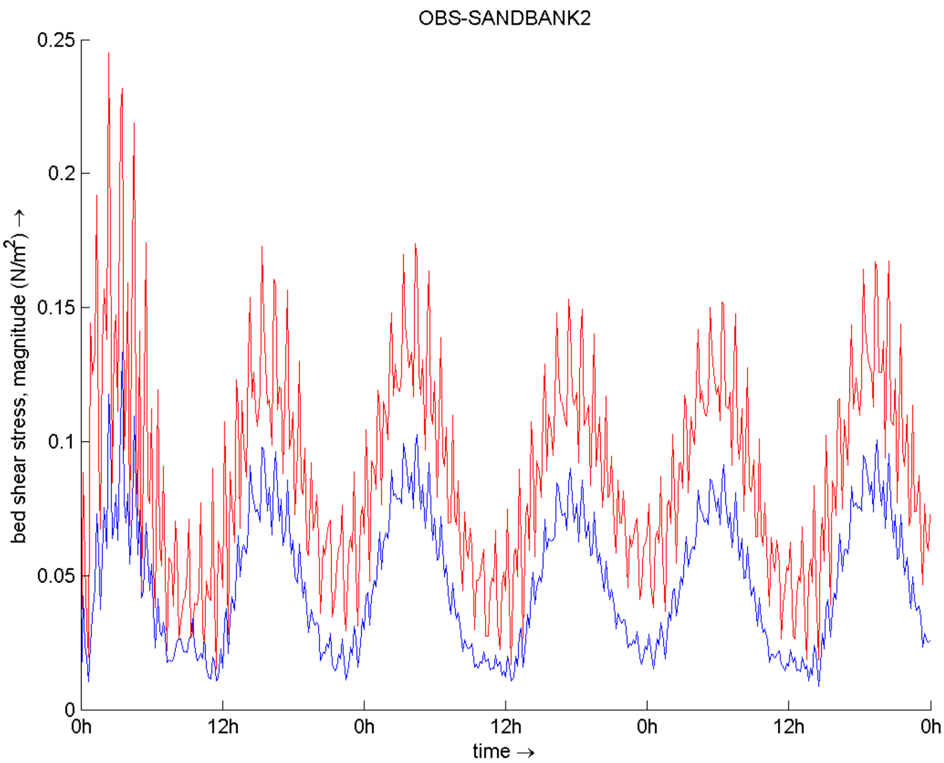


Figure 16b: Bed Shear Stress at OBS-SANDBANK2-N2 Scenarios (Blue=PRE, Red=POST, Option 3-D)

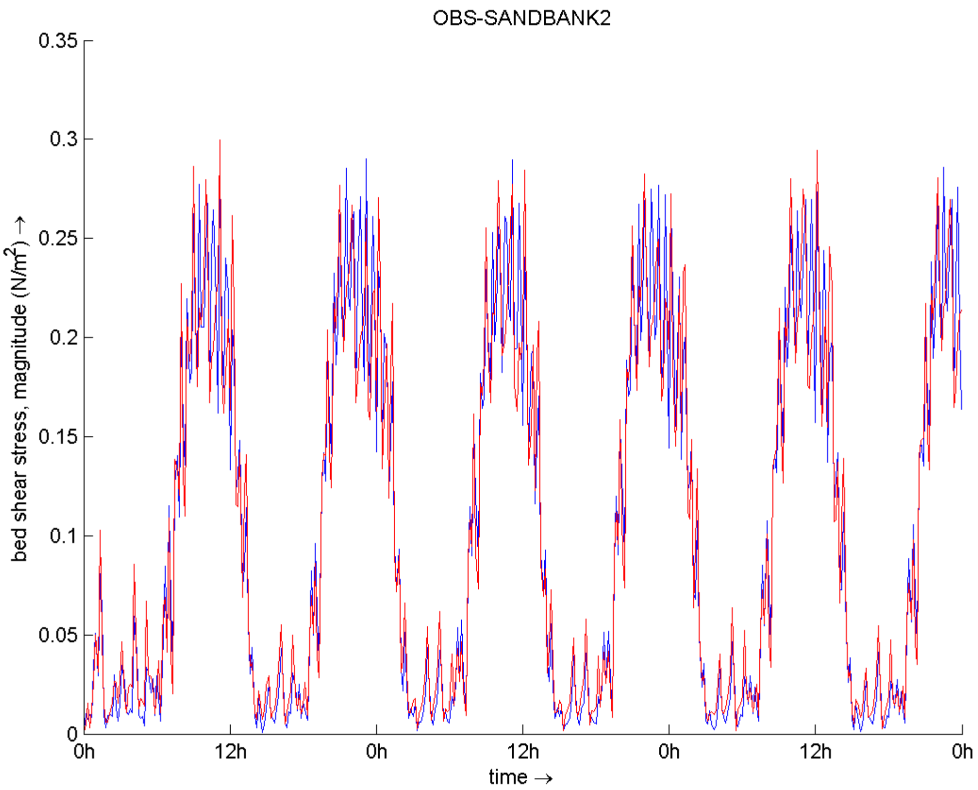


Figure 17a: Bed Shear Stress at OBS-SANDBANK2-S1 Scenarios (Blue=PRE, Red=POST, Option 3-B)

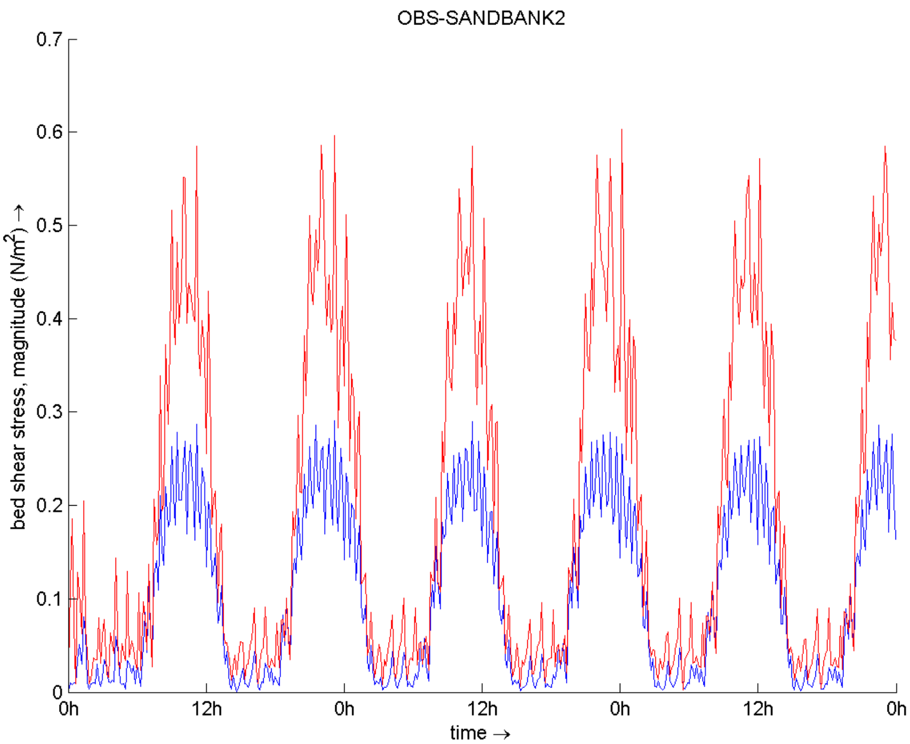


Figure 17b: Bed Shear Stress at OBS-SANDBANK2-S1 Scenarios (Blue=PRE, Red=POST, Option 3-D)

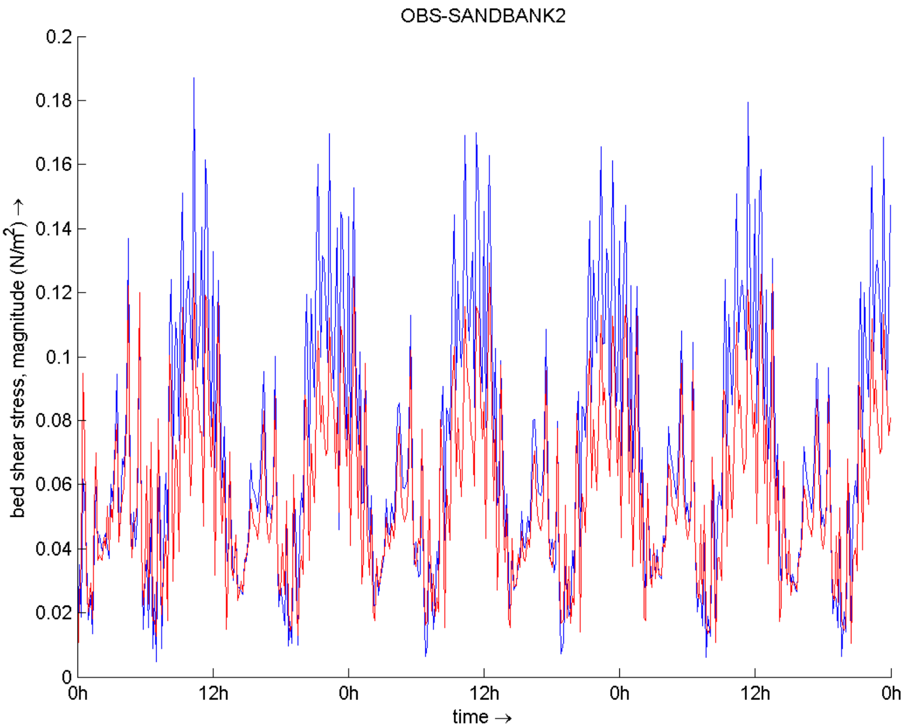


Figure 18a: Bed Shear Stress at OBS-SANDBANK2-S2 Scenarios (Blue=PRE, Red=POST, Option 3-B)

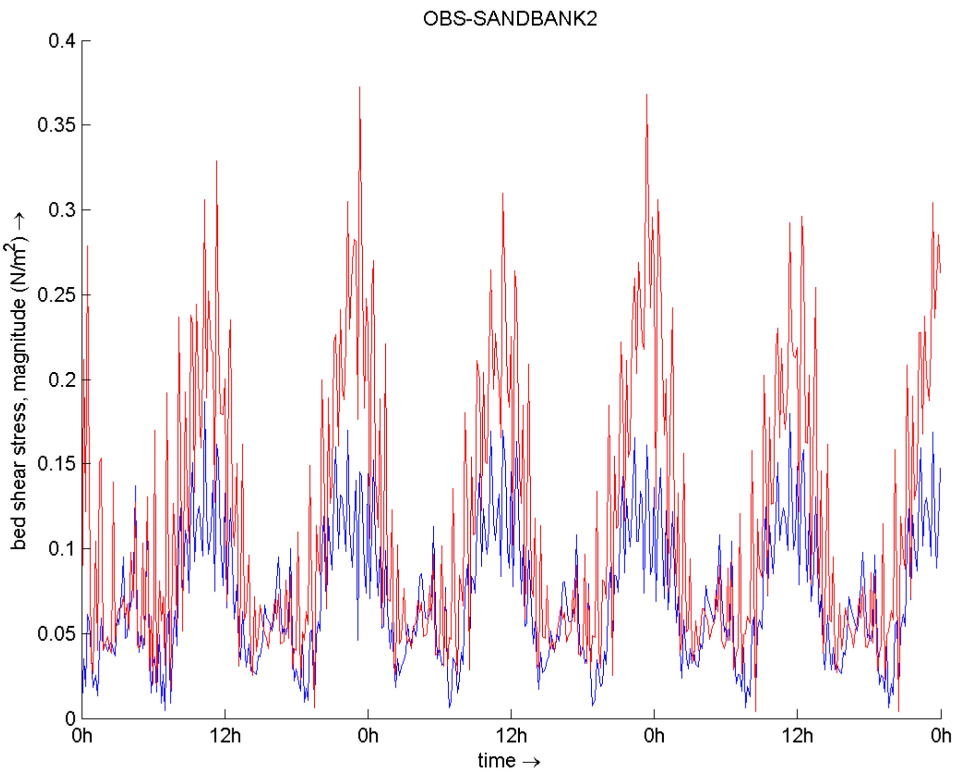


Figure 18b: Bed Shear Stress at OBS-SANDBANK2-S2 Scenarios (Blue=PRE, Red=POST, Option 3-D)

5.7.2 Turbidity due to Dredging at Berth 205

During pre-construction scenarios, the concentration of suspended clay sediments due to dredging has been tracked at observations points inside the Port. For each scenario, sediment concentration values for each of the six observation points inside the Port have been combined onto a single graph.

From the graphs it can be seen that peak suspended sediment concentrations reaching the main sandbank, are less than 0.028kg/m³ (Pre-S2) and levels for all scenarios tend to reach peaks and troughs corresponding to the tidal flow into and out of the Port. Background turbidity including inter alia storm water run-off, is not included in this simulation. Turbidity will be monitored during the dredging and dumping operations to ensure that the specifications are achieved in this regard.

Refer to Figures 19 to 26 for observation point recordings and map plots for an indication of probable plume dispersion for each scenario. The data Labels in these figures are explained in Table 6 below. (Note that bottom layer always has a higher concentration than surface layer)

TABLE 6 : Data Labels used in Figures 19 to 26 below

Data Label	Description	Data Label	Description
Data-1	Sandbank-1 Bottom Layer-5	Data-7	Maydon Wharf-1 Bottom Layer-5
Data 2	Sandbank-1 Surface Layer-1	Data-8	Maydon Wharf-1 Surface Layer-1
Data-3	Sandbank-2 Bottom Layer-5	Data-9	Maydon Wharf-2 Bottom Layer-5
Data-4	Sandbank-2 Surface Layer-1	Data-10	Maydon Wharf-2 Surface Layer-1
Data-5	Harbour Mouth Bottom Layer-5	Data-11	Maydon Wharf-3 Bottom Layer-5
Data-6	Harbour Mouth Surface Layer-1	Data-12	Maydon Wharf-3 Surface Layer-1

