

**SPECIALIST REPORT ON THE ENVIRONMENTAL IMPACTS
AND MONITORING GUIDELINES FOR THE LAND
EXCAVATION AND DISPOSAL, MARINE DREDGING AND
MARINE DISPOSAL OPERATIONS AT COEGA PORT**

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EXECUTIVE SUMMARY

The proposed Coega Port will be situated near the southern extreme of the Industrial Development Zone (IDZ) at the mouth of the Coega River to the east of Port Elizabeth. This specialist report deals with the issues and impacts associated with land disposal of excavated material, marine dredging and disposal, and outlines the monitoring guidelines for the dredging and disposal operation.

Chapter 1 describes the port layout, limits and its proposed functions, which include acting as an inter-modal transshipment point for bulk cargo and containers for industries in the IDZ and the hinterland. A brief summary of the guidelines for the management of dredged material is then presented. This section is largely based on the PIANC guidelines, but incorporates issues from the equivalent ANZECC and South African documents. The guideline's main purpose is to assist in the characterisation and subsequent management of dredged spoil based on contamination levels within the sediment. The next section broadly outlines the aims of the report and the scope of work for each section by the specialists, and finally the layout of the report is explained and the links between the various sections are revealed.

Approximately 13 million m³ of dry material from dewatered excavations at the inner harbour basin site and the container terminal area will need to be safely transported and disposed of at various land based sites. Chapter 2 summarises the location and biophysical environment of seven potential sites, assesses their suitability as a disposal site for excavated material, identifies a number of issues and impacts relating to the disposal, suggests mitigating measures to alleviate the severity of impacts, where possible, and presents a few general recommendations for the management of the excavated material.

Based on the environmental sensitivity (endangered or sensitive fauna and flora) of each of the seven proposed sites, four were identified as being suitable, namely the Eastern Headland, Eastern Beach, Back of the Breakwater and Back of the Quays.

The loss and fragmentation of sensitive habitats, impacts on threatened/sensitive species, threats to archaeological sites and changes in air quality due to particulate emissions were identified as the most severe and significant impacts. While mitigation could reduce the threat to archaeological sites to almost zero, the other issues remain moderate to moderately severe in terms of impact level after mitigation.

In addition to the mitigating measures discussed under the issues and impacts section, the following recommendations were put forward:

1. No dredge material should be disposed onshore, i.e. above the existing onshore highwater mark, without an additional EIA.
2. No excavated material should be deposited outside of the area assessed in the Subsequent EIA, i.e. the Core Coega Development Area.

Chapter 3 deals with the environmental impacts associated with the dredging operation. A total of 14.2 million m³ will be dredged from the approach channel and basin areas. The initial section of this chapter provides a detailed description of the physical and biological characteristics of the sites where the approach channel and harbour basin will be located. The results of the tests performed by the CSIR for contaminants in the sediment, are also presented. The following section details the dredging operation and includes the timetable for the construction of the breakwaters and how this is related to the dredging framework, as well as the issues of blasting, turbidity and monitoring.

The impacts of noise (dredger and blasting) and lights were deemed to be severe or of moderate to high significance, when considering the island avifauna (in particular the endangered or threatened species) and marine mammals. However, it was ascertained that mitigation would reduce the effects to acceptable levels. The impact on benthic marine organisms will be severe, as dredging is by nature destructive. When considered in the context of Algoa Bay as a whole, this impact is not of great importance. The concussion effect of blasting was identified as an issue, which could have severe and highly significant consequences for certain seabirds and mammals. It is anticipated that blasting will be an infrequent event and as such the threat is reduced. Increased turbidity was identified as an issue relating to primary production and the fish and bird communities. Of particular concern was the effect of turbidity close to Jahleel Island. Mitigation, which includes compliance with monitoring guidelines, would reduce the severity and significance of these impacts. While the destruction of the physical environment was seen as a very severe impact, the small area relative to other similar habitats in Algoa Bay meant that this is not thought to be a significant impact. Although mitigation should ensure that exotic species are not introduced, the threat remains and is identified as being very severe and of very high significance.

The chapter finishes with a brief summation of maintenance dredging, and addresses the possibility that it may be required at Coega in the future. If this is indeed the case, the present permit for the capital dredging operation would not be valid and an entirely new permitting process will be entered into.

The monitoring guidelines for ensuring acceptable levels of water quality with respect to turbidity are presented in Chapter 4. The objective of these guidelines is to ensure an acceptable impact on the immediate and nearby environment as well as the sensitive ecosystem associated with Jahleel and Brenton islands.

The turbidity issue is first put into context by explaining the environmental consequences of increased turbidity, and then some general and historical data relating to Algoa Bay and the Coega region are presented, including the guidelines proposed in the Probyn report and their analysis by Delft Dredging. Based on a number of borehole samples, the characteristics of the sediment to be dredged are described, then using information on settling speeds, prevailing currents and other physical features (e.g. winds, waves and thermoclines), the dynamics of the sediment plumes associated with the operation are described separately for the approach channel, basin and two offshore disposal sites.

The guidelines produced stipulate that the equipment to be used to measure turbidity will be calibrated once a week to the satisfaction of the PAD environmental officer. Monitoring is largely concerned with the dredging operation, but due to the proximity of the one offshore disposal site to Brenton Island, a site has been established nearby. For operations within the basin area, monitoring sites will be located 500 m from the end of each breakwater on either side of the mixing zone. For operations in the approach channel, sites will be located on either side of the channel along a line marking the edge of a 500 m mixing zone. Reference sites located 3.8 km to the NE and SW of the operation will be used for daily ambient turbidity readings. In addition, there will be two extra reference sites, one each 150 m from Jahleel and Brenton islands. Levels at the edge of the mixing zone must not exceed 150 mg/l above ambient under any circumstances, while those at the island reference sites must not exceed 80 mg/l above ambient. The minimum value along a depth profile at the reference sites will be taken as the daily ambient, while the maximum value along a depth profile will be taken as the SS level at the monitoring sites and island reference sites. These guidelines and the mitigating measures required to adhere to them are summarised in a flowchart at the end of the chapter.

Chapter 5 describes the disposal operation and the issues and impacts associated with it. The initial task of selecting an appropriate site, and the process by which an offshore site was finally chosen are described. Two offshore sites were initially tested; both lie directly off the Coega River mouth, one located around the 30 m contour, while the second site is in deeper water between 45 and 50 m. Each site's physical and biological characteristics are described from data available in the literature as well as from a survey undertaken at the two sites. A lower species richness and diversity as well as lower abundance estimates made the shallow site the obvious choice. In addition, the presence of a new species of phyllocarid, and evidence of high percentages of large particle sizes in the NE corner of the site, led to the recommendation that the site be moved 1nm to the SW.

It is possible that at least 10 million m³, and as much as 20 million m³ of dredged material may be disposed of offshore. The disposal of this much material is bound to have environmental consequences. Benthic organisms will be smothered, but, the small surface area in relation to the bay means that this severe impact is only of low significance. A similar scenario presents itself with the moderately severe impact of turbidity on primary production. As was the case under the dredging impacts, the destruction of the physical environment as it exists prior to any disposal, is viewed as a very severe impact, but one of low significance. There is no mitigation regarding this effect, but careful selection of the disposal site and the acceptance that it is in effect a sacrificial zone and a very small area in relation to the rest of Algoa Bay, should serve to put this issue into context. The consequences of a collision between a dredger and yacht would be very severe and very significant, but avoidance of this through communication and compromise was seen as altogether possible, so that there would be no danger. The majority of other impacts were considered only to be slight and of low significance, but of moderate to high significance with regards to the effect of dredger noise and lights on threatened marine mammals. With mitigation, however, this issue too should be reduced to insignificant levels.

The final chapter contains some concluding remarks about the issues and impacts presented in this report, and identifies the main issues which were seen as the greatest threats to the land disposal, marine dredging and offshore disposal operations at Coega. Strict adherence to the monitoring guidelines is reinforced, as an uninterrupted dredging operation is totally dependent on compliance with these recommendations.

TABLE OF CONTENTS

Executive summary	i
Table of contents	v
Chapter 1: Introduction and background	1
1.1 Aims of the report	1
1.2 Report layout and structure	2
1.3 Guidelines for the management of dredge spoil	3
1.4 Port layout	6
Chapter 2: The environmental impacts of land disposal at Coega Port	11
2.1 Introduction.....	11
2.2 Site and project actions	12
2.3 Proposed disposal sites	12
2.4 Issues, impacts and mitigation.....	15
2.5 Review of disposal sites	21
Chapter 3: The environmental impacts of marine dredging at Coega Port	25
3.1 Site description.....	25
3.2 Project description and action.....	35
3.3 Environmental impacts of dredging.....	36
3.4 Maintenance dredging.....	48
Chapter 4: Monitoring guidelines for the Coega Port dredging operation	53
4.1 Introduction.....	53
4.2 Turbidity assessment for dredging at the Coega harbour	55
4.3 Turbidity assessment for disposal of dredged spoil at offshore site 1	65
4.4 Turbidity assessment for disposal of dredged spoil at offshore site 2	66
4.5 Monitoring guidelines for the dredging and disposal operation at Coega Port	67
4.6 Conclusions	74
Chapter 5: The environmental impacts of offshore disposal of dredge spoil from the Coega Port dredging operation	75
5.1 Project description and action.....	75
5.2 Site selection.....	76
5.3 Site description.....	77
5.4 The environmental impacts of marine disposal of dredge spoil	86
Chapter 6: Conclusions	97
6.1 Land excavation.....	97
6.2 Marine dredging.....	97
6.3 Monitoring guidelines	98
6.4 Marine disposal.....	98
6.5 Conclusion	98
References	101

Appendix 1: Conceptual rehabilitation plan.

1. Introduction
2. Objectives
3. Conceptual rehabilitation plan
 - 3.1 Site preparation
 - 3.2 Landscaping
 - 3.3 Suitable species and planting
 - 3.4 Management
- References

Appendix 2: Report on trace metals in sediments from cores collected at Coega.

1. Introduction
2. Methods
3. Results and discussion
4. Recommendations
- References

Appendix 3: A description of methods used during the survey to assess the offshore disposal sites at Coega.

1. Methods
 - 1.1 Sampling strategy - phase 1
 - 1.2 Sampling strategy - phase 2
 - 1.3 Analysis of soft sediment samples
 - 1.4 Indices of abundance and diversity
 - 1.5 Statistical analysis
- References

Appendix 4: Co-ordinates for sample design (disposal sites, grab sites and dive sites). Ds1 – disposal site 1; ds2 – disposal site 2; bl – bottom left; br – bottom right; tl – top left; tr – top right. Transect lines at each site are labeled 1 – 7 from north to south and co-ordinates are provided for the southern (s) and northern (n) ends of each line.

Appendix 5: Raw data collected from the grab-sample sites.