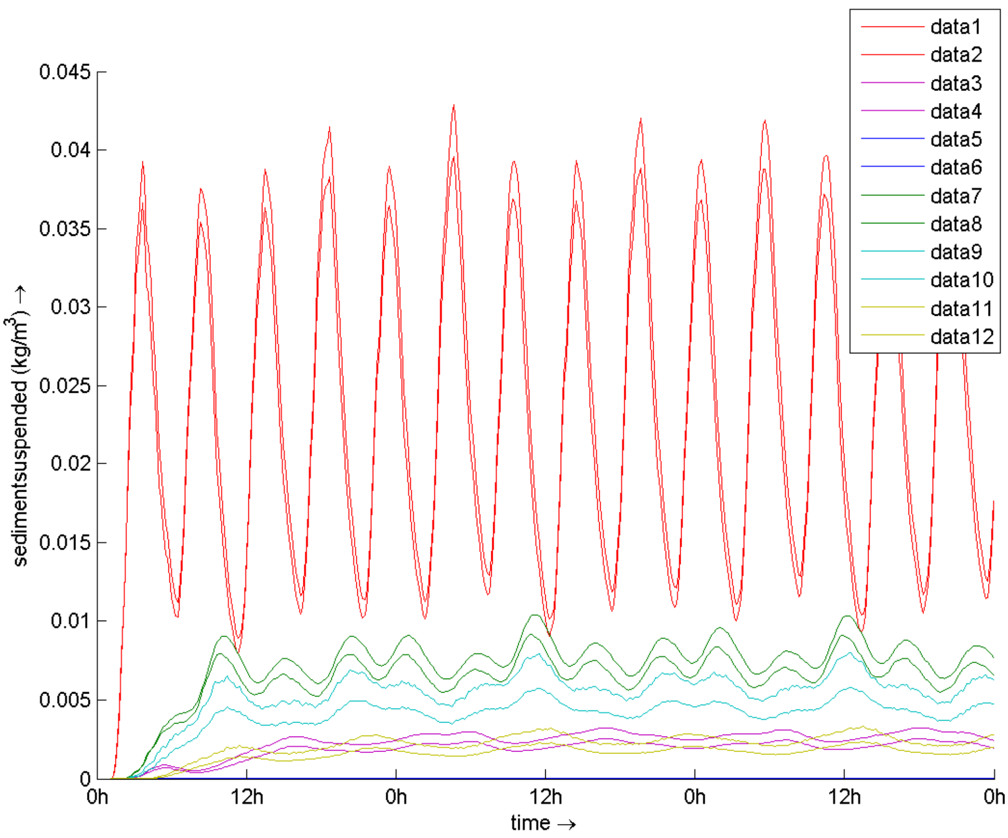


Figure 19: Suspended Sediment Concentrations – Pre-N1

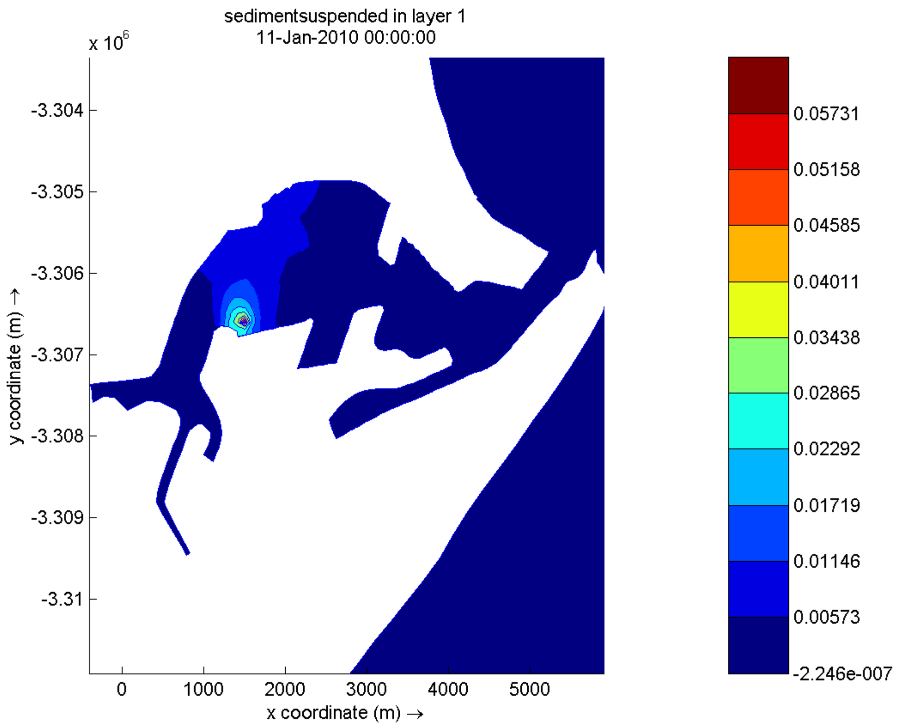


Figure 20a: Suspended Sediment Dispersion Surface Layer-1 – Pre-N1

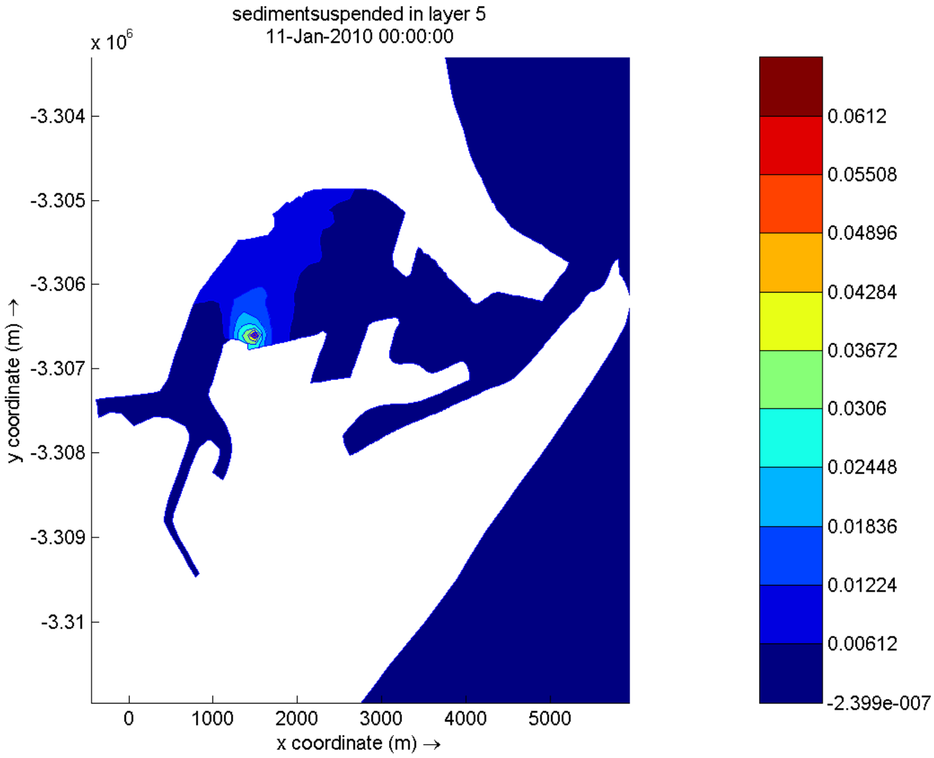


Figure 20b: Suspended Sediment Dispersion Bottom Layer-5 – Pre-N1

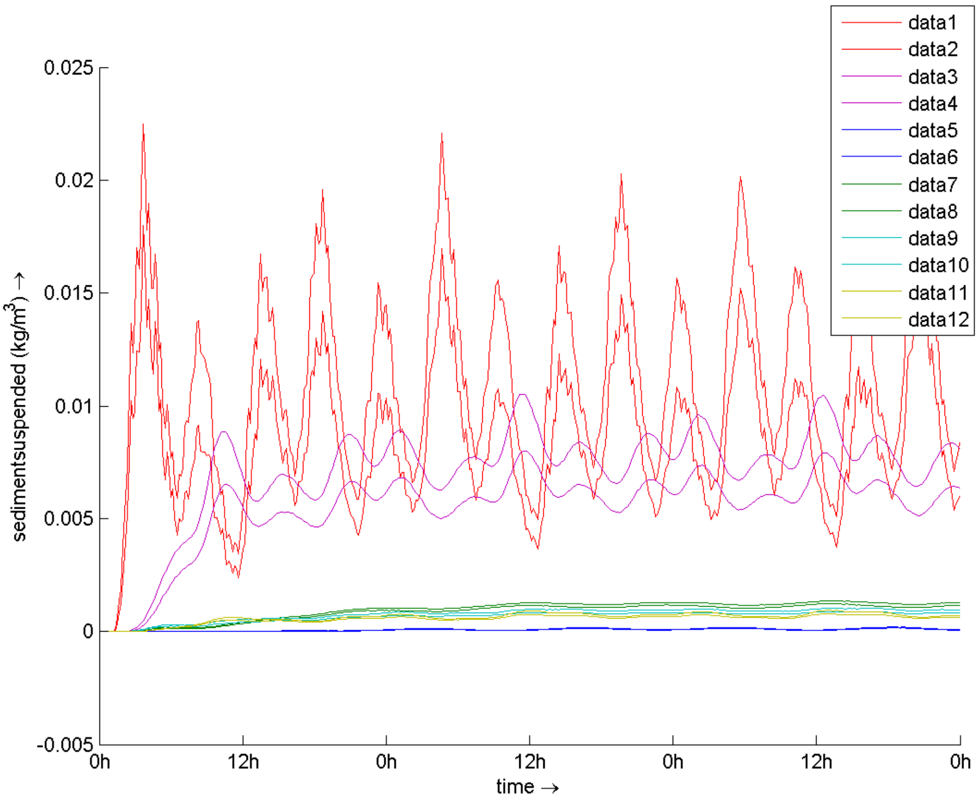


Figure 21: Suspended Sediment Concentrations – Pre-N2

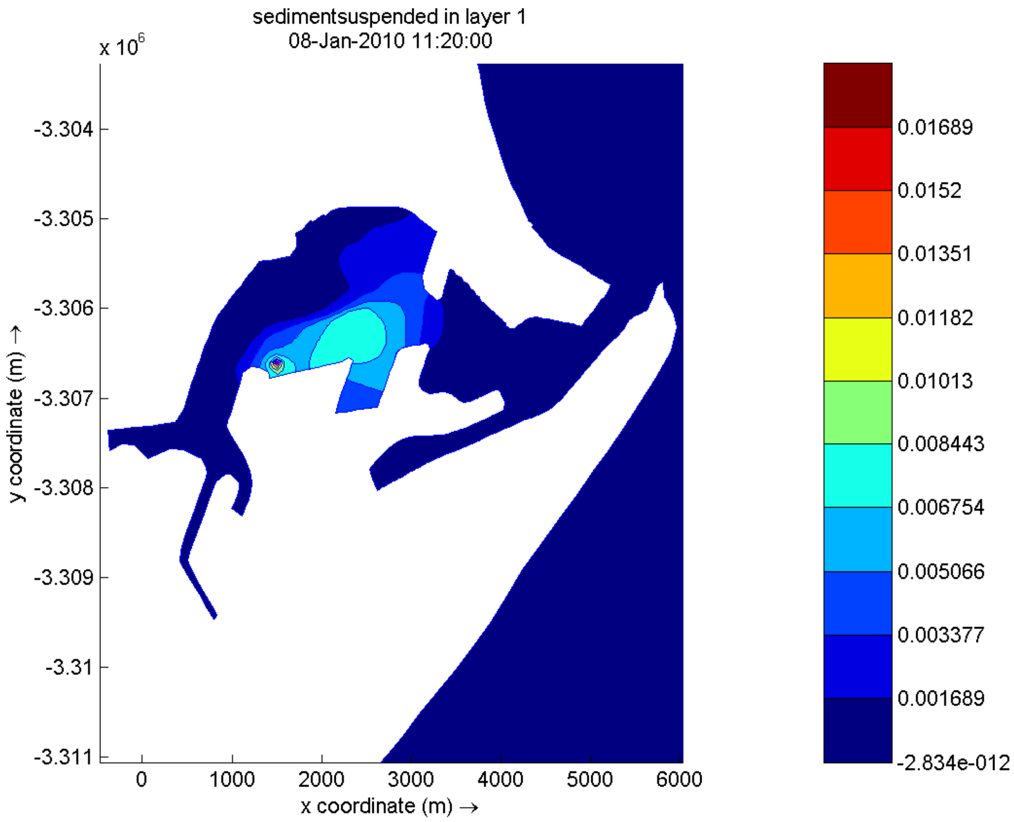


Figure 22a: Suspended Sediment Dispersion Surface Layer-1 – Pre-N2

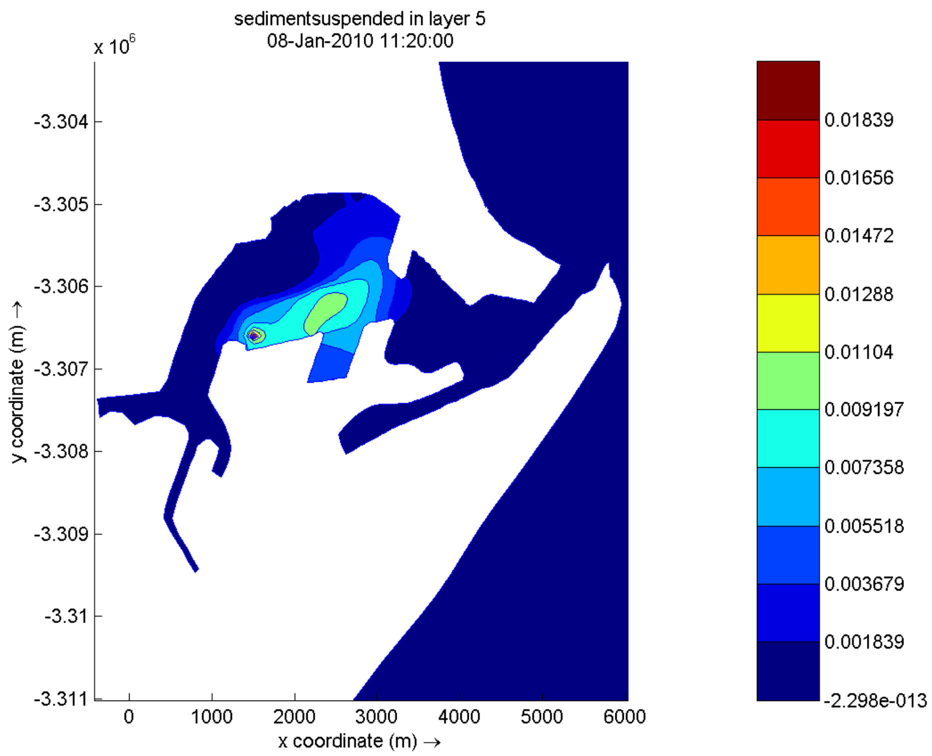


Figure 22b: Suspended Sediment Dispersion Bottom Layer-5– Pre-N2

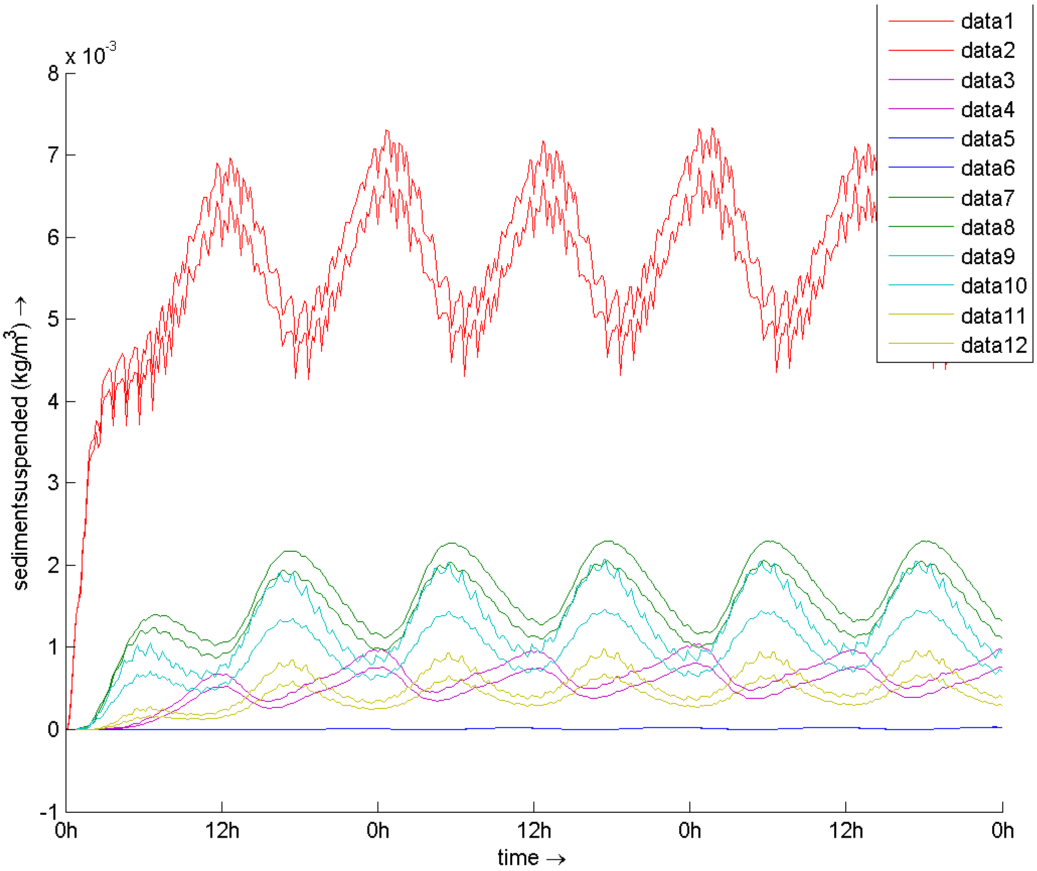


Figure 23: Suspended Sediment Concentrations – Pre-S1

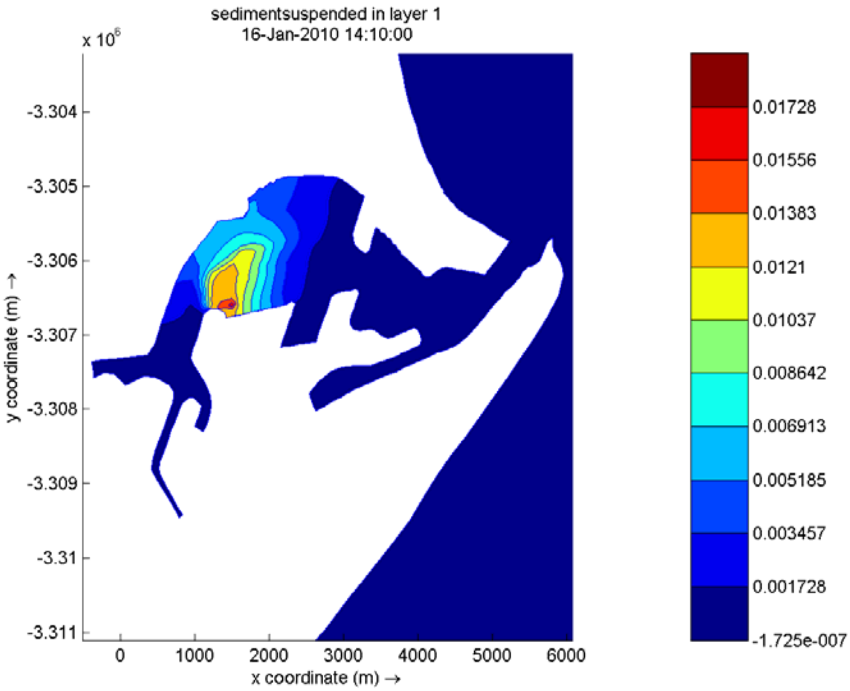


Figure 24a: Suspended Sediment Dispersion-Surface Layer-1– Pre-S1

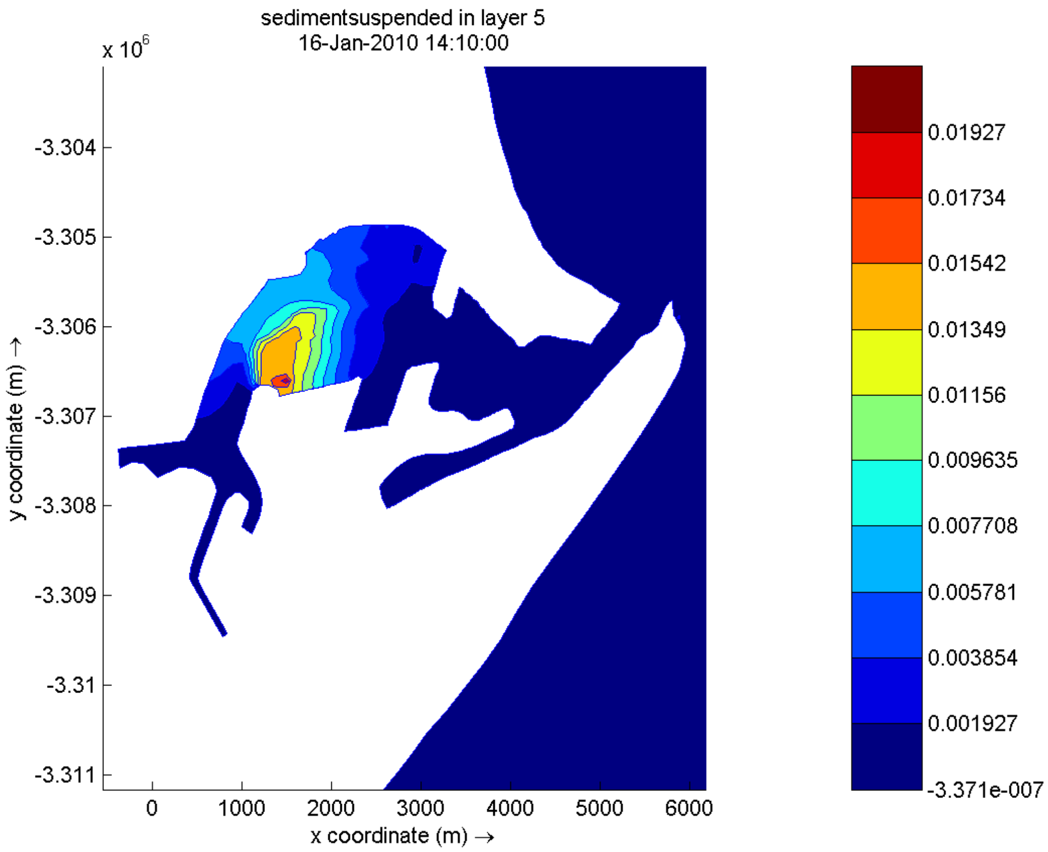


Figure 24b: Suspended Sediment Dispersion Bottom Layer-5– Pre-S1

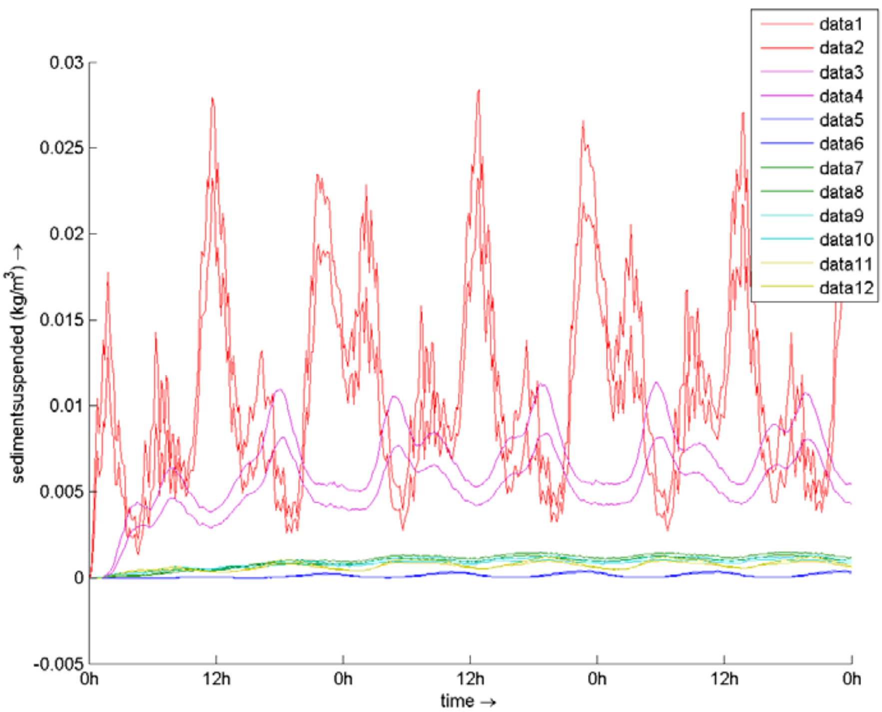


Figure 25: Suspended Sediment Concentrations – Pre-S2

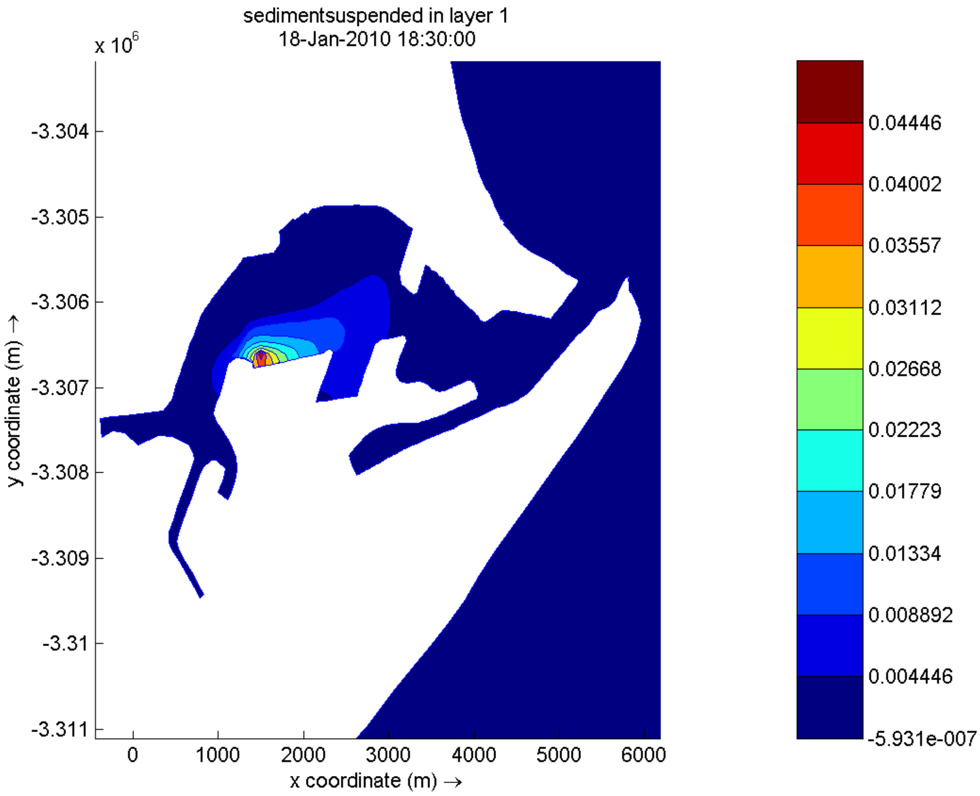