Appendix 6: Indices of abundance and diversity. Avg total = average of the total macrofaunal abundance per grab sample site; stdev total = corresponding standard deviation; cv = coefficient of variation; $\pm 95\%$ ci = 95% confidence interval; max total = maximum number of macrofaunal specimens in any grab at a grab sample site; avg tax = average number of taxonomic groups per grab; max tax = maximum number of taxonomic groups in any grab at that site.

Appendix 7: Available sediment size information analysed according to Brown & McLachlan (1990). All measurements are in phi-units, unless otherwise stated. Mps = median particle size; gmpd = graphic mean particle diameter; pqd = phi quartile deviation; igsd = inclusive graphic standard deviation; pqs = particle skewness; sk1 = inclusive graphic skewness; kg = graphic kurtosis.

Appendix 8: Evaluating and presenting the impact data.

1. Evaluation
 - 1.1 Temporal scale
 - 1.2 Spatial scale
 - 1.3 Severity/beneficial rating scale
 - 1.4 Significance scale
 - 1.5 Risk or likelihood
 - 1.6 Degree of confidence or certainty
2. Presentation of impacts
3. Summary tables

CHAPTER 1: INTRODUCTION AND BACKGROUND

1.1 AIMS OF THE REPORT

This report is made up of a number of specialists' reports on the land excavation, marine dredging and marine disposal operations required for the construction of the Coega Port.

1.1.1 LAND EXCAVATION

As part of the development of the Coega Port and associated Industrial Development Zone, large volumes of material from the proposed harbour basin need to be excavated, transported and safely deposited in a number of potential terrestrial disposal sites identified for this material. The scope of work dealing with the land excavation proposal will encompass a summary of the location and biophysical environment of the sites, an assessment of their suitability for receiving excavated material, and the identification of a number of issues relating to the proposal. The aims of this aspect of the report are to:

1. Assess the suitability of the proposed disposal sites for receiving material.
2. Identify and assess the impacts associated with the excavation, transportation and deposition of such material.
3. Recommend appropriate mitigatory measures where necessary.
4. Prepare detailed guidelines and recommendations for the landscaping and/or rehabilitation of selected disposal sites.

1.1.2 MARINE DREDGING, DISPOSAL AND MONITORING

The dredging of the port and the disposal of the dredged spoil is probably the single biggest operation after the building of the breakwaters and thus has the possibility to have significant environmental implications. The scope of work associated with this aspect of the report can be broken down into four activities, namely dredging and associated impacts (this includes blasting), identification of suitable disposal sites and the associated impacts, limited modeling of turbidity plumes and monitoring guidelines for suspended solids at the dredge sites. The overall aims of the specialist studies are to:

1. Assess the possible impacts associated with the dredging (and blasting) of the port and the disposal of spoil at two possible offshore sites.
2. Provide recommendations on possible mitigatory actions that can be taken.
3. Produce guidelines for monitoring the turbidity plumes which result from the dredging operation.

1.1.3 LIMITATIONS

The area under consideration has not been extensively studied by scientists, and a paucity of information exists with respect to the physical and biological environment around Coega. Although information on some aspects is available, e.g. physical oceanography, sandy beach ecosystems and fish, much of these data are applicable to Algoa Bay in general and not Coega specifically. This is regarded as being a severe limitation when taking the sensitive nature of the nearby St Croix Island Group into consideration. While some aspects such as the breeding and roosting areas of seabirds are specific to the Coega region, these data are sparse, and at times outdated and open to interpretation.

Bearing this in mind, the most significant limitation was the short time period provided for the specialist studies and compilation of this report. The six week period allocated for these tasks precluded any detailed studies, which would have provided a better understanding of the dynamics and possible consequences of disturbing the Coega environment.

The following limitations, specific to the disposal and monitoring studies, were identified by the specialists involved in the respective studies:

Disposal

1. Even though the resultant data might be able to detect changes in soft sediment macrofaunal abundance if the sampling were to be repeated at some point in the future, no inferences could be made with respect to whether or not disposal caused these changes, as replication of Disposal Sites in either space or time have not been considered, nor is there an adequate control site.
2. No quantitative statements can be made with respect to how the fauna of any of the benthic habitats might respond to the proposed disposal, as no manipulative experiments were conducted. The assessments of the impacts have, however, assumed a precautionary approach, which would take into account that all sessile organisms within a disposal site would be killed, and that this would be followed by subsequent recolonisation.

Monitoring and modeling

1. A paucity of current meter data describing the offshore current pattern for the region. The limited database will be combined with data on tidal and intertidal currents to reach a feasible and plausible outcome.
2. The location of the mixing zone concerned with the basin operation and the extent of the zone around Jahleel Island are dependent on the construction of the two breakwaters.

1.2 REPORT LAYOUT AND STRUCTURE

Chapter 1 provides the scope of work and limitations of the study. It also provides background detail on the management of dredge spoil, the port and its planned construction activities.

Chapter 2 deals with the issues surrounding land excavation and disposal. As it is the only section of the report dealing with any terrestrial aspect of the port development, it has few links with the remainder of the report, which deals with the marine dredging and disposal operations. Seven terrestrial sites were identified for receiving excavated material. Based on an assessment of issues and impacts associated with disposal, the seven proposed disposal sites are evaluated and classified as being unsuitable (2), partly suitable (1) and suitable (4) for use.

Chapter 3 comprises the marine dredging operation and its associated issues and impacts. This chapter paves the way for Chapter 4, which outlines the monitoring guidelines for the Coega Port dredging operation. The dredging sites described in Chapter 3, combined with the modeling of turbidity plumes associated with dredgers, determine the positioning of monitoring sites. In addition there are several reference sites, including one each at Jahleel and Brenton islands, to determine ambient turbidity levels at any given moment. The site at Brenton Island is the only monitoring station associated with the disposal operation, but it is seen as essential in the light of the importance of the island to the overall ecology of the region.

Chapter 5 describes the disposal operation, and deals with the process of site selection and the physical and biological survey undertaken to describe the two offshore sites earmarked as the disposal options. Based on survey results, a recommendation is made as to which of these sites is most suitable. The issues, impacts and mitigation associated with the disposal operation are then discussed.

1.2.1 TEAM STRUCTURE

As mentioned the report is multi-authored, with leading specialists with specific experience on Algoa Bay having contributed to its various sections.

Chapter 1 – Dr Aidan Wood (Gleneagle Environmental Consulting).

Chapter 2 – Dr William Branch (Bayworld).

Chapter 3 – Dr Aidan Wood, Dr Warwick Sauer (EnviroFish Africa) and Prof. Tris Wooldridge (UPE).

Chapter 4 – Dr Eckart Schuman (Seaways Corporation) and Dr Aidan Wood.

Chapter 5 – Dr Aidan Wood, Dr Warwick Sauer, Prof. Tris Wooldridge and Dr David Schoeman (UPE).

Chapter 6 – Dr Aidan Wood.

(The authors indicated above are listed in no particular order.)

1.3 GUIDELINES FOR THE MANAGEMENT OF DREDGE SPOIL

Due to the destructive nature of dredging, all activities relating to these operations should be limited to what is strictly necessary in order to limit environmental damage. Of primary concern is the fate of the material or spoil that needs to be disposed of. Disposal sites need to be carefully chosen so as to restrict impacts on biological communities and limit damage to the physical environment. Interference with other human related activities, such as fishing, recreation and navigation also needs to be kept to a minimum.

Most countries which are involved with dredging operations have specific guidelines that specify certain requirements that need to be fulfilled prior to the commencement of disposal operations. These guidelines are based on the provisions of the Convention on the Prevention of Marine Pollution by Dumping Wastes and Other Matter, otherwise known as the London Convention of 1972. For example, the ANZECC (Australian and New Zealand Environment and Conservation Council 1998), PIANC (Permanent International Association of Navigation Congresses; Vellinga 1997) and South African guidelines (Jackson 2000) are all founded on the London Convention proceedings. South Africa ratified the London Convention in 1978 and included its ideals in the *Dumping at Sea Control Act 73 1980*. Australia and New Zealand acceded to the LC in 1985 and incorporates its ideals under the Commonwealth's *Environment Protection (Sea Dumping) Act 1981*.

The primary goal of the London Convention is to prevent pollution of the sea and marine life, damage to amenities and interference with other marine orientated activities. However, in 1986 a special set of guidelines for dredged material was adopted. These have recently been revised as the Dredged Material Assessment Framework (DMAF), and form the basis upon which the following guidelines have been founded. Options, such as land-based disposal and treatment options, which are not incorporated by the London Convention, are also considered in most guideline documents. The following summary of the DMAF is largely based on the PIANC (1997) guidelines.

1.3.1 DREDGED MATERIAL ASSESSMENT FRAMEWORK

Need for dredging

The first step in any operation is obviously the decision as to whether dredging is absolutely necessary, and if so, the type and extent of such an undertaking. The DMAF recognises three types of dredging activity, namely capital dredging (e.g. the creation of new port areas such as Coega), maintenance dredging and clean-up or environmental dredging. Once this decision has been made, it is essential to characterise the sediment to be dredged.

Characterisation

Physical, biological and chemical characterisation is required in order to determine the dredging methods to be used, the possibility for beneficial use of the spoil, disposal or treatment options, possible environmental impacts, the level of additional biological and chemical testing, and the dynamics of a source control programme. Based on the sediment characteristics, and in particular the levels of contaminants, an action list may be prepared to aid in management decisions.

Physical

If the sediment to be dredged comprises mostly sand, gravel and rock, if it is mostly previously undisturbed geological material, and if the dredge site is far removed from existing and historical sources of pollution, it may be assumed to be uncontaminated and exempt from further analysis. Disposal procedures would then entail suitable site selection and an evaluation of associated impacts.

Chemical

There are many chemicals which may be found in marine sediments, but an evaluation of certain criteria will help limit the screening process. For example, information from tests on similar sediments from the region, potential sources and routes by which chemicals could have been introduced (industry, agriculture, municipal discharge and groundwater), natural deposits of minerals in the region and past spills of contaminants, should provide a good foundation for the screening process. Chemicals and toxic materials which may be encountered in marine sediments have been classified according to their characteristics and potentially harmful effects. The South African guidelines list the following contaminants (Jackson 2000):

Annex 1 substances – organohalogen compounds, mercury & cadmium (+compounds), persistent plastics and other synthetics, hydrocarbon fuels and oils, hydraulic fluids, radioactive wastes or matter, and biological or chemical warfare materials.

Annex 2 substances – arsenic, lead, copper & zinc (+ compounds), organosilicon compounds, cyanides, fluorides, pesticides (by-products), beryllium, chromium, nickel, vanadium and bulky metallic wastes.

In order to accurately assess the chemical composition of the sediment, samples must be taken from sufficient sites to provide results which would be representative of the vertical and horizontal distribution and variability of the sediment.