Figure 26a: Suspended Sediment Dispersion Surface Layer-1– Pre-S2

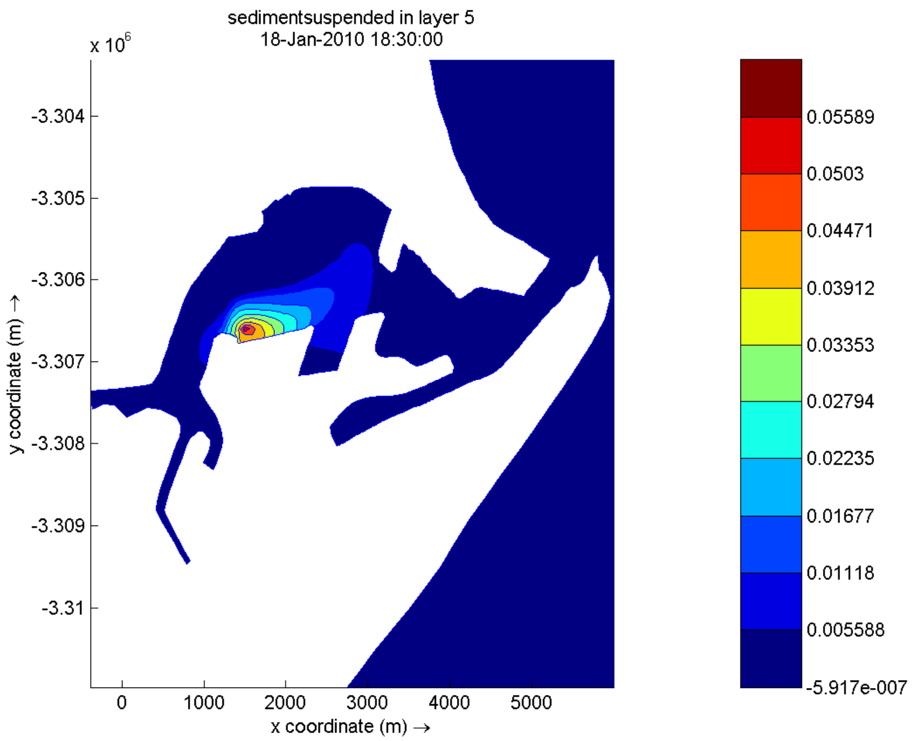


Figure 26b: Typical Suspended Sediment Dispersion Bottom Layer-5– Pre-S2

5.7.3 Beach Stability Due to Changes in Wave Energy

Figures 27 to 34 provide plots of bed shear stress versus time for all observation points along the North and South Beaches. Pre- and post-construction scenario values are plotted in blue and red respectively. It is evident that there is no significant change in bed shear stress at all observation points and all scenarios.

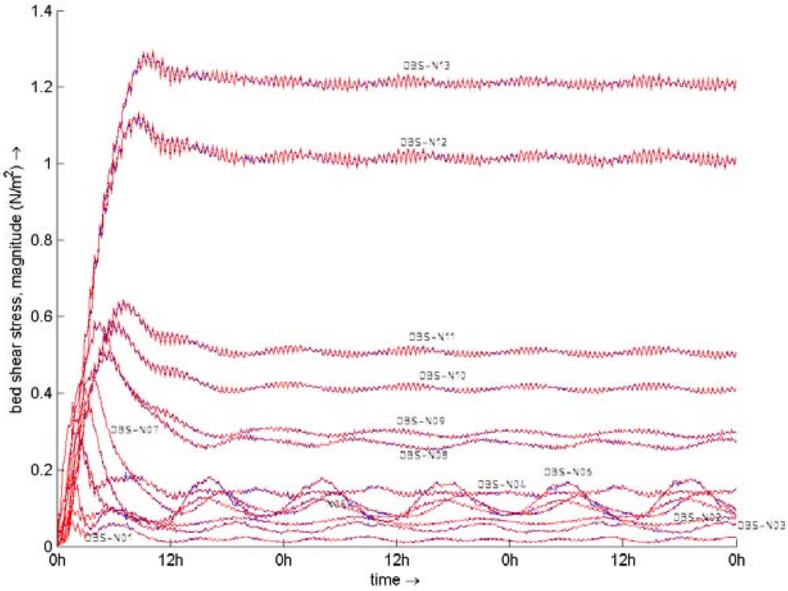


Figure 27: Bed shear Stress Along North Beach –N1 Scenarios (Blue=PRE, Red=POST)

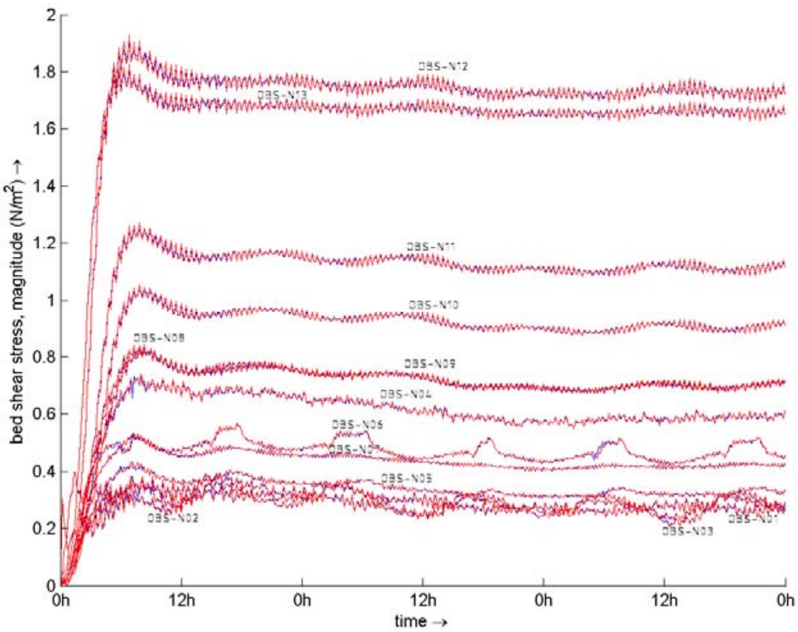


Figure 28: Bed Shear Stress Along North Beach –N2 Scenarios (Blue=PRE, Red=POST)

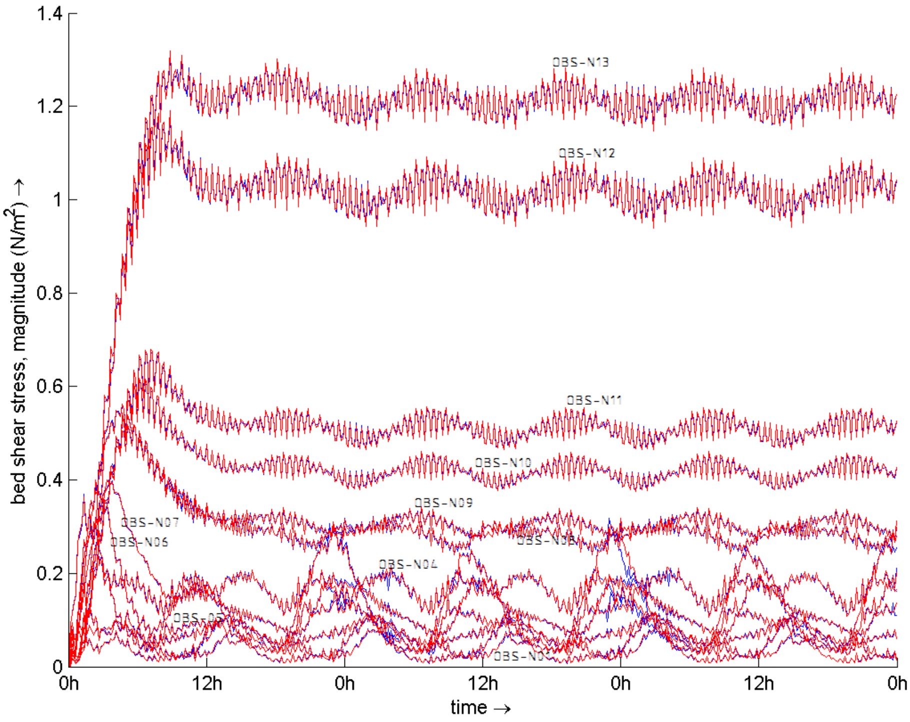


Figure 29: Bed Shear Stress Along North Beach –S1 Scenarios (Blue=PRE, Red=POST)

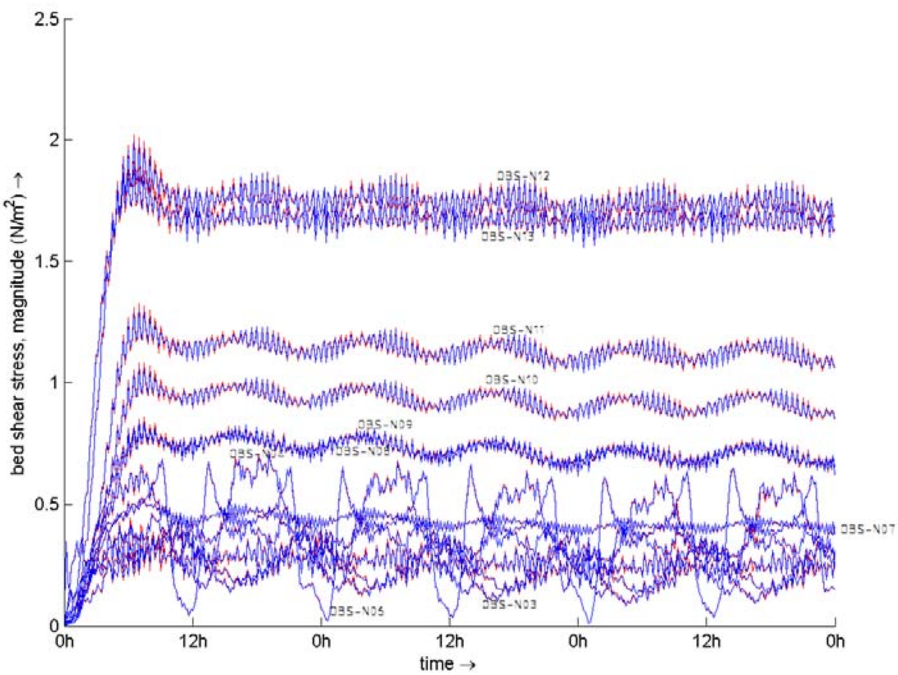


Figure 30: Bed Shear Stress Along North Beach –S2 Scenarios (Blue=PRE, Red=POST)

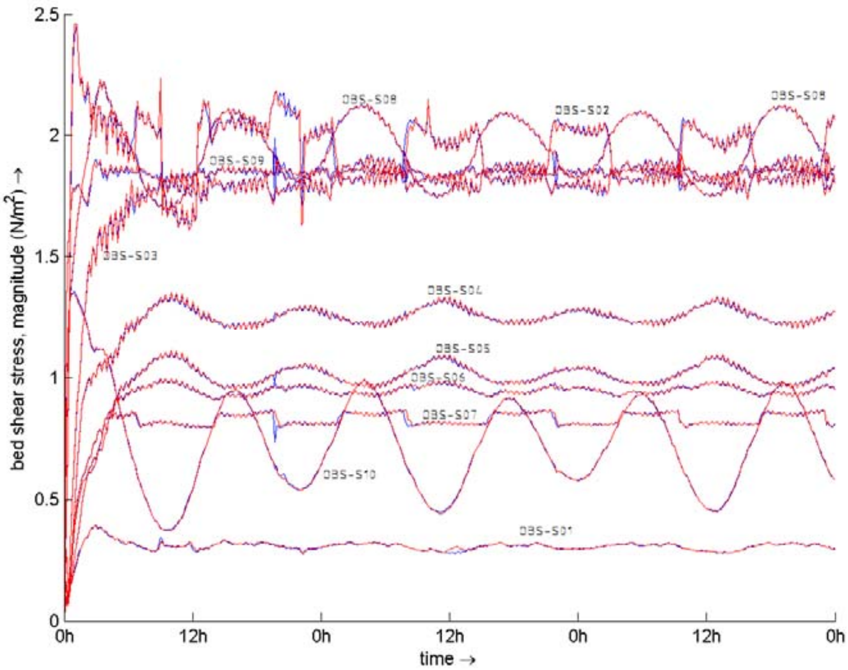


Figure 31: Bed Shear Stress Along South Beach –N1 Scenarios (Blue=PRE, Red=POST)

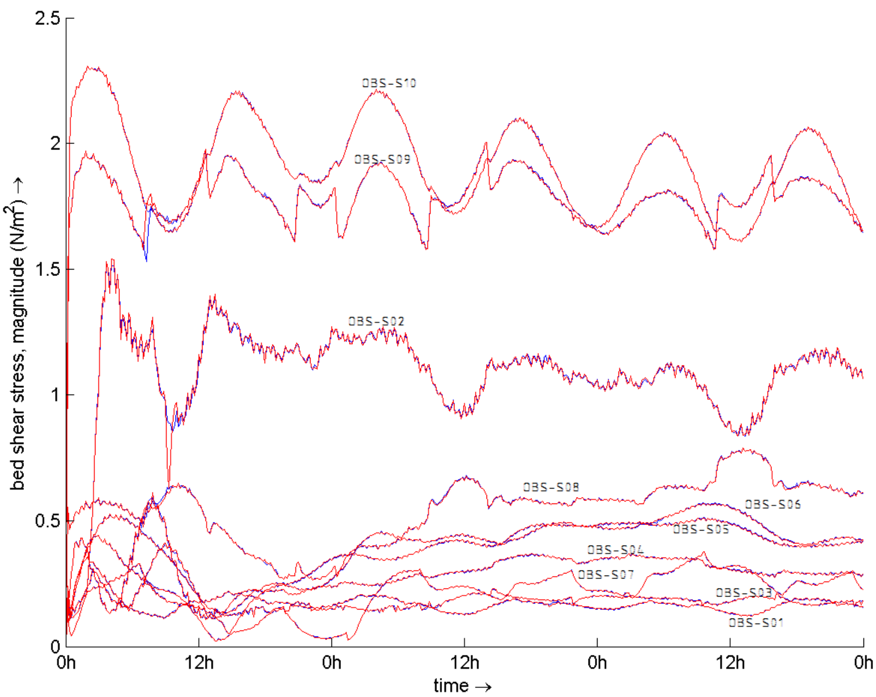


Figure 32: Bed Shear Stress Along South Beach –N2 Scenarios (Blue=PRE, Red=POST)

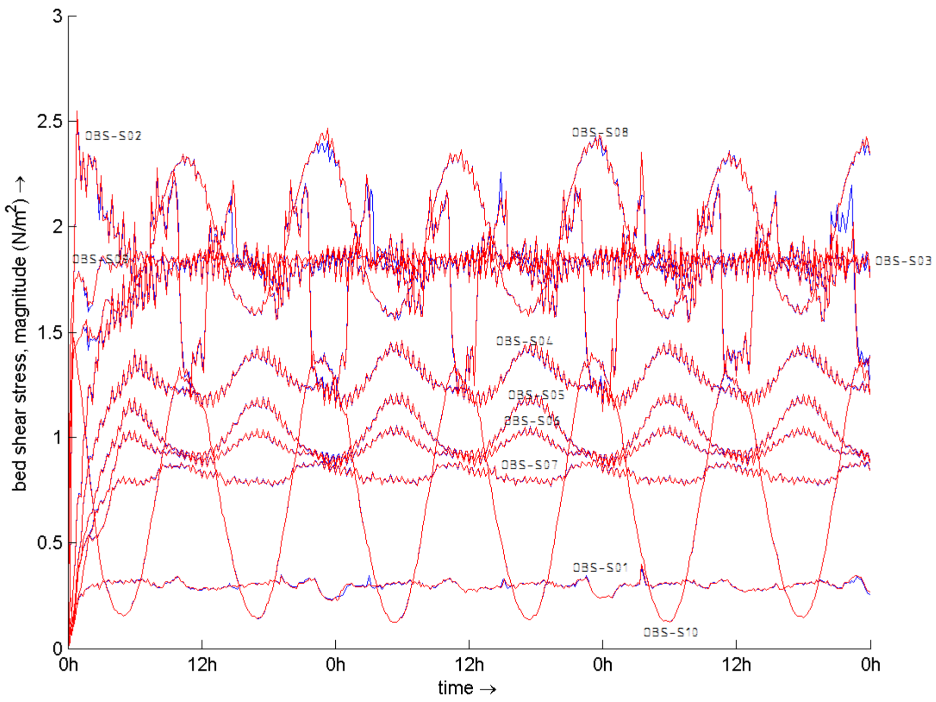


Figure 33: Bed Shear Stress Along South Beach –S1 Scenarios (Blue=PRE, Red=POST)

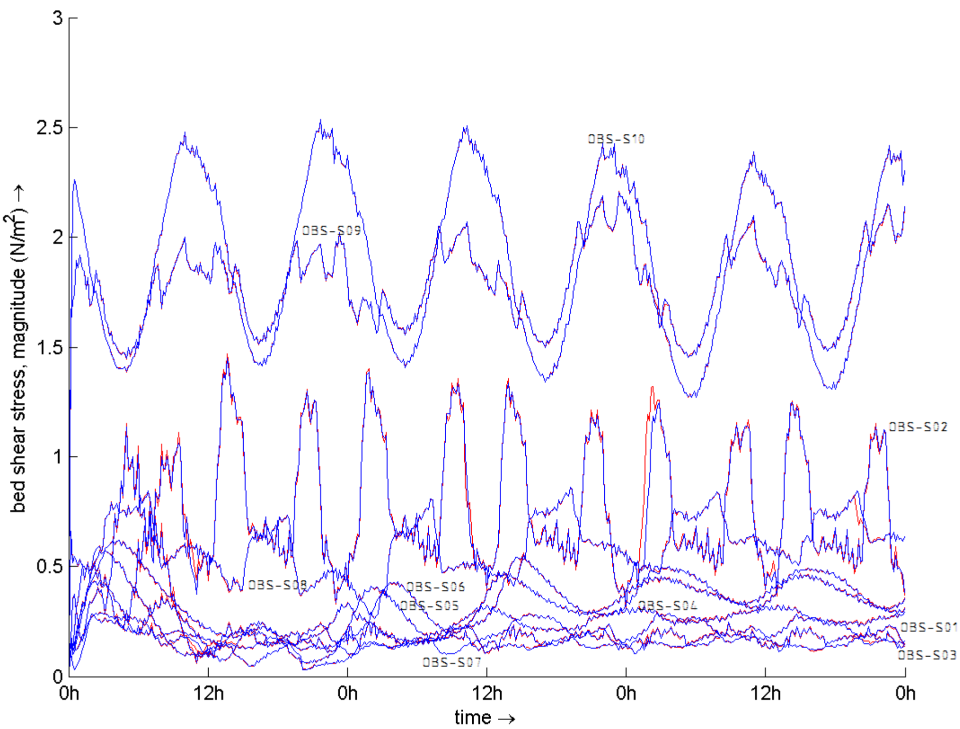


Figure 34: Bed Shear Stress Along South Beach –S2 Scenarios (Blue=PRE, Red=POST)

5.7.4 Turbidity Due to Offshore Dumping

The turbidity generated by sand winning offshore is much lower than that generated by the offshore dumping. This study has therefore concentrated on the offshore dumping process and the associated turbidity.

Figures 35 to 38 provide typical dispersion patterns for sediment plumes resulting from offshore dumping, based on the calculated discharge concentrations. The remnants of four hourly discharge plumes can clearly be seen as they are dispersed out of the model area. Under north easterly wind conditions it is clear that dispersion is more rapid due to the increased current velocity toward the south west.

The analysis indicates that suspended sediment concentrations four hours after discharge events are unlikely to exceed 0.005kg/m³, or 5mg/l and that concentrations, exceeding low risk levels, will not reach the shoreline.

The probability of greater than low risk suspended sediment concentrations due to dumping reaching the shoreline is very low and most probably negligible..

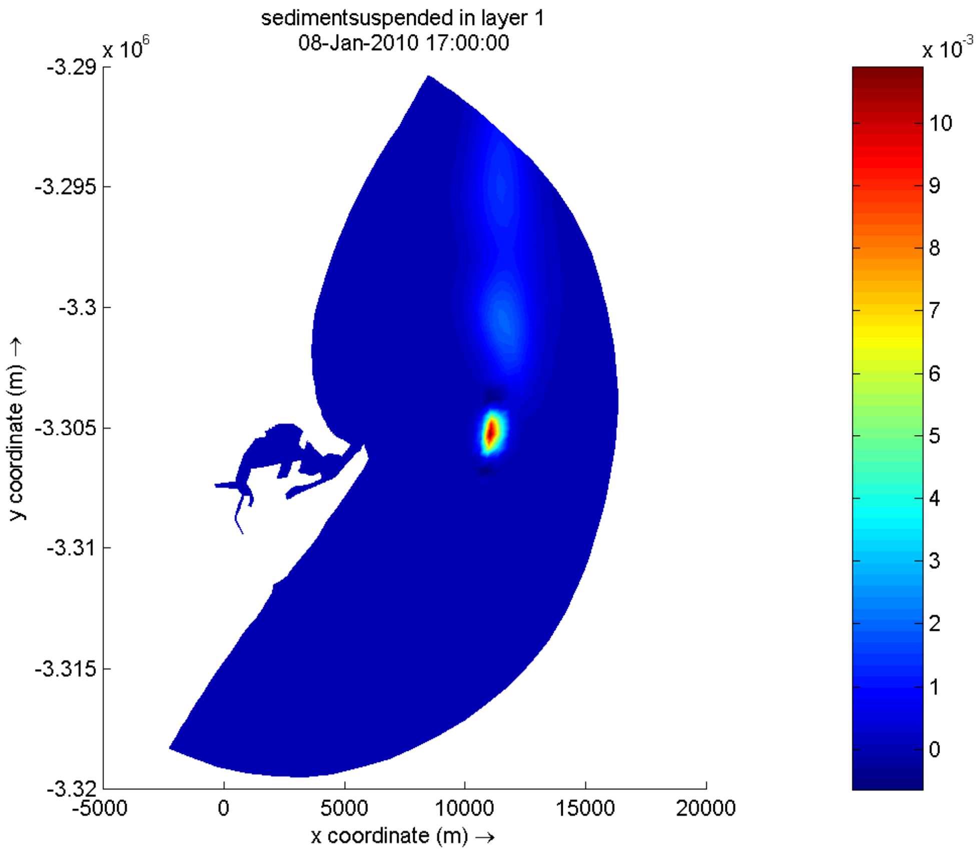


Figure 35a: Suspended Sediment Dispersion Due to Offshore Dumping- Surface Layer-1, N1 Scenario

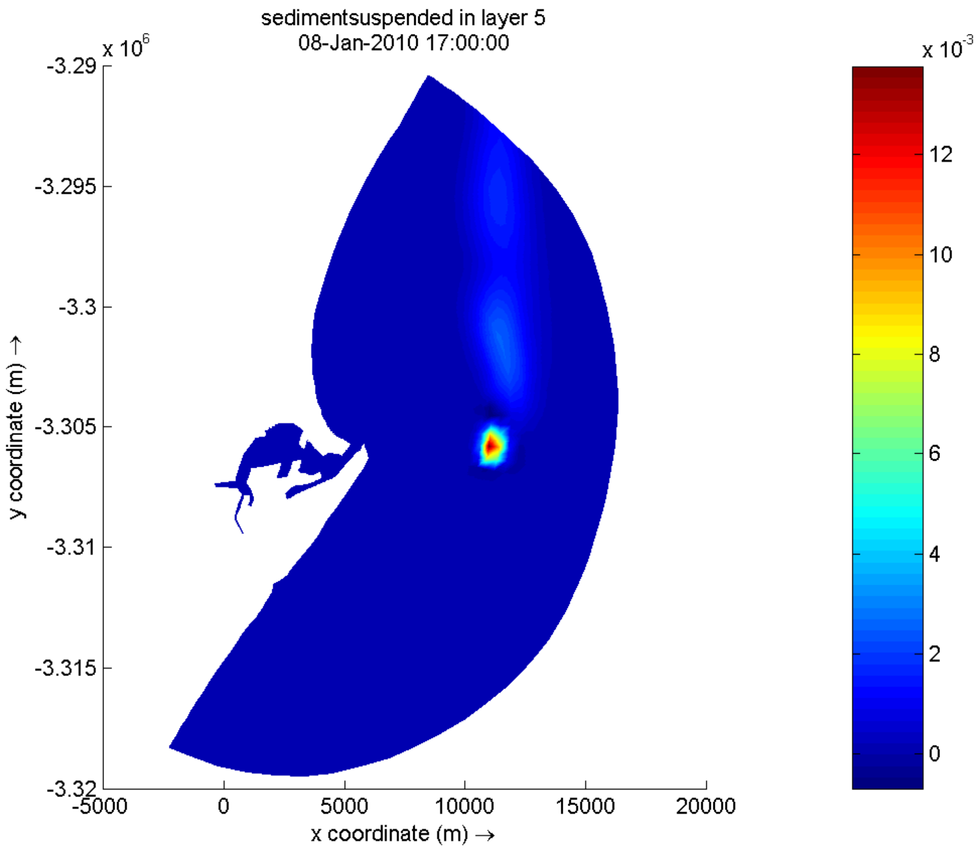


Figure 35b: Suspended Sediment Dispersion Due to Offshore Dumping Bottom Layer-5, N1 Scenario

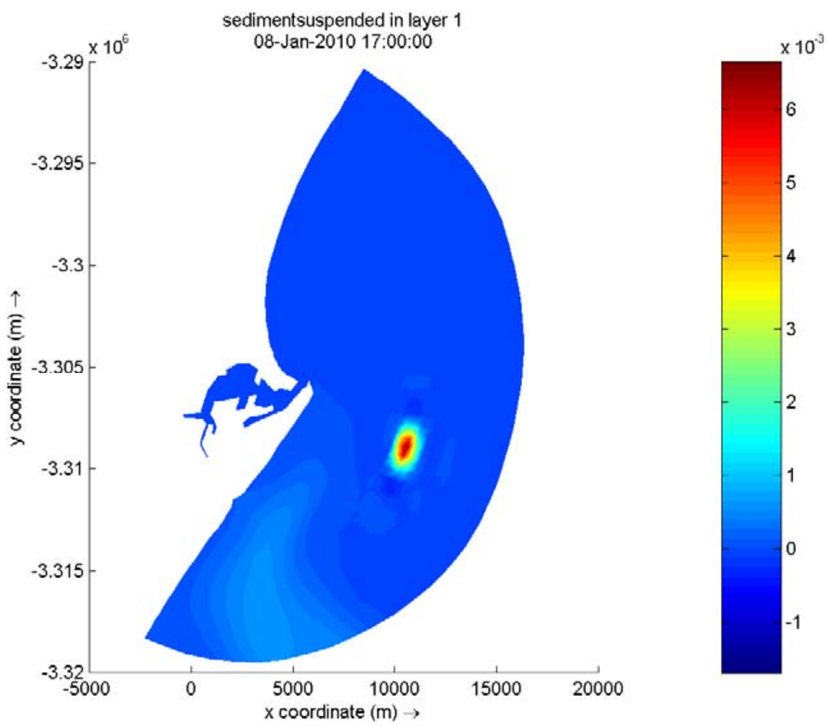


Figure 36a: Suspended Sediment Dispersion Due to Offshore Dumping Surface Layer-1, N2 Scenario