Biological

Biological testing may be required if chemical and physical characterisation are not sufficient to assess possible impacts. It is important to make use of species which are found in the area and which are deemed sensitive and representative of the community associated with the potential disposal site. Testing should involve the sediments to be dredged and their chemical constituents, and should determine acute and chronic toxicity, bioaccumulation and the potential for tainting.

Action list

The contaminants listed in Annex 1 and 2 usually have designated upper and lower limits, which determine the following actions:

- Dredge spoil containing contaminants or which causes biological responses in excess of a specified upper level is deemed unsuitable for unrestricted disposal.
- Dredge spoil containing contaminants or which causes biological responses below a specified lower level is deemed eligible for unrestricted disposal.
- Dredge spoil characterised as intermediate, i.e. between upper and lower limits, should be considered for more detailed assessment.

Beneficial use and sustainable relocation

Clean or even slightly contaminated dredge material (CDM) can be regarded as a valuable resource, and instead of being disposed of elsewhere in the marine environment, could be used for a variety of beneficial purposes depending on sediment characteristics.

Coarse sediments are suitable for construction purposes in and around coastal areas, e.g. land creation and improvement, beach maintenance, offshore berms, dykes and dams, capping for contaminated spoil, replacement fill and construction material.

Sand, silt and clay mixtures with their organic content can improve soil structure for agricultural purposes, and disposal areas could be utilised for various aquaculture ventures.

A host of sediment types can be used to enhance or establish wetlands, create upland habitats and nesting sites, and improve fisheries. Together with sustainable river management and control of coastal erosion and mudflat degeneration, these options are classed as sustainable relocation of spoil.

If no clear beneficial use can be found, or if it is not deemed to be financially viable, then disposal and/or treatment should be considered.

Source control

In the case of contaminated sediments, it may be feasible in the long term, both financially and environmentally, to institute a programme to control the source of the contaminants. This would involve the identification of sources, reduction in their output, prevention of further contamination at the site and the implementation of a monitoring plan to assess the results. These steps require cooperation amongst the dredging contractors and the agencies or industries responsible for controlling the point sources of the contaminants.

Disposal

In some cases, neither sustainable relocation nor beneficial use options are feasible, which leaves disposal as the only solution. Dispersive or confined open water disposal and confined or unconfined land-based disposal are the options available.

Dispersive or unconfined disposal sites should not be used for unsuitable dredge spoil, i.e. contaminated sediments. In terms of open water disposal, which is the option selected for the Coega operation, effects may be permanent or transitory in nature. Physical changes to the morphology of the site would be permanent, while increased turbidity and smothering effects would be transitory. These effects need to be minimised through mitigation and careful site selection, which should also take into account other legitimate uses of the region. A monitoring programme during and after the operation needs to be initiated.

Confined disposal sites are usually reserved for contaminated dredge material (CDM), which are not an issue with regards to the capital dredging operation at Coega (Connell and Parsons 1999). The management of CDM and procedures required for effective control and monitoring are more complex than those required for clean spoil.

Treatment

The levels of contamination in CDM can be reduced to meet environmental regulations. There are different treatment techniques for various contaminants, so that sediments with a host of contaminants need to undergo several different treatment techniques in series. Treatments can be grouped into the broad categories of pretreatment, biological, chemical, thermal and immobilisation. The costs involved with treatment of CDM are often higher than those incurred by

disposal in a confined site, and a cost versus effectiveness evaluation normally decides which option will be used.

Impact assessment

The impact assessment involves the identification, evaluation and mitigation (where possible) of effects on the environment (physical and biological) as a result of the dredging operation. A thorough understanding of the proposed operation and the existing environment are required. Information on the nature of the dredged material and the disposal site (offshore open water in the case of the Coega operation), and any possible interactions, including indirect effects, between the two need to be identified and assessed. Chapters 3 and 5 in this report deal with the impacts associated with dredging and disposal respectively, so this aspect will not be elaborated upon here.

Permit issue

For most dredging operations, an authorising permit is required. This can be an important tool for managing dredge spoil and should contain the terms and conditions under which disposal can take place, as well as provide a framework (monitoring programme) for ensuring compliance.

Monitoring

All dredging operations require a monitoring programme, and its guidelines are stipulated in the permit. Some operations have monitoring programmes for dredging and disposal, and the programme ensures compliance with the permit requirements and assesses the condition or change in condition of the respective sites. The dredge sites will be monitored with regards to turbidity levels to ensure that suspended solid concentrations levels are kept below specified levels beyond a designated buffer zone. These monitoring guidelines are very specific about the potential impacts if recommended levels are exceeded, and the dredge operators will need to comply with these guidelines in order to adhere to the permit regulations. The disposal site will be monitored in terms of the levels of dredged material build-up and rate of material dispersion. To avoid any permanent impacts at Brenton Island, suspended solids will be monitored close by and the dredging operator will be required to remain with the specified limits (see Chapter 4).

1.4 PORT LAYOUT

1.4.1 LOCATION

The Coega Port is situated at the mouth of the Coega River near the southern corner of the proposed Development Zone. The area to the north and west of the port has been set aside for port related activities, whilst immediately to the north, the area is occupied by a saltworks. A rock quarry lies to the northwest at a distance of approximately 10 km. Figure 1.1 shows the port and surrounding areas.

1.4.2 PORT LIMITS

The area enclosed by the port limits is described in the following paragraphs (Government Gazette No. 19401 of 28 October 1998). The seaward area of the port is bounded by a line commencing at the extreme point on the east bank of the Swartkops River thence due east (true) for a distance of one nautical mile to a point in the Indian Ocean; then from that point to a second point in the Indian Ocean one nautical mile due east (true) from Cape Recife; then from that point to a third point in the Indian Ocean one nautical mile south east (true) from the extreme point on the east bank of the Sundays River; then along the high water mark between the extreme point of the east bank of the Sundays River and the extreme point of the east bank of the Swartkops River, excluding the islands of Jahleel, St Croix and Brenton, and the 500 m marine reserve surrounding each island. This enables the Port Authority to control all shipping activities within the defined area.

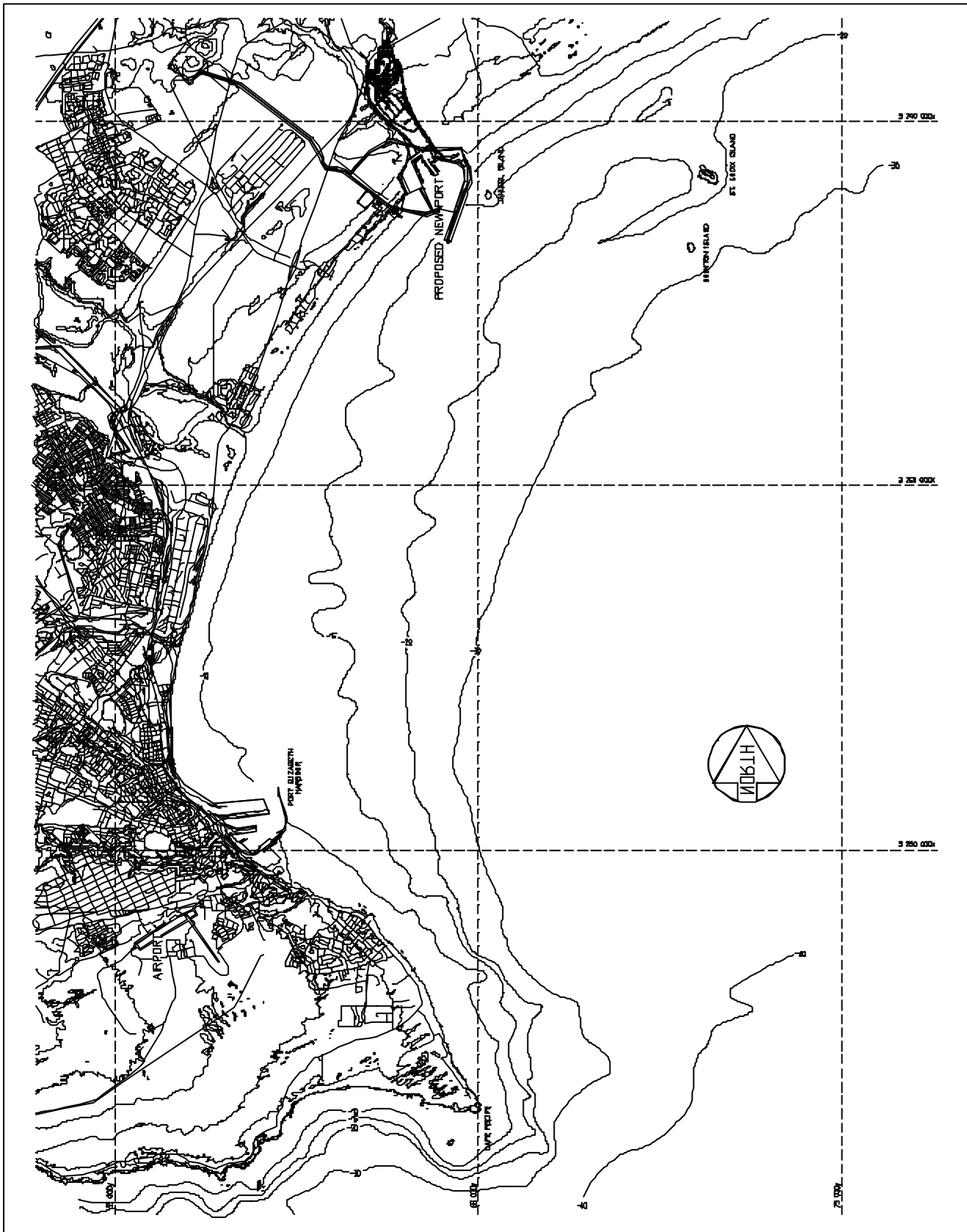


Figure 1.1: Location of the proposed port at Coega.

The landside of the port shares a common boundary with the logistics park on the Neptune site, which extends down to the high water mark to include a coastal strip of between 500 and 1000 m

wide up to St George's Strand. To the north east the boundary runs between Hougham Park and Sonop Farms and to the high water mark in the south east. This area will be vested in the port authority division (PAD) of Portnet.

1.4.3 GENERAL LAYOUT

The maritime infrastructure of the port comprises three main components. These are the breakwaters, the quay walls, and the dredged navigation basin and channels. These components are discussed with relevant technical information in the following paragraphs and are shown in Figure 1.2. The main land based developments are expected to include transportation corridors, road and rail access, a container terminal, staging yards, dry bulk stockpiles, a bulk liquid tank farm and port administration buildings.

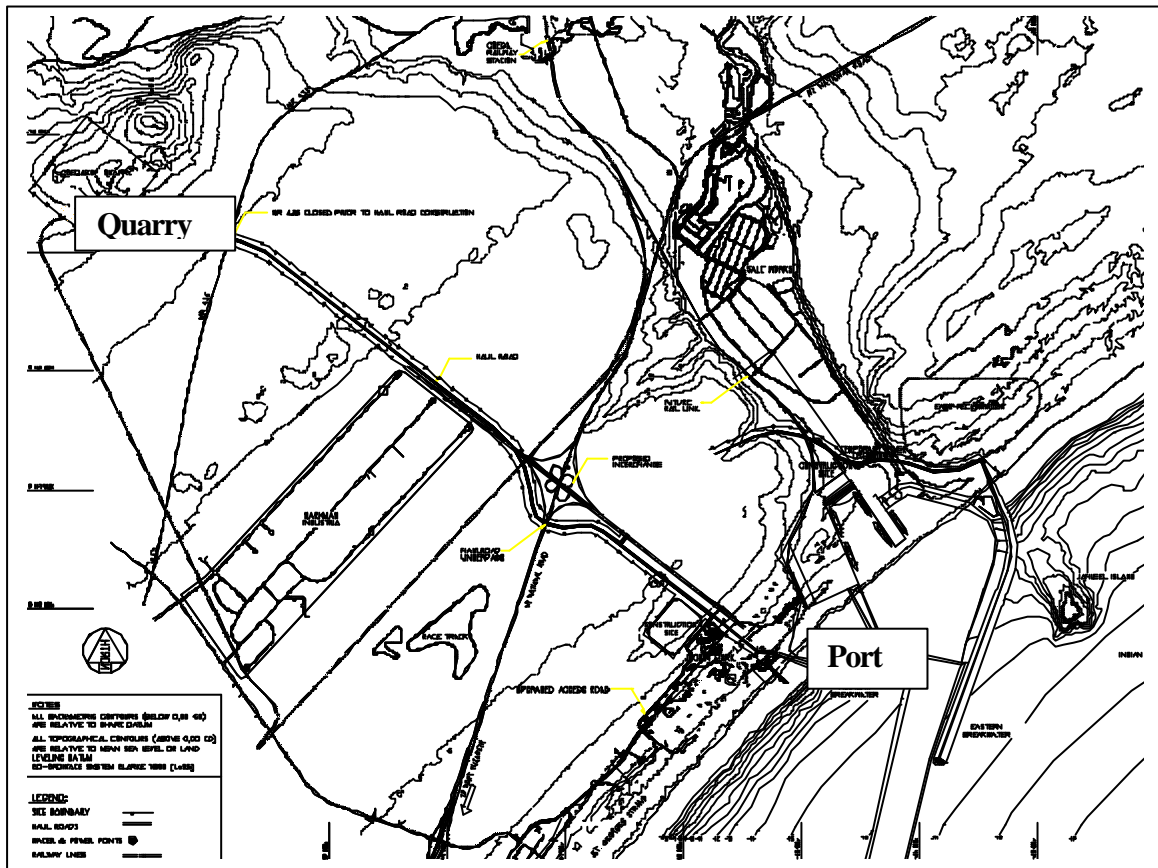


Figure 1.2 Layout of proposed Port at Coega (Phase 1) and surrounding area. (Approximate Scale 1 : 50 000).

The main breakwater (eastern) is on the north-eastern side of the port entrance and extends from the beach in a southerly direction for a distance of approximately 2 500 metres. At its head it will stand in 16.5 metres of water and project 10 metres above sea level for the bulk of its length. The secondary breakwater (western) extends from the beach in an easterly direction for a distance of just over 1 100 metres. At its head it will stand in 14.5 metres of water. The cross sectional width of the breakwater will be approximately 120 metres wide on the seabed in the deeper areas. The crown section on the top of the breakwater will have a width of 12.2 metres. The breakwater will be constructed using core rock (5 kg to 2 000 kg), armour rock (2 tonne to 5 tonne), and Dolos concrete armour units (30 tonnes).

The 4 kilometre long approach channel will extend from the –18 metre contour in the south, to the port entrance (Figure 1.3). The width of the approach channel will vary from 300 metres to 500 metres at the bend and be dredged throughout to –18 metres chart datum. From the entrance channel through the turning basin and into the berth areas, the seabed will be dredged to –16 metres chart datum. The entrance channel will have a width of approximately 380 metres, the turning basin a diameter of 800 metres whilst the channel section in the container berth area will have a minimum width of 350 metres.

The container terminal, located on the north west side of the port will comprise 620 m of berthing quay wall with a depth of –16.5m chart datum. The container handling area will comprise a 400 m wide paved area behind the quay for the storage of containers. A further 100 m wide transportation corridor, which will include access roads and rail, will be located behind the container terminal. This transportation corridor will provide a link to national, regional and local transport networks. Two dry bulk berths totalling 600 m of quay wall will be located in the central portion of the basin. In the early stages of the port these berths will perform a multi-purpose role, handling break bulk and other miscellaneous cargo. Dry bulk product will be moved by conveyor via the transportation corridor from a proposed 300 by 1 000 m bulk storage area located north of the N2. This site will be serviced by rail and road. The bulk liquid berth will be used to convey bulk liquids (mainly fuels) to a tank farm located on the north eastern bank of the river. This facility may be moved from Port Elizabeth to Coega. The area will provide a 500 m radius buffer zone within which no development will be allowed.

The natural longshore movement of sand in Algoa Bay is from the south to the north. The breakwater structures are expected to interrupt this process. In order to maintain the continuous movement of sand, a permanent sand bypass system will be installed.

The sand bypass system will consist of a fixed row of jet pumps deployed from a jetty, a pump house, a slurry pipeline, booster pump stations and a discharge point. The jet pumps will be installed on the south western side of the port and will pump sand around to the north-eastern side of the port. The system will be designed to maintain the current dune and beach forms on the adjacent beaches by artificially maintaining the longshore drift.

1.4.4 FUNCTIONS

The primary function of the port will be to act as an inter-modal transshipment point for bulk cargo and containers for industries in the Development Zone and the hinterland. The land areas beyond the quayside, but within the port area described in section 1.1.2 will serve as staging and storage areas for transit cargo.

CHAPTER 2: THE ENVIRONMENTAL IMPACTS OF LAND DISPOSAL AT COEGA PORT

2.1 INTRODUCTION

As part of the development of the Coega Port and associated Industrial Development Zone, large volumes of material from the proposed harbour basin need to be excavated, transported and safely deposited in a number of potential disposal sites identified for this material. This report summarises the location and biophysical environment of the sites, assesses their suitability for receiving excavated material, and identifies a number of issues relating to the proposal.

2.1.1 AIM

The proposed study aims to:

- Assess the suitability of the proposed disposal sites for receiving material.
- Identify and assess the impacts associated with the excavation, transportation and deposition of such material.
- Recommend appropriate mitigatory measures where necessary.
- Prepare detailed guidelines and recommendations for the landscaping and/or rehabilitation of selected disposal sites.

2.1.2 APPROACH

Existing information has been compiled relating to:

- The proposed disposal sites.
- The composition and nature of the material to be disposed.
- The methods of excavation and transport to be used.
- The existing and proposed topographies of the disposal sites.
- The need for landscaping or rehabilitation of the disposal sites.
- The physical and biotic environments that will be affected.

Using the above information, an assessment and screening of the suitability of the proposed land disposal sites for receiving excavated material was undertaken. The suitability of these sites for the disposal of excavated material was screened using the following criteria:

- The presence of sensitive vegetation communities.
- The presence of sensitive or threatened fauna (butterflies, etc).
- The situation of the site on existing drainage lines, and its relation to the water table.
- The presence of previously identified 'NoGo' areas.
- The presence of possible archaeological sites.
- The proposed future use and need for possible rehabilitation of the site.
- The severity of the associated impacts (noise, light and air pollution, etc) during disposal and subsequent landscaping/rehabilitation.

2.1.3 ASSUMPTIONS

The proposed study to address the aims outlined above is based on the following assumptions:

- There will be no disposal of marine dredged material(s) above the existing highwater line.
- No dredge or excavated material will be disposed of outside of the review area covered by the Subsequent EIA.

- The excavated material contains no chemical contaminants other than those detailed in previous reports (e.g. Connell and Parsons 1999).
- Contractual guidelines specified by the developer will be adhered to during the excavation, haulage and disposal of material.
- Recommended guidelines will be followed, should previously undetected archaeological sites (Binnerman 1997; Binnerman and Webley 1998) or populations of endangered fauna and flora be discovered during the operations.

2.2 SITE AND PROJECT ACTIONS

2.2.1 HARBOUR BASIN AND CONTAINER TERMINAL AREA

The preparation of the harbour basin, entrance channel and port approaches will require the removal of large amounts of material. Details of the project site, including the proposed inner harbour basin excavation, are summarised in Chapter 1. The excavation of the inner basin and container terminal area will require the removal and disposal of approximately 13 million m³ of dry material from dewatered excavations.

2.2.2 GEOTECHNICAL INVESTIGATIONS

The material to be excavated from the inner basin area of the port has been analysed and declared free of significant levels of contaminants (Connell and Parsons 1999).

2.3 PROPOSED DISPOSAL SITES

Various disposal sites for dry excavated material have been identified in close proximity to the works (Figure 2.1). These are described in the following sections.

2.3.1 SITE 1 – EASTERN HEADLAND

This disposal site is on the sea facing dunes adjacent to the river mouth. An extent of 1 000 metres by 700 metres of sea facing coastal dunes east of the port could be covered with material excavated from the basin. It is estimated to accommodate 12 million m³ of excavated material. No future developments occur on the site, which will need to be landscaped and rehabilitated.

It is covered in sensitive Dune Vegetation, with Foredunes and Hummocks bordering the shore, patches of Dune Woodland in the gullies, and Dune Grassland on the upper slopes. The Foredune and Hummock communities have been classified as sensitive vegetation communities as these vegetated dunes act as a barrier for sand blowing from the beach onto the site, and once disturbed are extremely sensitive to erosion.

The sandy habitats shelter a number of endemic species, including the Algoa Bay dwarf legless skink (*Scelotes anguineus*), Duthie's golden mole (*Chlorotalpa duthiae*), and the pygmy hairy-footed gerbil (*Gerbillurus paeba exilis*).

A number of small archaeological sites were identified (Binnerman and Webley 1997; Binnerman 1998), including a number of shell middens located 0.5 km east of the Coega River mouth east towards the boundary of the IDZ. The shell middens were small with little depth of deposit, dominated by one shellfish species and with virtually no cultural or food remains. Disposal of excavate at the site will cover but not destroy possible archaeological sites.