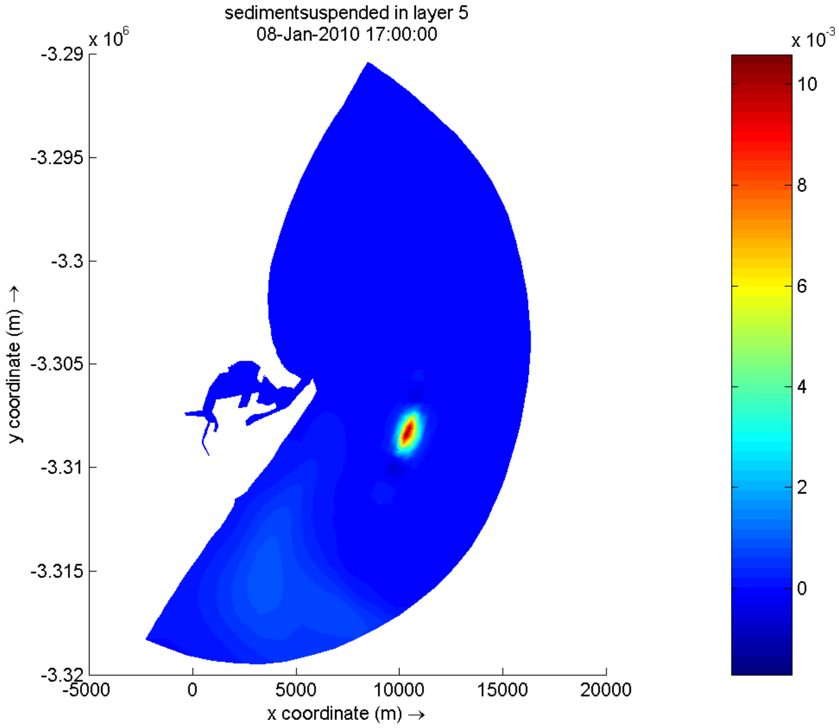


Figure 36b: Suspended Sediment Dispersion Due to Offshore Dumping Bottom Layer-5, N2 Scenario

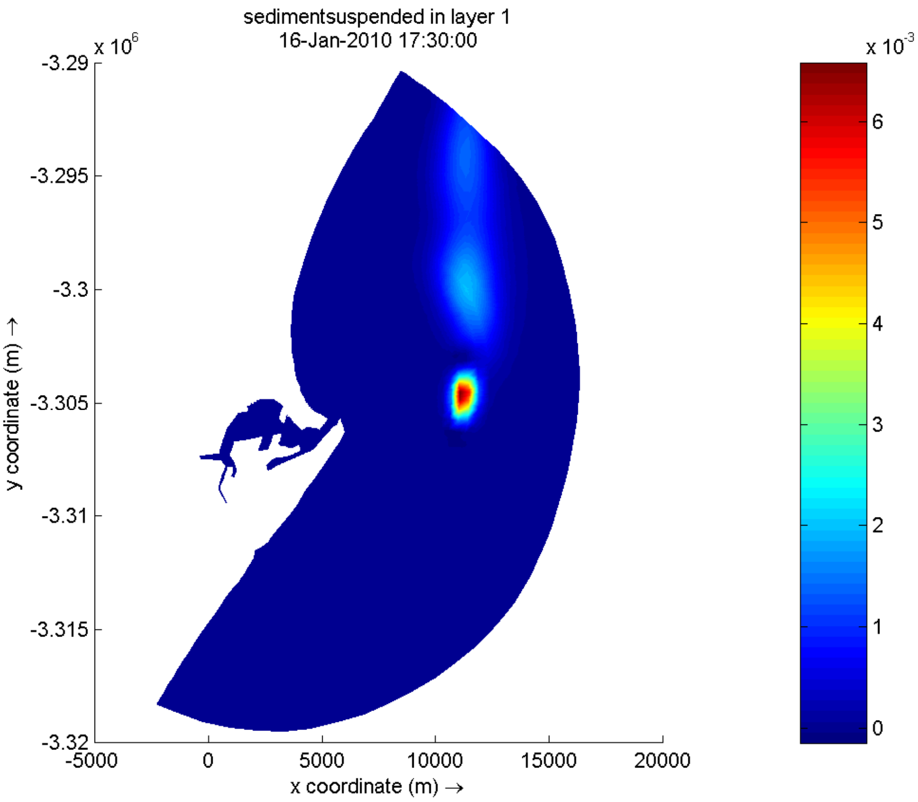


Figure 37a: Suspended Sediment Dispersion Due to Offshore Dumping Surface Layer-1, S1 Scenario

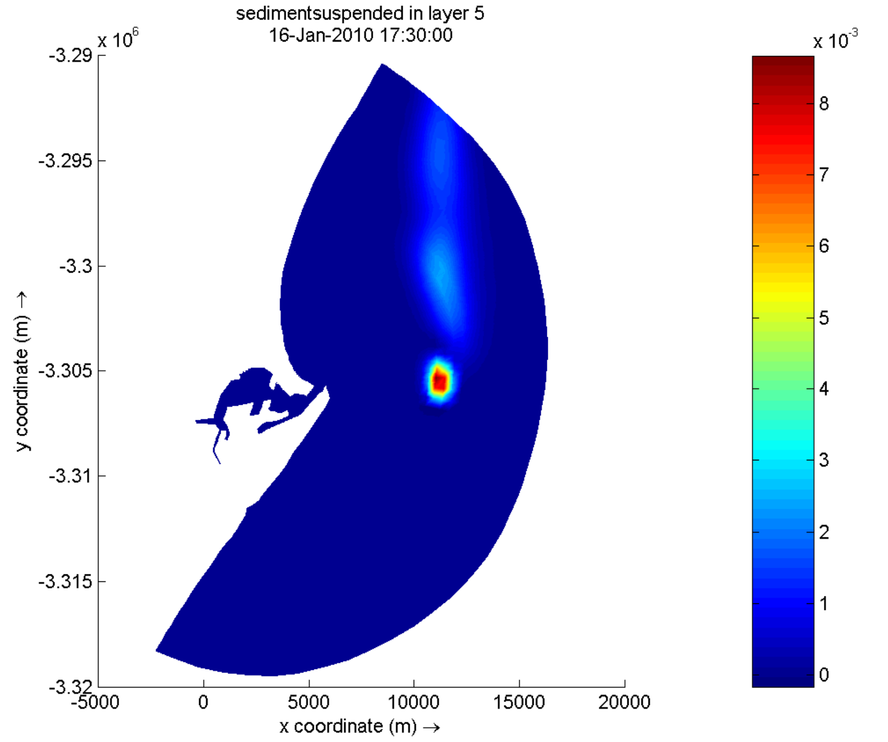


Figure 37b: Suspended Sediment Dispersion Due to Offshore Dumping Bottom Layer-5, S1 Scenario

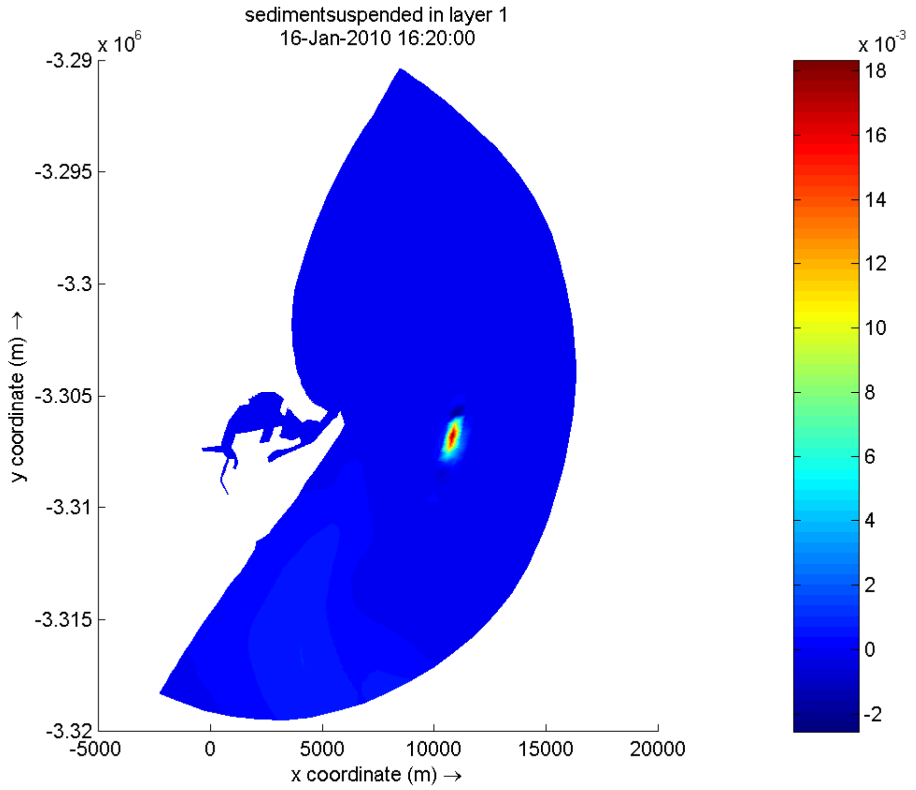


Figure 38a: Suspended Sediment Dispersion Due to Offshore Dumping Surface Layer-1, S2 Scenario

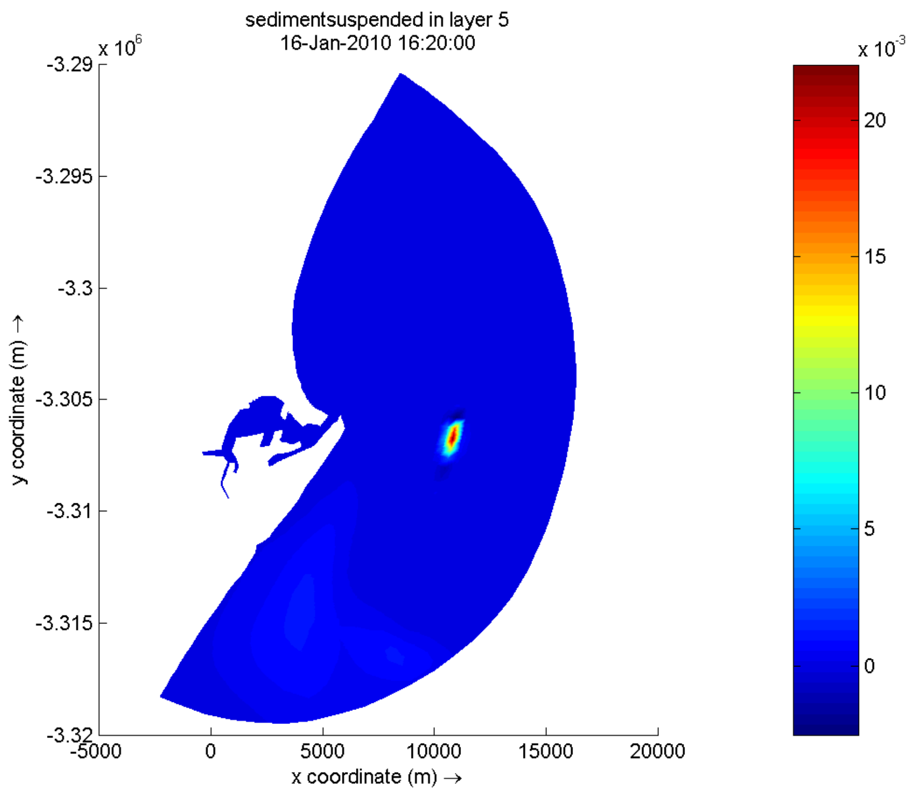


Figure 38b: Suspended Sediment Dispersion Due to Offshore Dumping Bottom Layer-5, S2 Scenario

6.0 CONCLUSIONS AND RECOMMENDATIONS

At the present stage of the feasibility study for the Deepening of Berths 203 to 205, no significant negative impacts on the environment as described and relating to increased turbidity and sediment erosion have been identified.

It is concluded that the physical extent of the proposed works is too limited to have any significant impact on the surrounding coastline and beaches.

In all cases the calculated suspended sediment concentrations have been found to be low, the peak values being less than 0.045kg/m³ (45mg/l) at dredging works being performed at Berth 205 and falling off rapidly to less than low risk levels at adjacent areas.

From the offshore disposal site maximum concentrations have been estimated to be below 0.005kg/m³ (5mg/l) after 4 hours and will not reach the shoreline at concentrations above low risk levels.

It is not anticipated that special dredging procedures or equipment will be required in order to reduce turbidity. All methods proposed in Report ZAA 1370-RPT-004 - Dredging Design and Survey, are well suited for the task and the preferred option may be selected based on type of material to be dredged and / or economic criteria. Nevertheless, turbidity levels will be monitored during the dredging and dumping process in order to ensure that the specified upper limits are not exceeded.

In mitigation for the loss of Central Sandbank area due to the deepening of the berths, an extension to the Little Lagoon was proposed for Options 3-C and 3-D, but this is currently not under consideration by TCP. However the extension of the Central Sandbank shown in Figures 1 and 2 is to proceed.

7.0 REFERENCES

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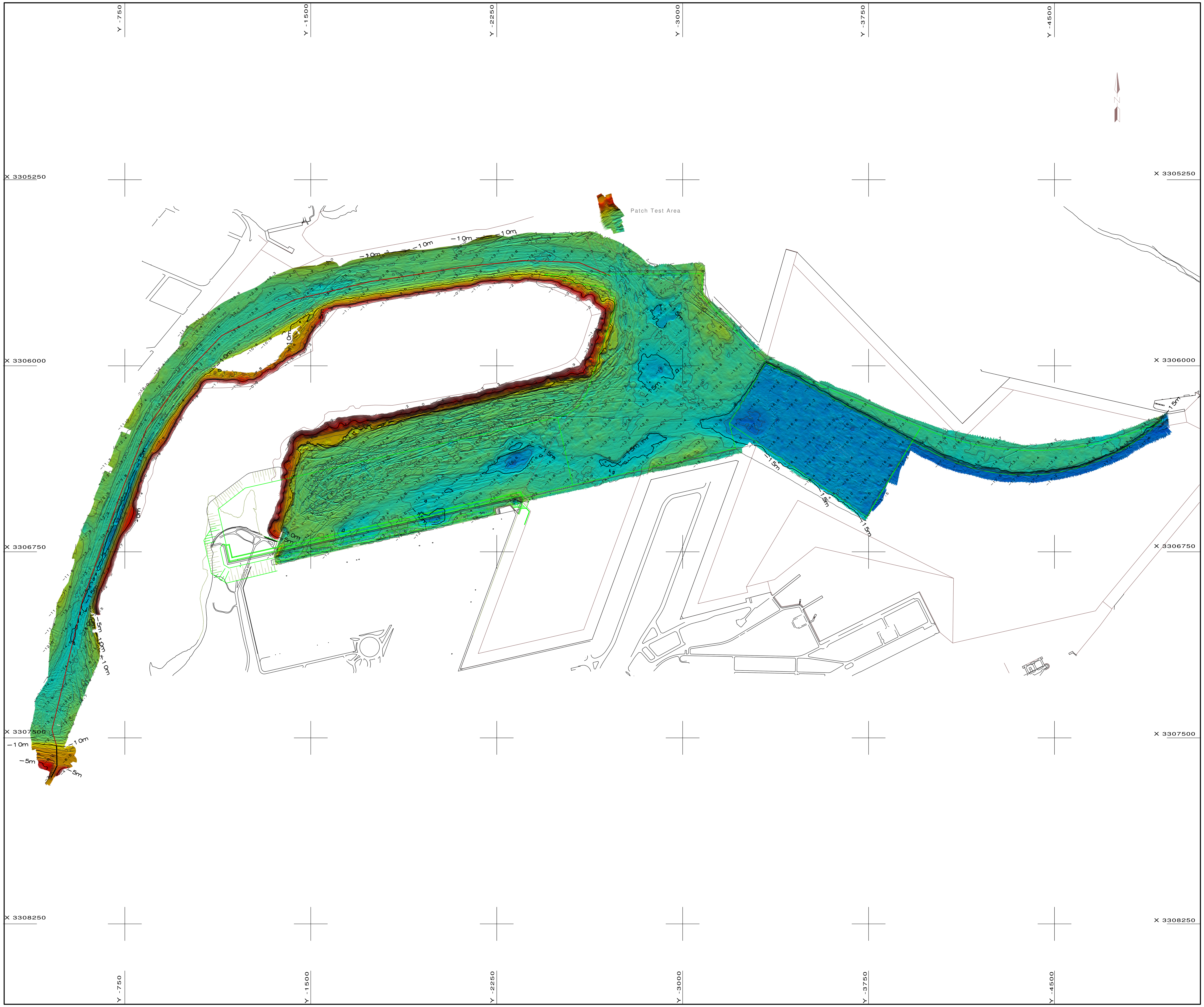
ANNEXURE 1 BATHYMTERIC SURVEYS : UWS



LEGEND:

WORK SCOPE AREA
MAJOR CONTOUR EVERY 5M
MINOR CONTOUR EVERY 1M
SOUNDINGS
LOT 10 CHANNEL CL < 12M
LOT 10 CHANNEL CL > 12M

COLOUR SCALE

0.00
-5.00
-10.00
-15.00
-20.00
-25.00

CHART DATUM

NOTES:

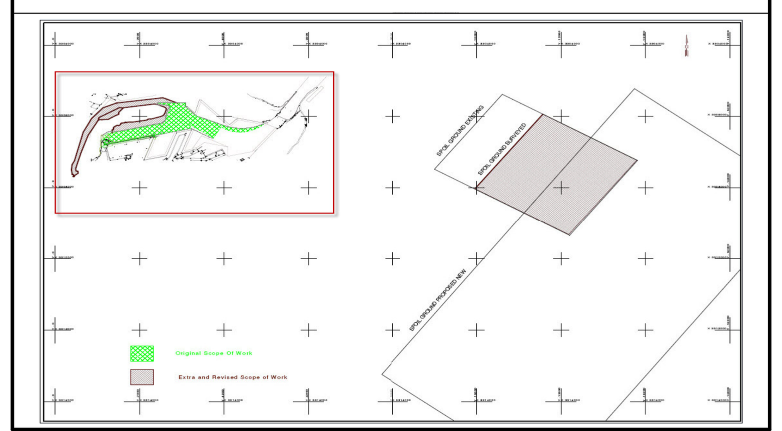
1. BOUNDARIES OF SURVEYED AREAS SUPPLIED BY CLIENT

GEODETIC PARAMETERS:

HORIZONTAL COORDINATE SYSTEM

GEODETIC DATUM	: HARTEBEESTHOEK (WGS 84)
ELLIPSOID	: WGS 84
Semi major axis	: 6378137.00
Inverse flattening	: 298.257223563
PROJECTION	: Gauss Conform LO 31
Central Meridian (CM)	: 31° East
Latitude of Origin	: 0°00' North
False Easting	: 0.00 m
False Northing	: 0.00 m
Scale factor at CM	: 1.0
VERTICAL DATUM	: CHART DATUM- (Port) - 0.9m Below MSL

LOCALITY MAP



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E-mail: info@underwatersurveys.com

BATHYMETRIC SURVEY

Durban Harbour Areas

1) Berths 203 to 205, Turning Basin and part of Channel
2) Sand Bank Perimeter
3) Lot 10 Dock and channel to the Turning Basin

SCALE 1 : 7500

0 80 400 800 metres

Vessel: BLUE DOLPHIN	Survey Date: APRIL 2012	Project Ref: 12/016				
Issue No:	Date:	Description:	Interpr:	Drawn:	Chkd:	Appr:
1	25-04-2012	FINAL	ADM	AJM	PV	SH

Contract No.:	Drawing No:	Chart:	Encl:
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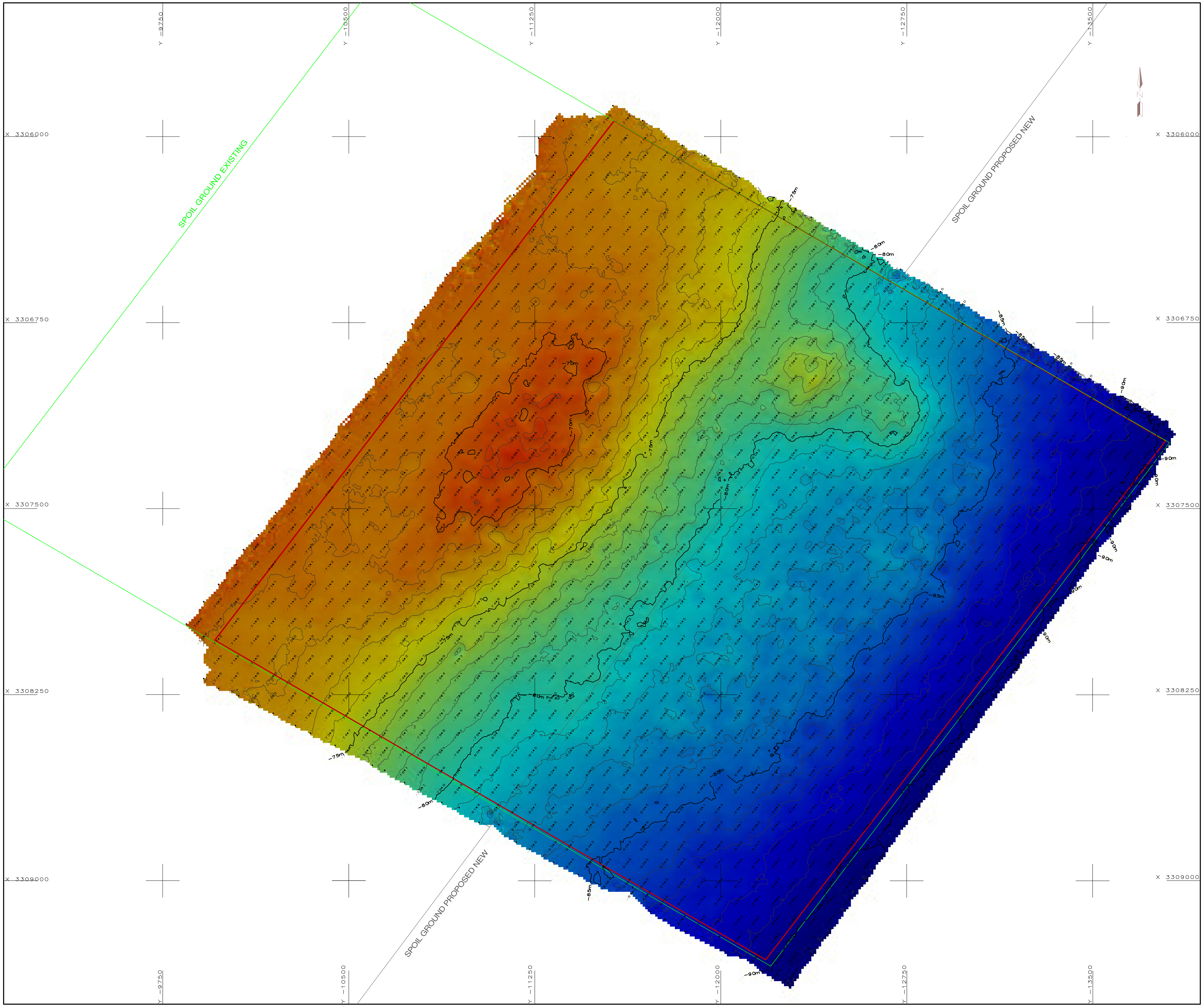


LEGEND:

- EXISTING DUMP SITE BOUNDARY
- PROPOSED DUMP SITE BOUNDARY
- WORK SCOPE AREA
- MAJOR CONTOUR EVERY 5M
- MINOR CONTOUR EVERY 1M
- SOUNDINGS

COLOUR SCALE

-60.00
-67.00
-74.00
-81.00
-88.00
-95.00

CHART DATUM

NOTES:

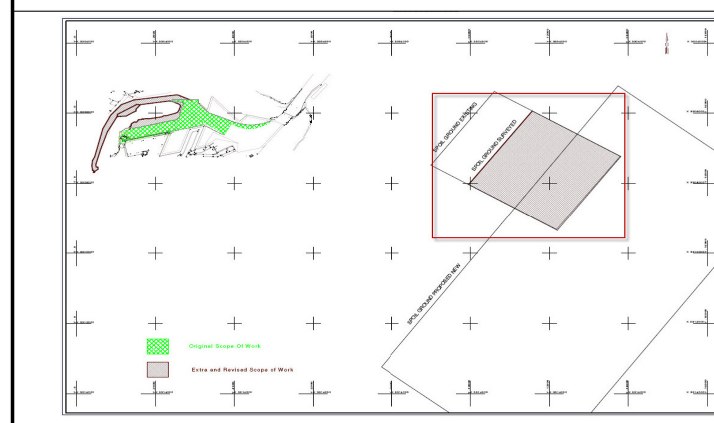
1. BOUNDARIES OF SURVEYED AREAS SUPPLIED BY CLIENT

GEODETIC PARAMETERS:

HORIZONTAL COORDINATE SYSTEM

GEODETIC DATUM	:HARTEBEESTHOEK (WGS 84)
ELLIPSOID	:WGS 84
Semi major axis	:6378137.00
Inverse flattening	:298.257223563
PROJECTION	:Gauss Conform LO 31
Central Meridian (CM)	:31° East
Latitude of Origin	:0°00' North
False Easting	:0.00 m
False Northing	:0.00 m
Scale factor at CM	:1.0
VERTICAL DATUM	:CHART DATUM (Port) - 0.9m Below MSL

LOCALITY MAP



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E-mail: info@underwatersurveys.com

BATHYMETRIC SURVEY

Dump Site

1) Part Existing and Part Proposed Spoil Areas

SCALE 1 : 7500

0 80 400 800 metres

Vessel: BLUE DOLPHIN		Survey Date: APRIL 2012	Project Ref: 12/016			
Issue No:	Date:	Description:	Interpr:	Drawn:	Chkd:	Appr:
1	25-04-2012	FINAL	ADM	AJM	PV	SH

Contract No.:	Drawing No:	Chart:	Encl:
	12-016_ZAA_DUMP_BATHY_CD_DCT1370	2 of 2	

ANNEXURE 2 : DREDGING DESIGN ALTERNATIVES

DO NOT SCALE - IF IN DOUBT, ASK

PLAN: DREDGING LAYOUT

1:5000

PORT APPROVAL			
TITLE	NAME	SIGNATURE	DATE
PORT ENGINEER			
HARBOUR MASTER			

DRAWING NO.	REFERENCE

REFERENCE DRAWINGS

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1370-DWG-1710 REV P00

NO.	DESCRIPTION	BY	CHK'D	APP'D	DATE
P00	PRELIMINARY	AYG	JZ	JZ	12-09-25

REVISIONS / ISSUE AUTHORIZATION

EPCM CONSULTANT: TCP

TITLE	NAME	SIGNATURE	DATE
LEAD DES. ENG.			
ENG. COORD.			
ENG. MANAGER			
AREA MANAGER			
PROJECT MGR.			

DIVISION

DIV.	TITLE	NAME	SIGNATURE	DATE

ORIGINATOR: ZAA

TITLE	NAME	SIGNATURE	DATE
DRAWN	AYG		12 09 25
CHECKED	JZ		12 09 25
ENG. COORD.	WV		12 09 25
DISCIP. ENG.			
ENG. MANAGER			
AREA MANAGER			

PR.ENG. / PR.TECH.

NAME: J. ZIETSMAN — DATE: 12 09 25
SIGNATURE
REG. NUMBER: 760293
SCALE : OR AS NOTED A1

TRANSNET

DURBAN CONTAINER TERMINAL
BERTH 203–205 DEEPENING

DREDGING MOORING BASIN LAYOUT OPTION 3G

PROJECT NUMBER	DV	FBS	DIS.	TYPE	DRG. NO.	SHT.	REV.	ID

Q:\1370 TCP 408 FEL 3 BERTHS 203 AND 205\Z-DRAWINGS\DWGS\1370-DWG-1700-OPTION3G.DWG
ANGELO GANGERDINE
2012-08-14

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PLAN: DREDGING LAYOUT

1:5000

NO.	DESCRIPTION	BY	CHK'D	APP'D	DATE
P01	REVISED SANDBANK AREA	AYG	JZ	JZ	12-08-31
P00	PRELIMINARY	AYG	JZ	JZ	12-08-01

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1370-DWG-1700 REV P01

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AREA MANAGER			
PROJECT MGR.			

DIVISION

DIV.	TITLE	NAME	SIGNATURE	DATE

ORIGINATOR: ZAA

TITLE	NAME	SIGNATURE	DATE
DRAWN	AYG		12 08 31
CHECKED	JZ		12 08 31
ENG. COORD.	WV		12 08 31
DISCIP. ENG.			
ENG. MANAGER			
AREA MANAGER			

PR.ENG. / PR.TECH.

NAME	J. ZIETSMAN	DATE
SIGNATURE		12 08 31
REG. NUMBER	760293	
SCALE :	OR AS NOTED	A1

TRANSNET

DURBAN CONTAINER TERMINAL

BERTH 203-205 DEEPENING DREDGING GENERAL LAYOUT OPTION 3F

PROJECT NUMBER	DV	FBS	DIS.	TYPE	DRG. NO.	SHT.	REV.	ID

$FILE$ $DATE$ $USERNAME$ $TIME$

SIZE:A1 DATE: 2006/12/05

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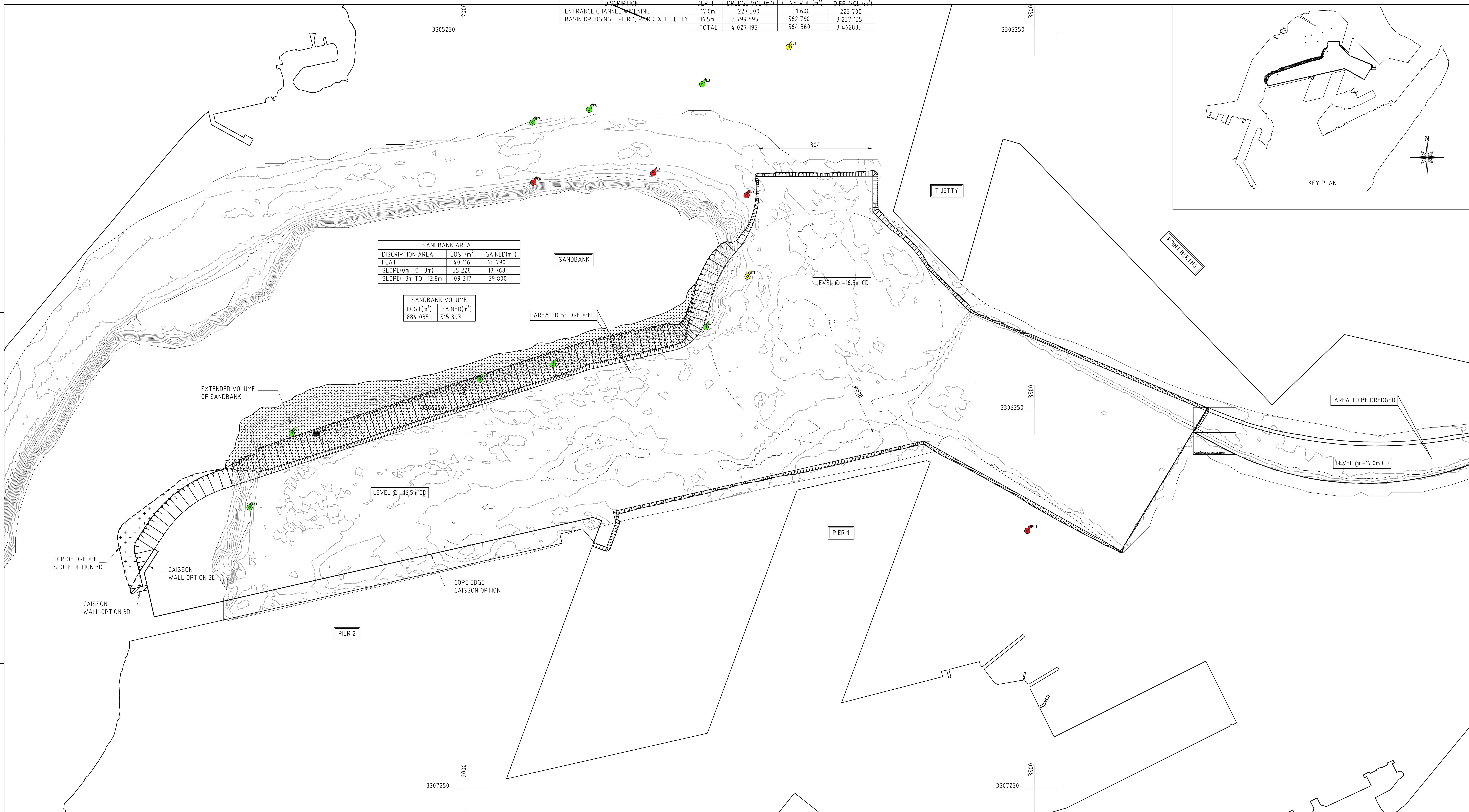
DISCRIPTION	DEPTH	DREDGING VOLUME: DREDGE VOL (m^3)	CLAY VOL (m^3)	DIFF. VOL (m^3)
ENTRANCE CHANNEL WIDENING	-17.0m	227 300	1 600	225 700
BASIN DREDGING - PIER 1, PIER 2 & T-JETTY	-16.5m	3 799 895	562 760	3 237 135
	TOTAL	4 027 195	564 360	3 462835

SANDBANK AREA		
DISCRIPTION AREA	LOST(m^2)	GAINED(m^2)
FLAT	40 116	66 790
SLOPE(0m TO -3m)	55 228	18 768
SLOPE(-3m TO -12.8m)	109 317	59 800

SANDBANK VOLUME	
LOST(m^3)	GAINED(m^3)
884 035	515 393



PLAN: DREDGING LAYOUT

1:5000

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P00	PRELIMINARY	AYG	JZ	JZ	12-07-25

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AREA MANAGER			
PROJECT MGR.			