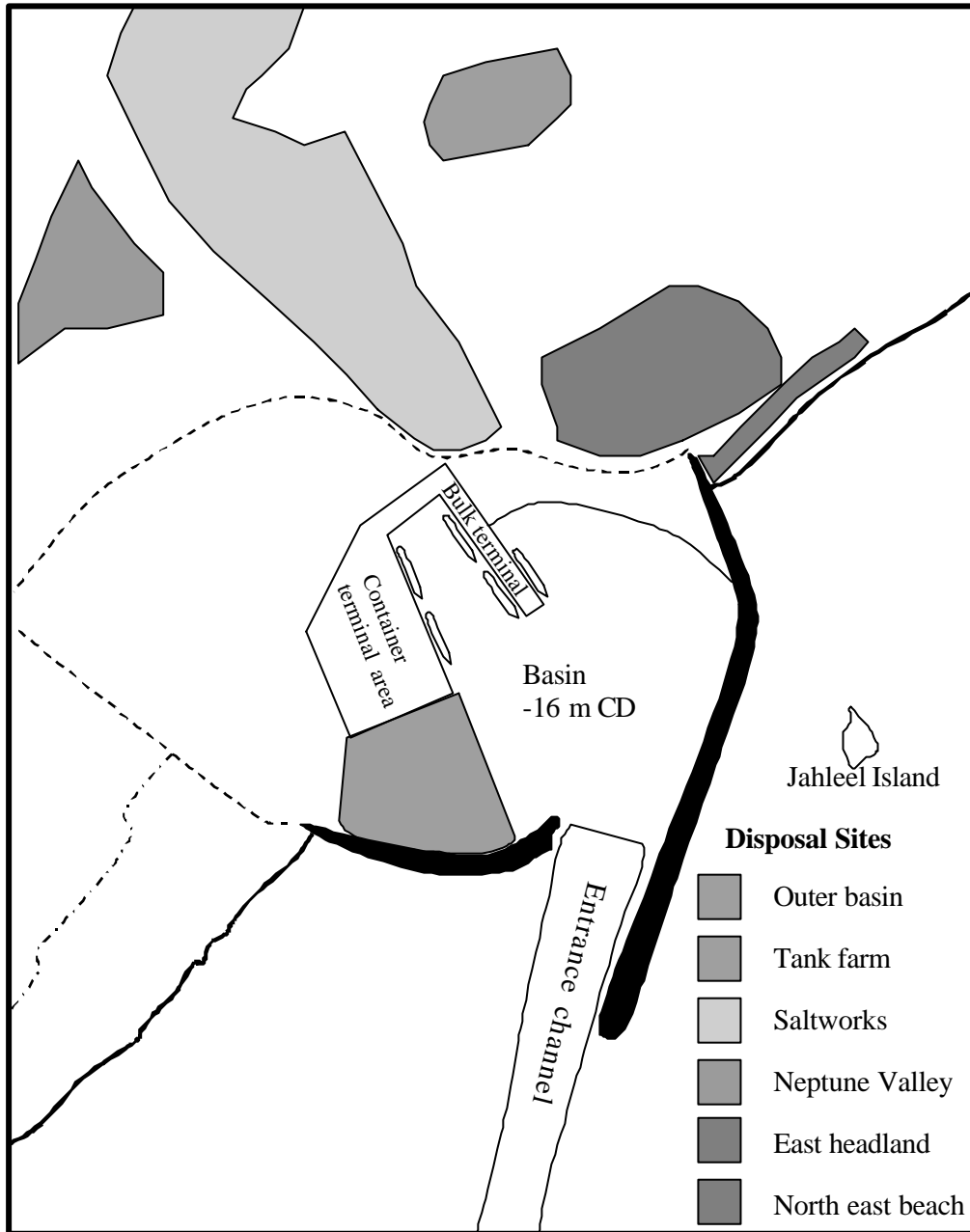


Figure 2.1: Various disposal sites identified for the deposition of excavation spoil from the basins and container terminal area.

2.3.2 SITE 2 – NEPTUNE VALLEY

The site is a deep valley adjacent to the N2 highway, west of the Coega River. It is estimated to accommodate 4 million m³ of excavated material. The site could be incorporated into the proposed industrial park, and would only need to be landscaped.

The steep slopes of Neptune Valley are covered with a wind-pruned subtype of Mesic Succulent Thicket, which has been classified as highly sensitive owing to the erosion implications of clearing steep slopes. The subtype is only found in the Algoa Bay coastal plain and therefore has a very limited extent. It has therefore been classified as highly sensitive and unsuitable for development.

Neptune Valley is a site of critical importance to the rare lycaenid butterfly *Aloeides clarki*, which has a complex life cycle. The female lays her eggs on the foodplant, a species of *Aspalthus*, whilst the larvae shelter in nests of the ant *Acantholepis capensis*. Other endemic species linked to Mesic Succulent Thicket include Tasman's girdled gecko (*Cordylus tasmani*) and the Albany adder (*Bitis albanica*). The habitat also serves as a refuge for small mammals and for many breeding birds.

2.3.3 SITE 3 – TANK FARM

The site is situated on the plateau to the east of the Coega River. It is estimated to accommodate 2 million m³ of excavated material. The site is to be leveled and bunded for the proposed tank farm, and would need to be landscaped.

The western region of the tank farm site is covered in Mesic Succulent Thicket, whilst the eastern region comprises threatened Bontveld vegetation. The presence of Bontveld has great implications for conservation as this vegetation type is already under severe threat from mining by PPC in the Grassridge area. The vulnerable, endemic species *Syncarpha recurvata* is present in an isolated pocket in the Bontveld community to the east of the port development. Although this colony occurs outside the tank farm site, its presence on the site should be carefully checked.

Bontveld is a major habitat for the endemic Albany adder (*Bitis albanica*), which is the most endangered vertebrate species in southern Africa (Branch 1999). It is restricted to the Albany region of the Eastern Cape Province and only eight specimens of this critically threatened snake have been collected during the last 87 years. Karst formation in the limestone pavement of Bontveld may provide essential refugia for hibernating small reptiles.

2.3.4 SITE 4 – SALT WORKS

The site is located on the saltpans currently occupied by the salt works. It is estimated to accommodate 3 million m³ of excavated material. It would be reworked in future extensions to the port in Phase 2 and would only need to be landscaped.

Salt marshes surround the salt reclamation ponds of the salt works, and remnants of salt marsh communities can be found on the pond banks. These salt marshes exhibit little zonation, indicating that they have been severely disturbed by the surrounding infrastructure.

Estuarine habitats are among the most threatened in southern Africa. Although the Coega Estuary is now extensively modified from its natural condition due to the development of the Coega Salt Works, it remains an important bird habitat, particularly for specialist salt-tolerant species. Among these are a number of Near Threatened species (Barnes 2000), including the Chestnutbanded plover (*Charadrius pallidus*), Greater (*Phoeniconaias ruber*) and Lesser (*Phoeniconaias minor*) flamingo. The estuary is also used as a feeding and resting ground by large numbers of Palaeractic wading birds during the austral summer, and is the eighth most important wetland in the Eastern Cape Province. It is home to one of only two colonies in the Eastern Cape of the winter-breeding Grey-headed gull (*Larus cirrocephalus*).

2.3.5 SITE 5 – EASTERN BEACH

It is proposed to relocate the existing mobile sand dunes in the Coega River mouth by bulldozing them approximately 500 m to the east of the existing mouth and east of the proposed eastern breakwater. It is estimated to accommodate 1 million m³ of excavated material. The material will

have a temporary beneficial impact, maintaining beach sand dynamics along the beach until the sand bypass system is installed. No landscaping or rehabilitation is needed. The site is unvegetated.

A number of threatened sea birds are associated with the coastal dunes and seashore (La Cock and Cohen 1997; Wooldridge *et al.* 1997; Boshoff and Sigwela 1998; and references therein), including the endangered Roseate tern (*Sterna dougalli*) and Damara tern (*Sterna balaenarum*) (Barnes 2000). The African black oystercatcher (*Haematopus moquini*) and Caspian tern (*Hydroprogne caspia*) also use the beach and are classed as Near Threatened (Barnes 2000). Roseate and Damara terns are two of the most endangered coastal species in South Africa. The former breeds on the offshore islands, but forages in the surf zone and has been observed roosting in the dunes of the Eastern beach. Damara terns breed in the coastal dunes and are threatened by habitat loss and human disturbance (CEN 1997, CSIR 1997).

2.3.6 SITE 6 – BACK OF BREAKWATER AREA (OUTER BASIN)

This area is currently below the hightide mark. It is estimated to accommodate 3 million m³ of excavated material. The site is landfill, requiring neither landscaping nor rehabilitation. The site is suitable for the disposal of wet dredge material from the harbour basin.

2.3.7 SITE 7 – BEHIND QUAY WALLS

This site is landfill used to level the site for infrastructure behind the quay walls. It is estimated to accommodate 1 million m³ of excavated material. It is landfill and no landscaping or rehabilitation is needed.

2.4 ISSUES, IMPACTS AND MITIGATION

A number of environmental impacts affecting the biophysical environment result from project actions associated with the disposal of excavated material. These environmental impacts are grouped into a number of Key Issues. They include both potentially permanent impacts and temporary impacts arising from project actions. Impacts were evaluated according to standardised criteria defined by CES guidelines (Appendix 8), and are discussed below and summarised in Table 2.1.

ISSUE 1: THE IMPACT OF LAND DISPOSAL ON SENSITIVE HABITATS

Impact 1: Loss and fragmentation of sensitive habitats

Cause and comment: A variety of habitats will be impacted by land clearance in the container terminal area, along the haulage links between the excavation and disposal sites, and at the various disposal sites themselves. These habitats include Dune thicket (Site 1, Site 7, and container terminal area), Mesic Succulent Thicket (Sites 2 and 3) and Bontveld (Site 3) vegetation, and estuarine (inner harbour basin), salt pan (Site 4) and shore (Site 5) habitats. Different and often specialised floras and faunas are associated with these habitats, and they may be impacted in different ways by the various project actions. A number of vegetation types, e.g. Dune Woodland, Salt Marsh, Grassy Fynbos, etc. are less sensitive, due mainly to infestation with alien plants. Impacts on these vegetation types will therefore be of low significance. Fragmentation of habitats can lead to the loss of viable populations, especially in animals requiring large home ranges (e.g. birds of prey, bovids, carnivores, primates, etc). The disruption to gene flow between isolates also reduces biological fitness in the long term, compromising the abilities of populations to adapt to future environmental perturbations.

Significance statement: Project actions will cause the loss and fragmentation of sensitive habitats. These include areas of Dune vegetation, Mesic Succulent Thicket and Bontveld. Important estuarine, salt pan and shore habitats will also be lost. These actions will **definitely** result in a permanent, **severe** impact at a *localised* level. The environmental impact resulting from the loss of this vegetation will be of HIGH significance.

Mitigation and management: Mitigation includes protection of sensitive habitats and rehabilitation. Bontveld is the most sensitive habitat in the region and development of sites on Bontveld habitat should therefore be avoided. Many disposal sites form the foundations for subsequent developments, e.g. Sites 3 (in part), 6 and 7, and do not require rehabilitation. Site 5, the eastern beach, will naturally rehabilitate its profile. Sites on which future developments are not immediately planned include Sites 1, 2 and 4, which would require rehabilitation. Recommendations for landscaping and rehabilitation are given in Appendix 1. Mitigation, involving rehabilitation and not using sensitive sites, will **probably** reduce the impact to **moderately severe** and of LOW to MODERATE significance.

ISSUE 2: THREATENED OR SENSITIVE SPECIES

Impact 1: Impacts to threatened or sensitive species

Cause and comment: Numerous threatened and sensitive plants and animals occur in the region and may be impacted by the proposed project actions. Among the plants are eight Red Data listed species (2 Endangered, 4 Vulnerable, and 2 Rare species). The estuary and salt pans are important for specialist salt-tolerant birds, including three Near Threatened species (Chestnutbanded plover, *Charadrius pallidus*; Greater flamingo, *Phoeniconaias ruber*; and Lesser flamingo, *Phoeniconaias minor*). A number of threatened sea birds are associated with the coastal dunes and seashore (La Cock and Cohen 1997; Wooldridge *et al.* 1997; Boshoff and Sigwela 1998; and references therein), including the endangered Roseate tern (*Sterna dougalli*) and Damara tern (*Sterna balaenarum*) (Barnes 2000). The African black oystercatcher (*Haematopus moquini*) and Caspian tern (*Hydroprogne caspia*) also use the beach and are classed as Near Threatened (Barnes 2000). Roseate and Damara terns are two of the most endangered coastal species in South Africa. The former breeds on the offshore islands, but forages in the surf zone and has been observed roosting in the dunes of the Eastern beach. Damara terns breed in the coastal dunes and are threatened by habitat loss and human disturbance (CEN 1997, CSIR 1997). Among sensitive mammals, Duthie's golden mole (*Chlorotalpa duthiae*) and the pygmy hairy-footed gerbil (*Gerbillurus paeba exilis*) are endemic to the region. Both are restricted to dune habitats, the former in the dune woodland, and the latter in the open dune sand where there is little or no vegetation (Van Teylingen *et al.* 1993). Reptiles of special concern that may be impacted by the loss of Bontveld, Mesic Succulent Ticket and Dune Vegetation habitats include Tasman's girdled lizard (*Cordylus tasmani*), the Algoa dwarf burrowing skink (*Scelotes anguineus*) and the Albany adder (*Bitis albanica*). The rare lycaenid butterfly *Aloeides clarki* inhabits coastal flats to the north of Port Elizabeth and along the Sundays River. It has a complex life cycle and the Neptune Valley site is of critical importance to this localised species.

Significance statement: Impacts on threatened and sensitive species will occur. Disturbance will **probably** result in a long term, **severe** impact at a *localised* or *international* level, depending upon the species impacted and mitigation. The environmental impact will therefore be of HIGH significance.

Mitigation and management: Mitigation involves the selection and rehabilitation of disposal sites. Site 2 – Neptune's Valley – is in an environmentally sensitive area and includes a critical breeding site for a rare and localised butterfly. It should not be disturbed, and disposal and development at

this site should not occur. Similarly, Bontveld habitat should be fully protected. Impacts on many threatened birds would be reduced if the salt pans remained as effective habitat or compensatory habitat was developed elsewhere (e.g. the relocation of the salt works to the Sundays River region). Sites in Dune Vegetation and Mesic Succulent Thicket should be landscaped and rehabilitated after use. Recommendations for landscaping and rehabilitation are given in Appendix 1. Compliance with the suggested mitigatory measures, particularly the selection and rehabilitation of disposal sites, will **probably** reduce this impact to *moderately severe* and of LOW to MODERATE significance.

ISSUE 3: ARCHAEOLOGICAL SITES

Impact 1: Threats to archaeological sites

Cause and comment: A number of shell middens were located 0.5 km east of the Coega River mouth and east towards the boundary of the IDZ (Binnerman and Webley 1997; Binnerman 1998). The sites were of low importance and no 'new or unique' features or material were found during the survey. However, it was noted that further, more important sites may be covered by dunes and vegetation and may be exposed during project actions. Additional sites may be uncovered during disposal of excavated material on the eastern headland, and during excavations in the container terminal area.

Significance statement: Project actions may uncover archaeological sites of scientific interest. Depending upon the cultural importance of the sites, disturbance will **probably** result in a permanent, *moderately severe* impact at a *localised* or *national* level. The environmental impact will therefore be of HIGH significance.

Mitigation and management: In terms of the National Heritage Resources Act (Act No 25 of 1999), if an artefact or any other object of possible cultural or historic significance is uncovered during an excavation, all work on the site will have to be terminated and the advice of an expert must be obtained. Any suspected site or object located during construction should therefore be reported immediately to the National Monuments Council. All construction site staff must be briefed to immediately report any sites that are located during the construction of the facility. The Contractors and Coega Environmental Officer must be informed of the sensitive areas and be fully briefed on what archaeological remains may be encountered. Compliance with the suggested mitigatory measures and adherence to legal specifications will **probably** reduce any impacts to *slight* and of LOW significance.

ISSUE 4: THE IMPACT ON NORTHERN BEACHES

Impact 1: Temporary change to beach profile

Cause and comment: It proposed to move approximately 1 million m³ of beach sand from the Coega River mouth approximately 500 m north of the existing mouth and along a 2 km frontage of beach, mainly in the intertidal zone. This material comprises clean beach sand overburden and will be moved by heavy earthmoving equipment.

Estimates indicate that net longshore movement of sand in the mobile dune belt around Algoa Bay is a longshore in a northeasterly direction. The rate of movement is approximately 1500 m³ yr⁻¹. Because of disruption to longshore transport of sand by the southern harbour breakwater, it is necessary to install a jet pump system immediately south of the harbour in order to transfer 150 000 – 200 000 m³ yr⁻¹ of sand to the northern side. This is necessary to counter beach erosion adjacent to the harbour and as sediment transport continues. However, a temporary measure is required during initial harbour construction and before the jet pump system is operational. This temporary

measure involves the deposition of the above clean sand. This will temporarily alter the beach profile to a new level 1m higher than the existing profile.

Significance statement: The change in beach profile will definitely increase by approximately 1 metre. This will **probably** have a *slight* negative impact in the short term at a *local* level, but no significant impact at the *district* or *regional* scale. The environmental significance of the unmitigated impact to the beach immediately north of the harbour breakwater will be of LOW significance.

Mitigation and management: The dynamic nature of the intertidal zone will sort and transport material deposited north of the harbour. The impact of the northern breakwater could, however, accelerate sediment transport (particularly if grain size is relatively fine compared to beach sand) and lead to localised erosion. Erosion may become problematic if the jet pump system is not yet operational. It is therefore recommended that a more flexible beach deposition programme be implemented, determined by circumstances and executed along a shorter stretch of beach. The same gross amount of sand could be separated into 2 units deposited over 1 000 m of beach, according to recommendations by the sedimentologist monitoring the beaches. Mitigation of the impact by introducing a more flexible programme of sand deposition will probably reduce any impact to one of NO significance.

ISSUE 5: THE EFFECT ON HYDROLOGY

Impact 1: Changes to hydrology

Cause and comment: Disposal onshore of excavated material may disrupt and modify existing aquifers and drainage patterns upon which the existing landforms and biota are dependent. The southern portion of the port area is underlain at depth by a major aquifer (the Coega Ridge Aquifer Unit) which is protected under the Government Proclamation No. 260 of 1957 and No. 958 of 1958. Due to its depth, the disposal of excavated material at any of the proposed sites will have no impact on this aquifer.

Groundwater flow in the Sundays River and Kirkwood Formations is towards the sea in the east and down toward the Sundays River, which forms a local base level in the north-east. The gentle groundwater gradient does not imply a highly permeable formation but represents a remnant of a groundwater system that is equilibrating slowly in the absence of significant recharge. The relatively impermeable clays have thin discontinuous sandstone horizons that yield low sustainable volumes of poor quality water. Although large volumes of excavated material are to be disposed of, it is generally of high porosity (approx 5% clay). It is thus unlikely to significantly impact groundwater movement in the long term. Excavated material deposited in natural drainage lines will affect the movement of surface water, possibly leading to increased erosion. The most sensitive sites, e.g. sites 1, 2 and 3, occur along the steep slopes bordering the Coega River.

Significance statement: Changes in hydrology resulting from the onshore disposal of excavated material may occur, and will **probably** result in a medium term, *slight* impact at a *local* level. The environmental significance of this unmitigated impact would be LOW. Even with mitigation, the impact would remain *slight* and of LOW significance.

ISSUE 6: THE EFFECT ON WATER QUALITY

Impact 1: Changes to water quality

Cause and comment: Analysis of cores collected during geotechnical surveys reveal that the excavated material has been declared free of significant contaminants. All the samples complied to local and international standards with regard to their trace metal and chlorinated pesticide levels, as

well as being well below levels regarded as giving rise to risk of adverse ecological impact. The expected salinity levels of the excavated material are unknown. The inner harbour basin excavation lies in the mouth of the Coega River, the estuary of which has for many years been used as a commercial salt works. High salinity levels may thus be expected in the excavate, particularly that from the palaeochannel.

The impact of potential changes in water quality also depends on the location of the disposal site. Deposition of material in sites situated further inland and within natural drainage channels may have more significant impacts than material deposited in less sensitive regions. The disposal sites presenting the greatest risk of causing changes to water quality include Sites 2 and 3. Core sample analysis indicates that chemical contamination is not a significant risk.

Impacts from increased salinity may occur with onshore disposal. During the course of excavation material should be monitored for salinity levels. Material of high salinity should be placed at the bottom of a disposal site and covered with at least 1m of excavated material of low salinity on the upper, landscaped surface to enable rehabilitation with natural vegetation. Natural seepage will, over time, reduce salinity within the soil profile.

Significance statement: Changes in water quality associated with the onshore disposal of excavated material of high salinity may occur and will **probably** result in a short term, *slight* impact at a *local* level. The environmental significance of this unmitigated impact would be LOW, and would remain so even with mitigation. Any mitigation of the impact of increased salinity would **probably** only serve to decrease the effect to *very slight*.

ISSUE 7: THE EFFECT ON AIR QUALITY

Impact 1: Changes to air quality from particulate emissions

Cause and comment: A specialist study to assess quantitatively, where possible, the extent of particulate concentrations associated with the proposed development was undertaken (see Air Quality Specialist Study by Burger and Watson 2001 in Specialist Studies Series – Part 2). Emission rates for most constituents were calculated using information received from the project design team. Particulate emission rates were modelled for the paved haul road and two unpaved construction roads leading between the two dump sites. The particulate emissions from the outer basin reclamation dump site and east reclamation dump site, with offloading (tipping) of debris at each of the two dump sites were also assessed.

The results of the study are probably a slight underestimate as they did not include particulate emissions emanating from the tarred access roads leading from the St George's Park interchange to Joost Park, and the road from Joost Park to the main construction yard. All emissions from the construction yards and from the disposal of material on the breakwaters were also excluded. The exclusion of emission from these sources was due to limited information available on the vehicle traffic on these roads.