DIVISION

DIV.	TITLE	NAME	SIGNATURE	DATE

ORIGINATOR: ZAA

TITLE	NAME	SIGNATURE	DATE
DRAWN	AYG		12 07 25
CHECKED	JZ		12 07 25
ENG. COORD.	WV		12 07 25
DISCIP. ENG.			
ENG. MANAGER			
AREA MANAGER			

PR.ENG. / PR.TECH.
NAME: J. ZIETSMAN
SIGNATURE — DATE 12 07 25
REG. NUMBER: 760293
SCALE: OR AS NOTED — A1

TRANSNET

DURBAN CONTAINER TERMINAL
BERTH 203-205 DEEPENING
DREDGING
GENERAL LAYOUT
OPTION 3E

PROJECT NUMBER	DV	FBS	DIS.	TYPE	DRG. NO.	SHT.	REV.	ID

SIZE:A1 DATE: 2006/12/05

DRAWING NUMBER

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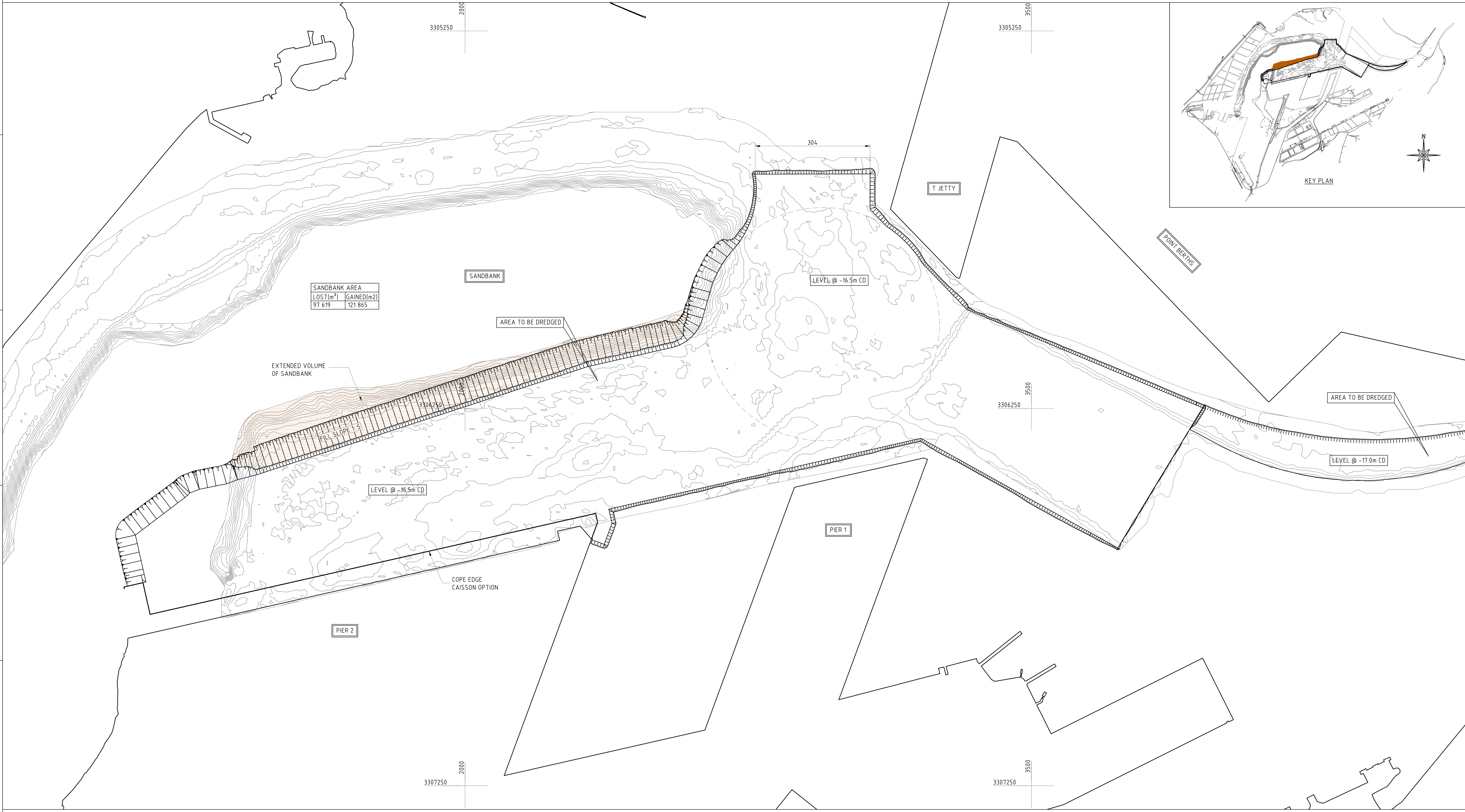

PLAN: DREDGING LAYOUT

1:5000

DRAWING NO.	REFERENCE

REFERENCE DRAWINGS

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AREA MANAGER			
PROJECT MGR.			

DIVISION

DIV.	TITLE	NAME	SIGNATURE	DATE

ORIGINATOR: ZAA

TITLE	NAME	SIGNATURE	DATE
DRAWN	AYG		12 07 02
CHECKED	JZ		12 07 02
ENG. COORD.	WV		12 07 02
DISCIP. ENG.			
ENG. MANAGER			
AREA MANAGER			

PR.ENG. / PR.TECH.

NAME	J. ZIETSMAN	DATE
SIGNATURE		12 07 02
REG. NUMBER	760293	
SCALE :	OR AS NOTED	A1

TRANSNET

DURBAN CONTAINER TERMINAL
BERTH 203-205 DEEPENING
DREDGING
GENERAL LAYOUT
OPTION 3D

PROJECT NUMBER	DV	FBS	DIS.	TYPE	DRG. NO.	SHT.	REV.	ID

SIZE:A1 DATE: 2006/12/05

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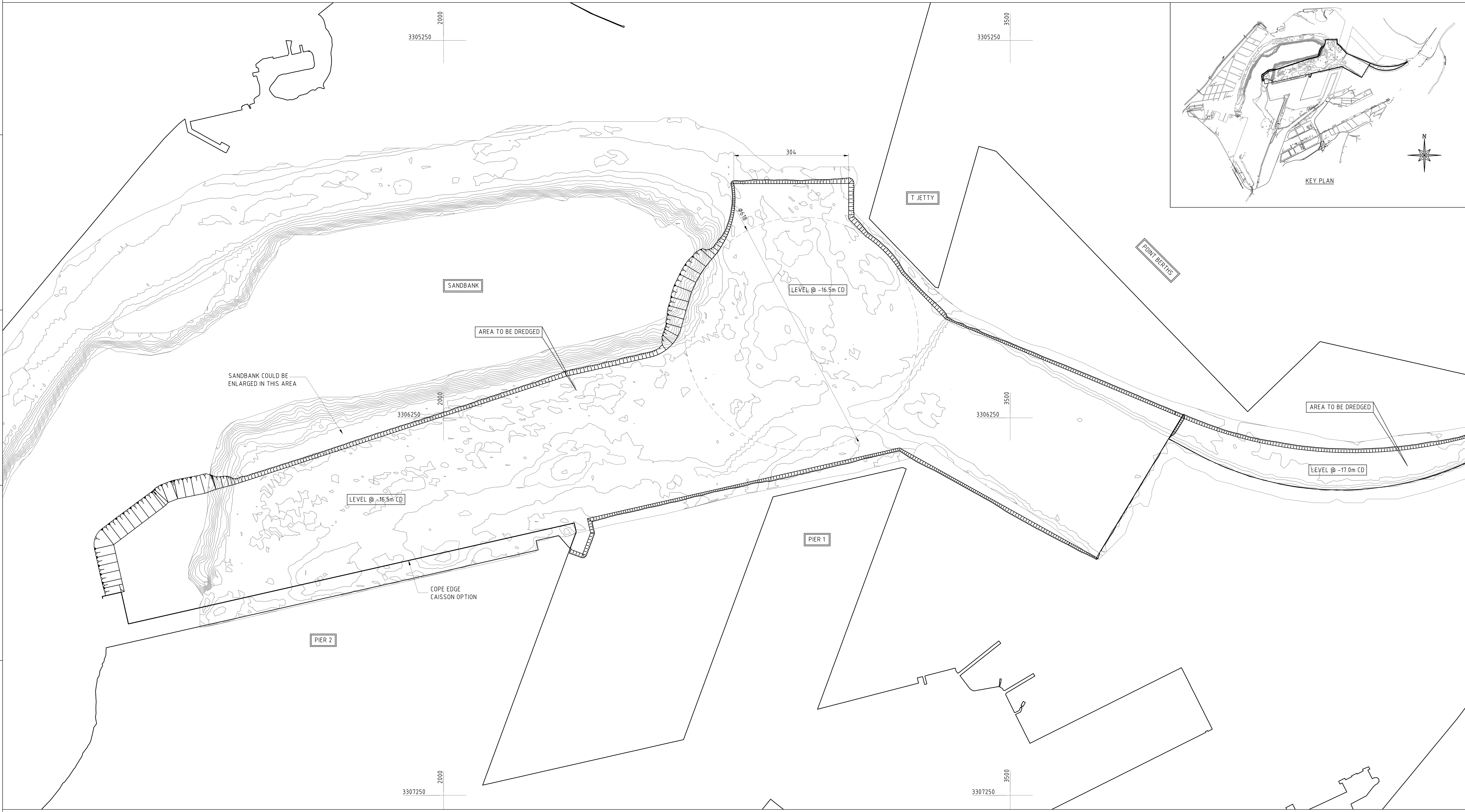
DO NOT SCALE - IF IN DOUBT, ASK



PLAN: DREDGING LAYOUT

1:5000

DRAWING NO.	REFERENCE
REFERENCE DRAWINGS	

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1370-DWG-1700 REV P00

NO.	DESCRIPTION	BY	CHK'D	APP'D	DATE
P00	PRELIMINARY	AYG	JZ	JZ	12-06-29

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LEAD DES. ENG.			
ENG. COORD.			
ENG. MANAGER			
AREA MANAGER			
PROJECT MGR.			

DIVISION

DIV.	TITLE	NAME	SIGNATURE	DATE

ORIGINATOR: ZAA

TITLE	NAME	SIGNATURE	DATE
DRAWN	AYG		12 06 29
CHECKED	JZ		12 06 29
ENG. COORD.	WV		12 06 29
DISCIP. ENG.			
ENG. MANAGER			
AREA MANAGER			

PR.ENG. / PR.TECH.

		DATE
NAME	J. ZIETSMAN	
SIGNATURE		12 06 29
REG. NUMBER	760293	
SCALE :	OR AS NOTED	A1

TRANSNET

DURBAN CONTAINER TERMINAL
BERTH 203-205 DEEPENING
DREDGING
GENERAL LAYOUT
OPTION 3C

PROJECT NUMBER	DV	FBS	DIS.	TYPE	DRG. NO.	SHT.	REV.	ID

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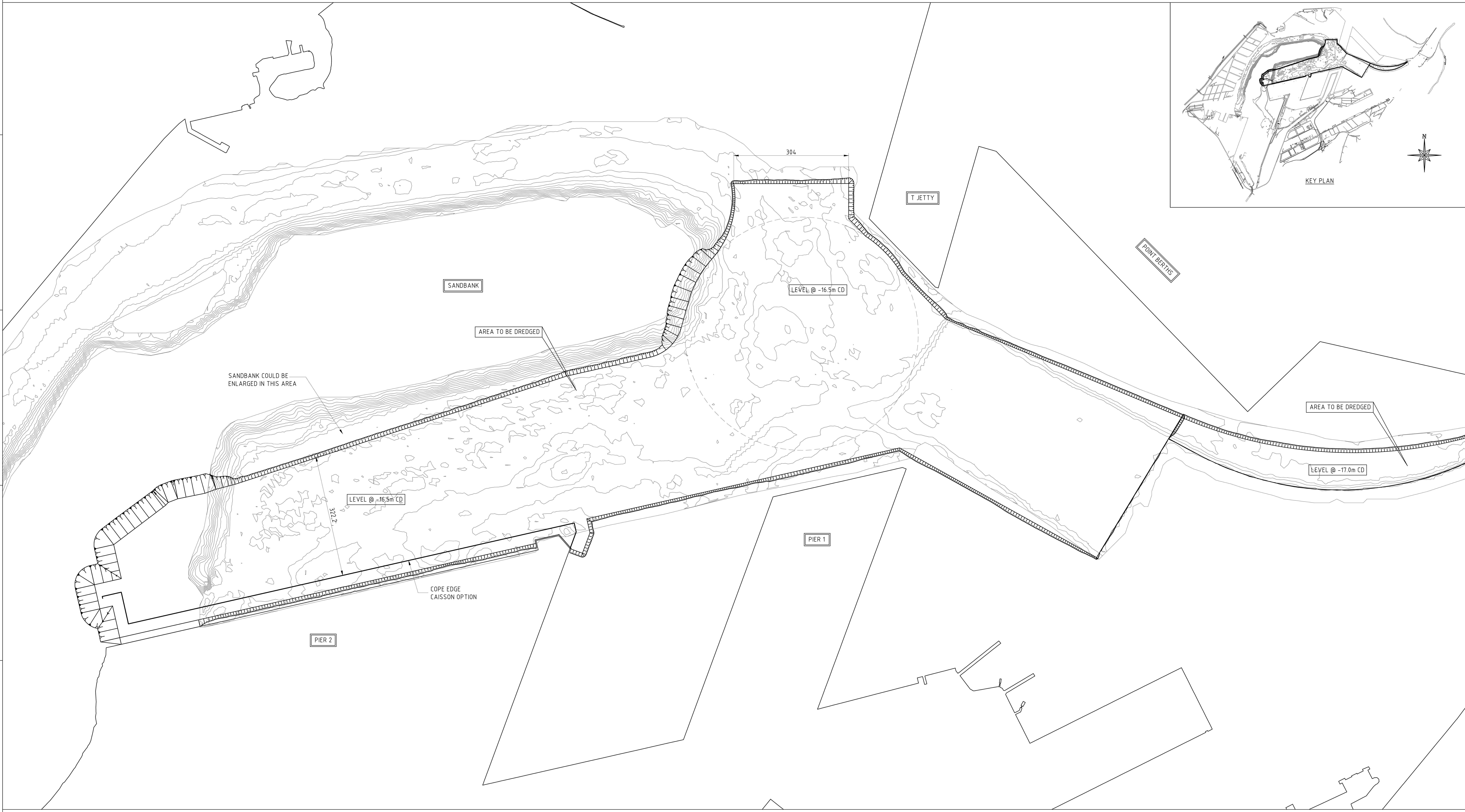
SIZE:A1 DATE: 2006/12/05

DO NOT SCALE - IF IN DOUBT, ASK



PLAN: DREDGING LAYOUT

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DRAWING NO.	REFERENCE

REFERENCE DRAWINGS

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P00	PRELIMINARY	AYG	JZ	JZ	12-06-18

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TITLE	NAME	SIGNATURE	DATE
LEAD DES. ENG.			
ENG. COORD.			
ENG. MANAGER			
AREA MANAGER			
PROJECT MGR.			

DIVISION

DIV.	TITLE	NAME	SIGNATURE	DATE

ORIGINATOR: ZAA

TITLE	NAME	SIGNATURE	DATE
DRAWN	AYG		12 06 18
CHECKED	JZ		12 06 18
ENG. COORD.	WV		12 06 18
DISCIP. ENG.			
ENG. MANAGER			
AREA MANAGER			

PR.ENG. / PR.TECH.

NAME	J. ZIETSMAN	DATE
SIGNATURE		12 06 18
REG. NUMBER	760293	
SCALE :	OR AS NOTED	A1

TRANSNET

DURBAN CONTAINER TERMINAL

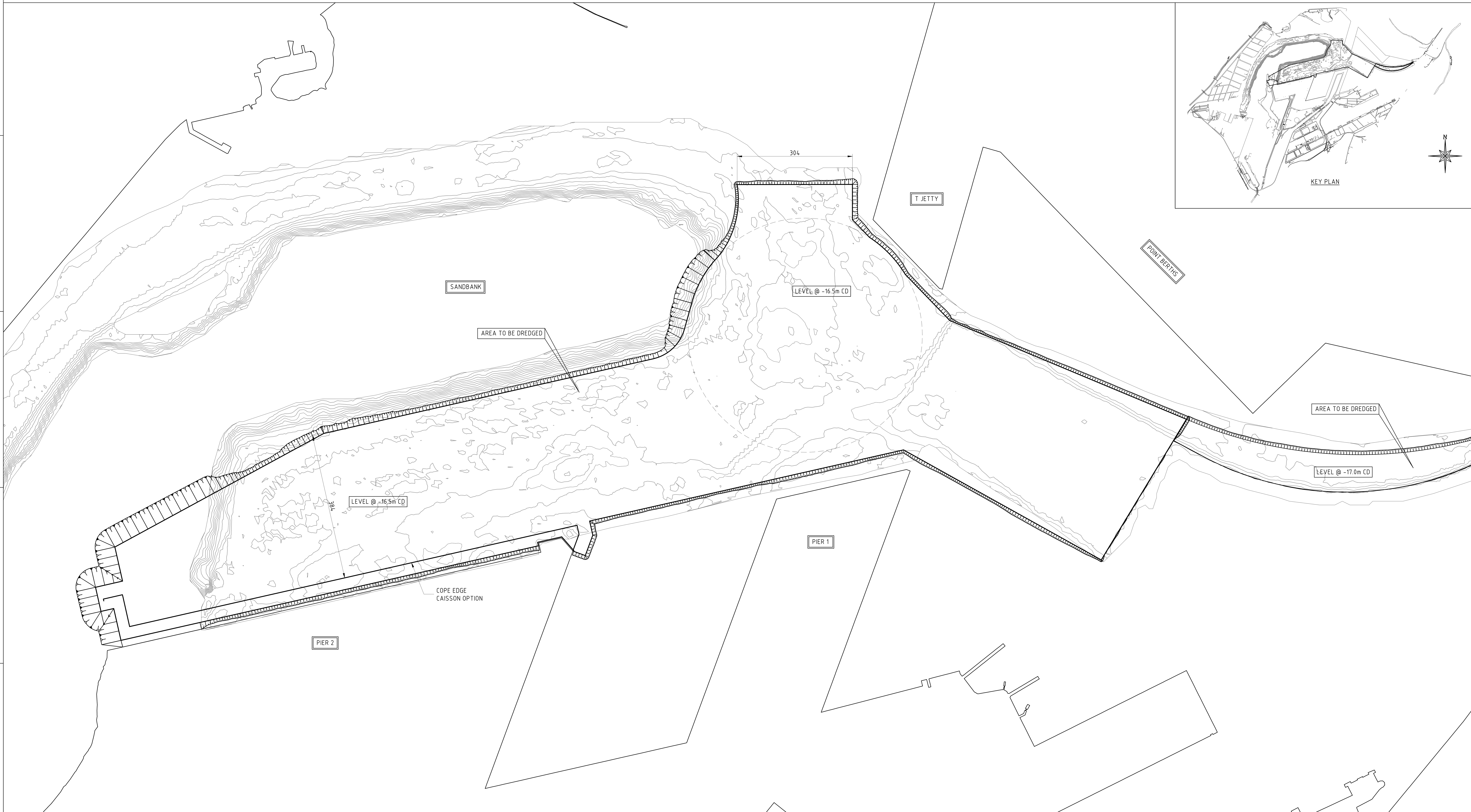
BERTH 203-205 DEEPENING DREDGING GENERAL LAYOUT OPTION 3B

PROJECT NUMBER	DV	FBS	DIS.	TYPE	DRG. NO.	SHT.	REV.	ID

SIZE:A1 DATE: 2006/12/05

$FILE$ $DATE$ $USERNAME$ $TIME$

DO NOT SCALE - IF IN DOUBT, ASK



PLAN: DREDGING LAYOUT

1:5000

DRAWING NO.	REFERENCE

REFERENCE DRAWINGS

Engineers

ZAA ENGINEERING PROJECTS & NAVAL ARCHITECTS

PO Box 26546
HOUT BAY 7872
Tel: +2721 791 9100
EMAIL : zaaepna@zaaepna.com

31 Melkhout Crescent
HOUT BAY 7806
Fax: +2721 790 4470
www.zaaepna.com

1370-DWG-1700 REV P00

NO.	DESCRIPTION	BY	CHK'D	APP'D	DATE
P00	PRELIMINARY	AYG	JZ	JZ	12-06-18

REVISIONS / ISSUE AUTHORIZATION

EPCM CONSULTANT: TCP

TITLE	NAME	SIGNATURE	DATE
LEAD DES. ENG.			
ENG. COORD.			
ENG. MANAGER			
AREA MANAGER			
PROJECT MGR.			