The findings may be summarised as follows:

- The main contributors to PM10 ground level concentrations are the unpaved roads linking the breakwaters and dump sites.
- The assumption of a realistic PM10 particle size fraction for the respective dump sites has a large impact on the accuracy of the predicted concentrations in the area being developed. The sensitivity of this parameter was clearly illustrated.
- The frequency of exceedance of the South African Department of Environmental Affairs and Tourism (DEAT) daily guideline of 180 µg/m³ is >30% of the year without control measures in place.

- The introduction of control mechanisms to limit 90% of the particulates originating from the unpaved roads, substantially improves the ground level PM10 concentrations predicted for the area.
- Ambient PM10 concentrations are at their maximum during the winter months. The addition of PM10 concentrations from the harbour development may result in substantial increases in these levels.

It was concluded that without mitigatory measures in place, ground level particulate concentrations will exceed the DEAT guidelines for the entire area associated with the development, with an incidence of 60% predicted closer to the construction area. Dust fallout can be classified as slight to very heavy, with very heavy indicated as any concentration $> 1\ 200\ \text{mg/m}^2/\text{day}$. Values predicted during unmitigated conditions indicate dust fallout classified as very heavy for the area directly associated with the harbour development site. Assuming a 90% control of emissions from the unpaved roads and a PM10 particle size fraction of 75% for the dump sites, the impact zone is reduced; however, dust fallout can still be classified as very heavy. Without the introduction of windbreaks to limit impact of ground level concentrations in the more sensitive areas like the salt works, predicted concentrations will grossly exceed DEAT guideline levels.

It is evident that particulate emissions will definitely have a high impact on the surrounding vegetation, and also the commercial salt works if this remains functional during the construction period.

Significance statement: Changes in air quality associated with dust generation during the onshore disposal of excavated material will definitely occur, and **definitely** result in a short term, **very severe** impact at a *local* level. The environmental significance of this unmitigated impact would be HIGH.

Mitigation and management: A number of mitigatory measures are recommended. The unpaved stockpile access roads were identified as a source of fugitive dust due to vehicle-entrainment. A variety of measures may be taken to reduce emissions from unpaved roads. They include measures aimed at reducing the extent of unpaved roads (e.g. paving); traffic control measures aimed at reducing the entrainment of material by restricting traffic volumes and reducing vehicle speeds; and measures aimed at binding the surface material or enhancing moisture retention, such as wet suppression and chemical stabilisation. The introduction of windbreaks may also limit the impact of particulate concentrations from dump sites on adjacent sensitive areas. Fuller details of potential mitigatory measures are given in Air Quality Specialist Study (Burger and Watson 2001 in Specialist Studies Series – Part 2). Mitigation of the impact would **probably** decrease the severity of the impact to *moderately severe* and the significance to MODERATE.

ISSUE 8: THE EFFECT OF INCREASED ROAD TRAFFIC ON LOCAL FAUNA

Impact 1: Mortalities resulting from an increase in road traffic

Cause and comment: Large volumes of road traffic will be associated with the excavation and haulage of material to the disposal site(s). Faunal mortalities on roads, particularly in pristine areas, may impact significantly on long-lived, wide-ranging species, e.g. tortoises. Short-lived, explosive breeders, i.e. species that undertake mass migrations to well-defined and long-established breeding sites (e.g. many amphibians), are also very susceptible to vehicles when crossing roads during their mass breeding migrations.

Significance statement: Increased road traffic within the Core Coega Development Area will definitely occur, and **probably** result in a short term, **slight** impact at a *local* level. The environmental significance of this unmitigated impact would be LOW.

ISSUE 9: NOISE

Impact 1: Increased noise levels

Cause and comment: Various operational activities associated with the excavation, haulage and disposal of excavated material will result in an increase in ambient noise levels and will probably have an impact on the fauna. Increased noise levels will reduce the abundance of many bird species, particularly shore and estuarine specialists. Increased noise and motor vibrations in wetlands will also impact amphibian breeding choruses, but these will be very localised and many amphibian species are surprisingly tolerant of urban noise.

Significance statement: Various project actions, but particularly the operation of earth-moving equipment, will definitely result in increased noise levels, which will **probably** cause a *moderately severe* impact of MODERATE significance at a *localised* level in the short term.

2.5 REVIEW OF DISPOSAL SITES

2.5.1 SUITABILITY OF DISPOSAL SITES

The proposed disposal sites differ in their environmental sensitivity and suitability as disposal sites.

Unsuitable sites

Site 2 – Neptune Valley. This site has previously been identified (CES 1997) as a ‘No Go’ area due to its sensitive Mesic Succulent Vegetation. It also harbours an important breeding colony of the endangered butterfly, *Aloeoides clarki*. Haulage routes from the harbour basin to the disposal site will also pass through sensitive regions. No disposal or future developments should occur at the site.

Site 4 – Salt Works. This site is unsuitable as a disposal site unless compensatory habitats are made available. The salt pans currently serve as an important habitat for estuarine birds, including Palaearctic waders and a number of threatened specialist species tolerant of hypersaline conditions. Although the site and habitat will be lost in future developments of the port, it can serve until such time as suitable habitat for these species.

Partly unsuitable site

Site 3 – Tank Farm. The proposed site is situated in a region of sensitive vegetation, including Mesic Succulent Thicket in the west and Bontveld in the eastern part. The latter extends into adjacent land within the Industrial Development Zone that has been earmarked for future development as part of the future Electronic and Technical Cluster. Bontveld habitat is particularly threatened and requires full protection. The Tank Farm and adjacent Electronic and Technical Cluster should be repositioned or re-orientated to avoid Bontveld habitat. If this is not possible then Bontveld habitat in adjacent regions should be acquired as compensatory land.

Suitable sites

Site 1 – Eastern Headland. Although covered with sensitive vegetation and close to identified archaeological sites, this site is suitable for use provided that certain mitigatory measures are taken. These include:

- Protection of the adjacent sensitive dune vegetation habitat that occurs along the IDZ. The dune area to the west of the port which is not being developed in the initial phases of the port must be protected. While these areas may be impacted upon in future developments, they must be protected in the interim. No development is planned in the coastal dunes to the east of the port

in the current or future phases of the port. These areas must be protected and regarded as compensatory land areas.

- The site should be suitably landscaped and rehabilitated after disposal of excavate. Faunal colonisation will successfully re-occur from the adjacent protected habitats.

Site 5 – Eastern Beach. This stretch of open beach could be beneficially used for disposal of clean beach sand currently located in the Coega River mouth. Due to the delay in construction and operation of the sand bypass system, disposal of beach sand to the Eastern beach site will maintain the existing sediment transport dynamics.

Site 6 – Back of Breakwater. There is no limitation on the use of this site. It will be reclaimed land, currently lying seaward of the existing highwater mark. It is suitable for disposal of dredged and excavated material. Surfaces not covered by port infrastructure should be suitably landscaped.

Site 7 – Back of Quay walls. This site will be covered by port infrastructure. There is no limitation on the use of this site. Surfaces not covered by port infrastructure should be suitably landscaped.

2.5.2 FURTHER RECOMMENDATIONS

In addition to the implementation of mitigatory measures identified under Issues and Impacts, the following recommendations should also be considered.

No dredge material should be disposed onshore, i.e. above the existing onshore highwater mark. Disposal of such material can occur at Site 6, the Back of Breakwater, which is a reclaimed site currently below the highwater mark.

No excavated or dredge material should be deposited outside of the area assessed in the Subsequent EIA, i.e. the Core Coega Development Area. Potential impacts in these areas have not been considered in this report.

Table 2.1: Summary of issues and impacts, before and after mitigation, resulting from the haulage and disposal of excavated material.

ISSUE/IMPACT	WITHOUT MITIGATION						WITH MITIGATION	
	RISK	TEMPORAL	SPATIAL	CERTAINTY	SEVERITY	SIGNIFICANCE	SEVERITY	SIGNIFICANCE
Issue 1: Loss and fragmentation of sensitive habitats	Will occur	Permanent	Localised	Definite	Severe	High	Mod-Severe	Low - Moderate
Issue 2: Impacts to threatened or sensitive species	Will occur	Long term	Localised – International	Probably	Severe	High	Mod-Severe	Low - Moderate
Issue 3: Threats to archaeological sites	May occur	Permanent	Localised – National	Probably	Mod-Severe	High	Slight	Low
Issue 4: Temporary changes to beach profile	Will occur	Short term	Localised	Probably	Slight	Low	Slight	None
Issue 5: Changes to hydrology	May occur	Medium term	Localised	Probably	Slight	Low	Slight	Low
Issue 6: Changes in water quality	May occur	Short term	Localised	Probably	Sight	Low	Very Slight	Low
Issue 7: Changes in air quality from particulate emissions	Will occur	Short term	Localised	Definite	Very Severe	High	Moderate	Moderate
Issue 8: Increased road traffic	Will occur	Short term	Localised	Probably	Slight	Low		
Issue 9: Increased noise levels	Will occur	Short term	Localised	Probably	Mod-Severe	Moderate		

CHAPTER 3: THE ENVIRONMENTAL IMPACTS OF MARINE DREDGING AT COEGA PORT

3.1 SITE DESCRIPTION

3.1.1 PHYSICAL

The terrestrial topography is typified by coast parallel dunes up to 30 m high, which give way to uniformly undulating hills up to 50 m high within 3-4 km of the coast. The construction area for the maritime infrastructure component of the port is on a beach at the mouth of the Coega River. The beach is periodically eroded by the Coega River when it is in flood.

The Coega River Valley represents the only major incision into the coastal landform in the area between the Swartkops and Sundays rivers. Over time, the river has created a flood plain valley between 400 and 1 000 m wide, which extends inland and has been extensively developed as a commercial salt works. The incision is a cost effective route through which a transportation corridor can be constructed linking the port with the industrial hinterland. It also provides a location for a harbour basin with reduced earthworks and dredging costs. The Coega River has been canalised around the north side of the salt works and runs through the area of proposed port construction.

The geology of the site is characterised by Quaternary alluvial and estuarine sediments in the estuary and dunes, and Tertiary formations in the flanking hills, which overlie Cretaceous mudstones, siltstones and sandstones. To the north of the estuary evidence of quartzitic sandstone has been recorded at depth. Of primary importance to the location of the port is the existence of an asymmetric palaeo-valley, filled with discontinuous layers of gravel, sand, silt and clay. The dredging of the harbour basin to -16 m CD will ostensibly be in unconsolidated material. The quay walls have been orientated to take advantage of the palaeo-valley in this respect.

A number of boreholes have been drilled in the basin area and extremity of the approach channel, and the geotechnical characteristics of the sediments established. The results and detailed composition of the sediment are presented in the Monitoring Guidelines section (see Chapter 5), and will not be repeated in any detail here.