DIVISION

DIV.	TITLE	NAME	SIGNATURE	DATE

ORIGINATOR: ZAA

TITLE	NAME	SIGNATURE	DATE
DRAWN	AYG		12 06 18
CHECKED	JZ		12 06 18
ENG. COORD.	WV		12 06 18
DISCIP. ENG.			
ENG. MANAGER			
AREA MANAGER			

PR.ENG. / PR.TECH.

NAME J. ZIETSMAN DATE 12 06 18
SIGNATURE
REG. NUMBER 760293
SCALE : OR AS NOTED A1

TRANSNET

DURBAN CONTAINER TERMINAL
BERTH 203-205 DEEPENING
DREDGING
GENERAL LAYOUT
OPTION 4

PROJECT NUMBER	DV	FBS	DIS.	TYPE	DRG. NO.	SHT.	REV.	ID

SIZE:A1 DATE: 2006/12/05

DO NOT SCALE - IF IN DOUBT, ASK

PLAN: SCOUR PROTECTION LAYOUT-OPTION 3 (CAISSON OPTION ILLUSTRATED)

1:5000

DRAWING NO.	REFERENCE
1370-DWG-1859	DECK ON PILE OPTION, SCOUR PROTECTION, SHEET 7 OF 7
1370-DWG-1858	SHEET PILE OPTION, SCOUR PROTECTION, SHEET 6 OF 7
1370-DWG-1857	CAISSON OPTION, SCOUR PROTECTION, SHEET 5 OF 7
1370-DWG-1856	SCOUR PROTECTION SECTIONS FOR ROCK, SHEET 4 OF 7
1370-DWG-1855	SCOUR PROTECTION SECTIONS FOR ROCK, SHEET 3 OF 7
1370-DWG-1854	SCOUR PROTECTION SECTIONS FOR MATS, SHEET 2 OF 7
1370-DWG-1853	SCOUR PROTECTION SECTIONS FOR MATS, SHEET 1 OF 7

REFERENCE DRAWINGS

Engineers

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1370-DWG-1852 REV P00

NO.	DESCRIPTION	BY	CHK'D	APP'D	DATE
P00	PRELIMINARY	AYG	JZ	JZ	12-05-31

REVISIONS / ISSUE AUTHORIZATION

EPCM CONSULTANT: TCP

TITLE	NAME	SIGNATURE	DATE
LEAD DES. ENG.			
ENG. COORD.			
ENG. MANAGER			
AREA MANAGER			
PROJECT MGR.			

DIVISION

DIV.	TITLE	NAME	SIGNATURE	DATE

ORIGINATOR: ZAA

TITLE	NAME	SIGNATURE	DATE
DRAWN	AYG		12 05 31
CHECKED	JZ		12 05 31
ENG. COORD.	WV		12 05 31
DISCIP. ENG.			
ENG. MANAGER			
AREA MANAGER			

PR.ENG. / PR.TECH.

NAME J. ZIETSMAN — DATE

SIGNATURE 12 05 31

REG. NUMBER 760293

SCALE : AS SHOWN OR AS NOTED A1

TRANSNET

DURBAN CONTAINER TERMINAL

BERTH 203-205 DEEPENING
SCOUR PROTECTION
GENERAL LAYOUT
OPTION3

PROJECT NUMBER	DV	FBS	DIS.	TYPE	DRG. NO.	SHT.	REV.	ID

$FILE$ $DATE$ $USERNAME$ $TIME$

SIZE:A1 DATE: 2006/12/05

DO NOT SCALE - IF IN DOUBT, ASK

PLAN: SCOUR PROTECTION LAYOUT-OPTION 2
(DECK ON PILE OPTION ILLUSTRATED)

1:5000

DRAWING NO.	REFERENCE
1370-DWG-1859	DECK ON PILE OPTION, SCOUR PROTECTION, SHEET 7 OF 7
1370-DWG-1858	SHEET PILE OPTION, SCOUR PROTECTION, SHEET 6 OF 7
1370-DWG-1857	CAISSON OPTION, SCOUR PROTECTION, SHEET 5 OF 7
1370-DWG-1856	SCOUR PROTECTION SECTIONS FOR ROCK, SHEET 4 OF 7
1370-DWG-1855	SCOUR PROTECTION SECTIONS FOR ROCK, SHEET 3 OF 7
1370-DWG-1854	SCOUR PROTECTION SECTIONS FOR MATS, SHEET 2 OF 7
1370-DWG-1853	SCOUR PROTECTION SECTIONS FOR MATS, SHEET 1 OF 7

REFERENCE DRAWINGS

Engineers

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1370-DWG-1851 REV P00

NO.	DESCRIPTION	BY	CHK'D	APP'D	DATE
P00	PRELIMINARY	AYG	JZ	JZ	12-05-31

REVISIONS / ISSUE AUTHORIZATION

EPCM CONSULTANT: TCP

TITLE	NAME	SIGNATURE	DATE
LEAD DES. ENG.			
ENG. COORD.			
ENG. MANAGER			
AREA MANAGER			
PROJECT MGR.			

DIVISION

DIV.	TITLE	NAME	SIGNATURE	DATE

ORIGINATOR: ZAA

TITLE	NAME	SIGNATURE	DATE
DRAWN	AYG		12 05 31
CHECKED	JZ		12 05 31
ENG. COORD.	WV		12 05 31
DISCIP. ENG.			
ENG. MANAGER			
AREA MANAGER			

PR.ENG. / PR.TECH.

NAME	J. ZIETSMAN	DATE
SIGNATURE		12 05 31
REG. NUMBER	760293	
SCALE : AS SHOWN	OR AS NOTED	A1

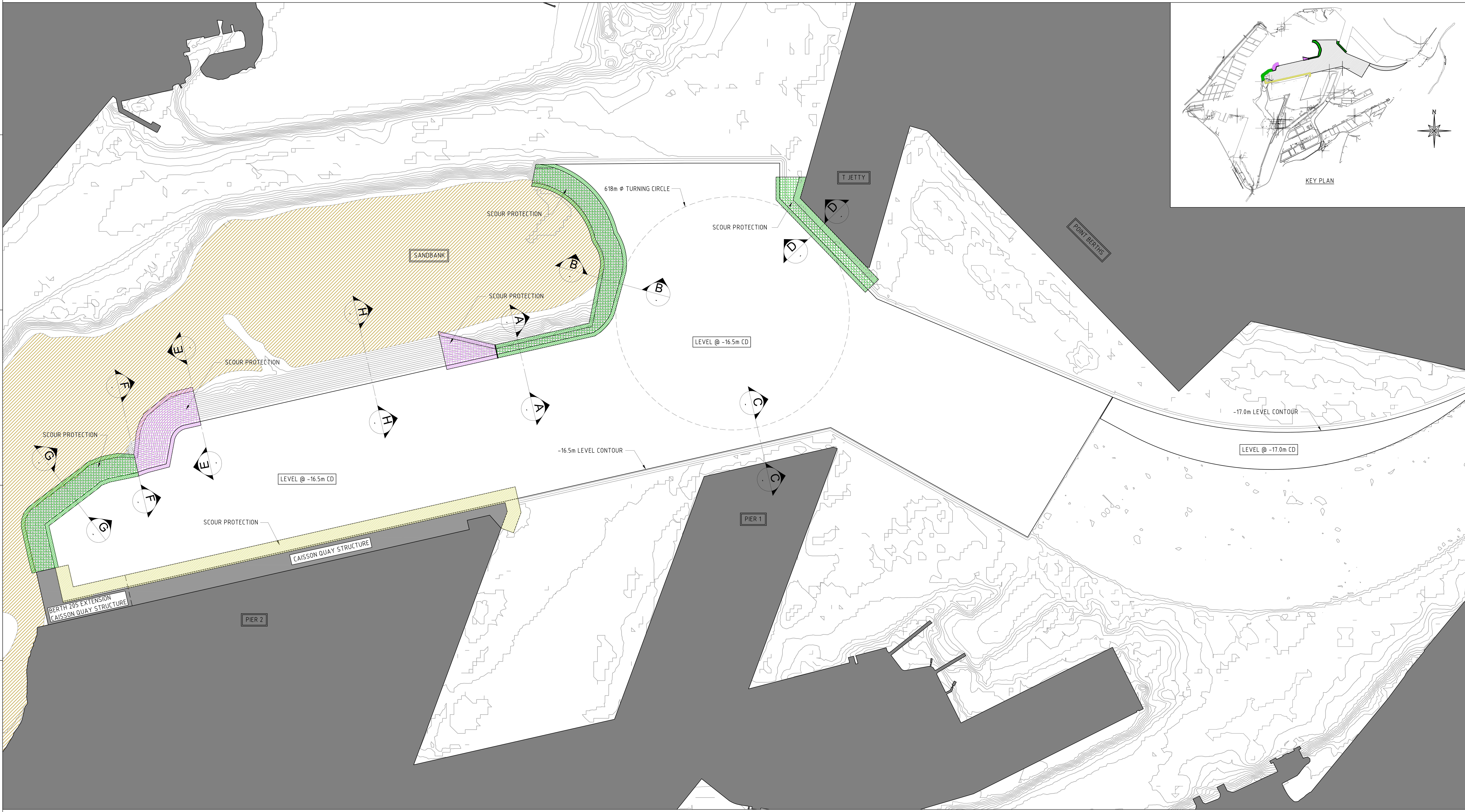
TRANSNET

DURBAN CONTAINER TERMINAL
BERTH 203-205 DEEPENING
SCOUR PROTECTION
GENERAL LAYOUT
OPTION2

PROJECT NUMBER	DV	FBS	DIS.	TYPE	DRG. NO.	SHT.	REV.	ID

SIZE:A1 DATE: 2006/12/05

DO NOT SCALE - IF IN DOUBT, ASK



PLAN: SCOUR PROTECTION LAYOUT-OPTION 1 (CAISSON OPTION ILLUSTRATED)

1:5000

DRAWING NO.	REFERENCE
1370-DWG-1859	DECK ON PILE OPTION, SCOUR PROTECTION, SHEET 7 OF 7
1370-DWG-1858	SHEET PILE OPTION, SCOUR PROTECTION, SHEET 6 OF 7
1370-DWG-1857	CAISSON OPTION, SCOUR PROTECTION, SHEET 5 OF 7
1370-DWG-1856	SCOUR PROTECTION SECTIONS FOR ROCK, SHEET 4 OF 7
1370-DWG-1855	SCOUR PROTECTION SECTIONS FOR ROCK, SHEET 3 OF 7
1370-DWG-1854	SCOUR PROTECTION SECTIONS FOR MATS, SHEET 2 OF 7
1370-DWG-1853	SCOUR PROTECTION SECTIONS FOR MATS, SHEET 1 OF 7

REFERENCE DRAWINGS

Engineers

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1370-DWG-1850 REV P00

NO.	DESCRIPTION	BY	CHK'D	APP'D	DATE
P00	PRELIMINARY	AYG	JZ	JZ	12-05-31

REVISIONS / ISSUE AUTHORIZATION

EPCM CONSULTANT: TCP

TITLE	NAME	SIGNATURE	DATE
LEAD DES. ENG.			
ENG. COORD.			
ENG. MANAGER			
AREA MANAGER			
PROJECT MGR.			

DIVISION

DIV.	TITLE	NAME	SIGNATURE	DATE

ORIGINATOR: ZAA

TITLE	NAME	SIGNATURE	DATE
DRAWN	AYG		12 05 31
CHECKED	JZ		12 05 31
ENG. COORD.	WV		12 05 31
DISCIP. ENG.			
ENG. MANAGER			
AREA MANAGER			

PR.ENG. / PR.TECH.

NAME J. ZIETSMAN — DATE 12 05 31

SIGNATURE

REG. NUMBER 760293

SCALE : AS SHOWN OR AS NOTED A1

TRANSNET

DURBAN CONTAINER TERMINAL

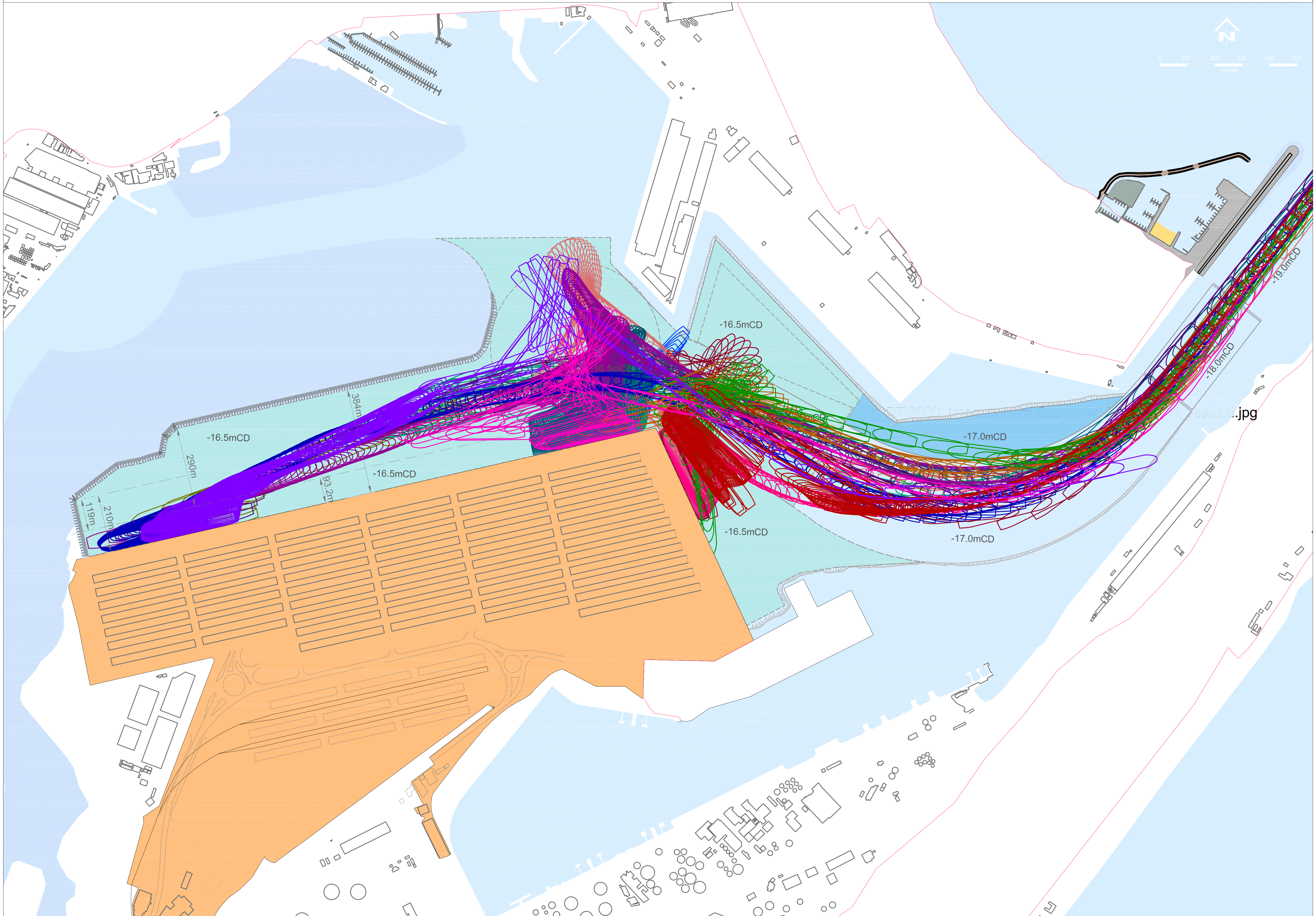
BERTH 203-205 DEEPENING SCOUR PROTECTION GENERAL LAYOUT OPTION1

PROJECT NUMBER	DV	FBS	DIS.	TYPE	DRG. NO.	SHT.	REV.	ID

SIZE:A1 DATE: 2006/12/05

$FILE$ $DATE$ $USERNAME$ $TIME$

DURBAN - SHIP SIMULATION RUNS



TRANSNET INFRASTRUCTURE PLAN