The results showed that sand and silty sand are the dominant components of the material to be dredged. The remainder of the sediment comprises fluvial gravel, estuarine clay and Kirkwood mudstone. It is evident that silt and clay percentages increase with depth, though nowhere do they comprise more than 50% of the different sediment types. The sand is composed primarily of quartz, though with a substantial percentage of shell fragments in places giving rise to the higher levels of calcium carbonate. These shell fragments form minor gravel beds within the region to be dredged.

A total of 23 cores were obtained by vibrocoreing in the region where the approach channel will be (Lord *et al.* 1997). Diver observations at each of the core sites suggested that the surface sediment was mostly fine sand overlying mud in a few cases. Only site 23, the one furthest NE and slightly inshore, had any visible reef and soft coral arrangements. Analysis of the cores showed most to comprise fine sand overlying pebbles, shells and clay in the upper layer. Below this interface, cores further offshore at the outer extremity of the approach channel were predominantly clay with some shell, sand and pebbles. Closer to the Coega mouth, the lower layers were once again predominantly sand, pebbles and shells with small amounts of hard clay. Some nearshore sites (e.g. site 20) exhibited larger sediment types below the interface, with rough shells and stones being recorded.

Malan (1991) sampled along two transects to the west (Bluewater Bay) and east (adjacent to the Sundays River mouth) of the proposed new port at Coega. At Bluewater Bay stations at 4, 6, 8 and 10 metres water depth had coarse gravel surface substrates, while deeper stations had sandy substrates. At the Sundays River site, all eight stations down to 20 m water depth were characterised by sandy substrata, with the two deeper stations (at 15 and 20 m water depth) having 15% and 27% subsieve fractions respectively (particles <62 microns in diameter). These data are therefore in accordance with the more recent information provided by Entech Consultants (2001).

Sandy beaches and their adjacent surf zones are dynamic environments where sand and water are always in motion. A series of morphodynamic states can be identified according to the scheme of Short and Wright (1983). These states range from dissipative through to reflective, with a series of four intermediate stages between the two extremes. Each state has a characteristic set of wave features and water circulation patterns that generate a distinct beach and surf zone shape. Circulation of water is driven by the interaction of surface waves advancing towards the beach, and longshore currents and rip currents that return water to the nearshore.

Flat dissipative beaches have broad surf zones with many lines of breaking waves that result in a progressive loss of wave energy towards the shore. This generates slow swashes with long periods on the gently sloping beach face. At the other end of the spectrum, beaches may be steep and reflective, with no surf zones. Part of the wave energy is "reflected" back to sea by the very steep beach face. Fine sand and high wave energy generally result in Dissipative systems, while low wave energy and coarse sand result in Reflective beaches. Between dissipative and reflective states, a series of Intermediate beach types occur. Bars and troughs, well-developed rip systems and a high degree of variability in space and time characterise these Intermediate states.

Although occasionally dissipative, the surf zone modal morphodynamic state in the eastern sector of Algoa Bay is classified as Intermediate-Transverse bar and rip. Beyond the Sundays River mouth, sandbars welded to the beach are separated by active rip systems that occur at a frequency of about 2 per running kilometre of shore (Talbot and Bate 1987a, b). The surf zone is generally 250 - 300 m in width, while wave height at the breakpoint ranges from 1 - 6 m. West of Sundays River, surf conditions become progressively less dynamic and the features described for the Sundays sector occur on a smaller scale. However, the same functional states are identifiable between Coega and the Sundays River mouth.

Sand is moved by moderate to heavy wave energy in a longshore direction in the nearshore zone. Movement is both north and south, although net movement is in the northerly direction (Schumann 1984). An estimation of net volume moved northward each year is in the order of 150 000 to 200 000 m³/year (Illenberger 1993 ; McLachlan *et al.* 1994).

The wind conditions at the Coega River mouth and surrounding areas are characterised by three dominant directions, these being WSW-SSW, E-ESE, and NW-NNW. Although westerly winds dominate throughout the year, a greater percentage of easterly component winds can be expected in summer months (Schumann 1997). Calmest periods occur in May/June, with the strongest winds in October/November. Data from Schumann and Martin (1991) show that it is rare for either easterly or westerly winds to blow consistently for longer than a few days. The wind velocities at Coega have an expected 1 in 1 year return velocity of 16 m/s, a 1 in 10 year return velocity of 17.3 m/s, and a 1 in 50 year return velocity of 18.1 m/s. The data used to calculate these values was collected at four wind stations located at Cape Recife, PE Airport, Coega River Mouth and at the Sundays River.

Tides in Algoa Bay, which are propagated from west to east, are classified as semidiurnal microtidal, with amplitudes generally below 2 m, and a high degree of variability between spring

and neap amplitudes (Schumann 1997). Tidal velocities over the Agulhas Bank typically measure < 5cm/s (Schumann and Perrins 1982) and can form an important component of the current field in Algoa Bay at times (Churchill 1995).

The wave and current conditions have been determined using data measured by a sub surface directional buoy in 16.5 metres of water. The results have indicated that the currents in Algoa Bay respond rapidly to the wind conditions. There are two distinct deep sea wave directions, the SW waves and the east waves. Significant wave heights for a 1 in 5 year and 1 in 50 year return periods are 7.6 m and 9.1 m respectively. The waves from the southwest refract around Cape Recife and approach the port from the SSE. The waves from the east refract and approach the port from the SE. The entrance to the port has therefore been orientated to face south thus reducing wave penetration into the harbour. The most damaging waves are those originating during strong easterly winds, and have been responsible for extensive damage to coastal structures and ships in the past (Schumann 1997).

Schumann and Campbell (1999) have discussed current measurements made to the north of the Port Elizabeth harbour, as well as at a position farther into Algoa Bay in a water depth of 42 m. These data were obtained at fixed mooring positions, with the current meters generally deeper than 5 m. The results show that close inshore the currents are sluggish, with some evidence for tidal and inertial oscillations. In deeper water the currents become stronger, with a marked southerly tendency.

It has generally been assumed in the past that currents in Algoa Bay were predominantly northeastward, and being driven by the dominant southwesterly wind (e.g. Harris 1978). The current meter results show that below the direct influence of the wind the southwestward-flowing Agulhas Current has a major influence. Although the Agulhas Current passes approximately 74 km offshore at Algoa Bay (Goschen and Schumann 1990), its warm waters occasionally penetrate into the Bay, presumably as a result of Natal Pulses combining with westerly winds. Upwelling may also occur along the inner boundary of the Agulhas Current and the continental shelf slope (Schumann 1987). Easterly winds then drive this cold water to the surface and could penetrate into the Bay from the direction of Bird Island (Schumann *et al.* 1988).

Schumann (1999) analysed data from the *InterOcean Systems* S4 current meter moored at a position about 1 km south of Jahleel Island. Seven deployments covering a period of approximately eight months were included. Considerable variability was recorded, and an overall average current speed of 4.9 cm/s was found, with a maximum speed in excess of 30 cm/s towards the east-northeast. The maximum current to the north-northwest was only 8 cm/s. More recently, PRDW have analysed currents from more deployments, and their results show that only 1.3% of currents had speeds greater than 20cm/s.

A rotary spectral analysis shows that both M_2 tidal and inertial oscillations are present at Coega. This means that currents at the M_2 period move backwards and forwards, probably along the line of the isobaths, with a period of 12.42 hours, while inertial currents move in an anticlockwise circle with a period of about 21.5 hours. These currents have been found to significantly contribute to the current field in the nearshore environment to the north of Port Elizabeth harbour (Churchill 1995). There is, however, considerable variability, with inertial currents being more prevalent at certain times compared to others (Schumann 1997).

It is important to recognise that at the sea surface the situation is probably different, coming more under the influence of the wind. Thus surface currents would probably be driven by the dominant southwesterly winds, though east-northeasterly winds increase in summer, with offshore land breezes also prevalent.

Apart from catastrophic flood events, which may occur every 15 years, density structures in Algoa Bay are determined largely by temperature (Churchill 1995). Both sea and air temperature affect insolation, wind and air column stability which control the extent to which water column mixing takes place. In Algoa Bay, thermoclines are evident in summer months due to the excess solar radiation input (Goschen 1991). A net loss of heat in winter leads to the dissipation of these thermal structures. Coastal temperatures can also be altered dramatically when warm Agulhas Current water enters the bay (see above). Cold waters which are the result of wind driven Ekman drift upwellings, penetrate into the Bay from the Cape Recife side, but it is not known if they extend beyond the north side of the main harbour (Goschen and Schumann 1995 ; Churchill 1995).

3.1.2 TESTING FOR CONTAMINATION OF THE SEDIMENT AT THE DREDGE SITE

Of particular concern at some dredge sites around the world is the generation of large volumes of contaminated sediment that are dredged and transported to disposal sites. Heavy metals, for example, are major anthropogenic contaminants of coastal waters that originate from urban runoff, industrial effluent, mining operations and atmospheric contaminants. These contaminants accumulate over time and dredging operations may cause the sudden release of these contaminants that would otherwise be retained or released slowly by diffusion. Although many of these heavy metals are biologically essential elements, all have the potential to be toxic to aquatic biota above certain threshold concentrations.

An earlier investigation by Connell and Parsons (1999 – see Appendix 3) indicated that sediments from the proposed dredge sites were suitable for disposal since they complied with local and international standards with regard to their trace metal and chlorinated pesticide levels. In addition, levels of contamination were well below levels regarded as giving rise to risk of adverse ecological impact. This result was not surprising as the area has had limited industrial activity and would best be described as a clean sands environment.

3.1.3 BIOLOGICAL

Surf zone invertebrates

A paucity of information exists on the macrobenthos found beyond the surf zone in Algoa Bay, and this was regarded as a constraint in the preparation of this aspect of the report. However, while the impacts on specific organisms may not necessarily be known, the general impact on marine invertebrates as a group should provide an accurate assessment of the dredging operation.

A distinctive feature of the surf zone along the eastern sector of Algoa Bay is the regular occurrence of visible accumulations of the diatom, *Anaulus australis*. These accumulations have the appearance of oil slicks on the water and occur where the surf zone is exposed to strong wave action. West of the Sundays River mouth, the surf zone becomes less dynamic and there is a concomitant decrease in the frequency of occurrence of diatom accumulations. However, *Anaulus* accumulations still occur near Coega.

Along the Sundays River beach, *Anaulus* accounts for over 95% of the plant production (Campbell and Bate 1988) and is the basic food source on which the rest of the foodweb in the surf zone and adjacent beach is based. *Anaulus* exhibits clear patterns of spatial and temporal distribution. During the day, accumulation of cells is generally associated with rip current activity and is the result of the hydrodynamic interaction between shoreward movement of water through wave activity and return currents via rips (Talbot and Bate 1988). Concentration of *Anaulus* cells is also greatest near the water surface and is due to their positive buoyancy through cell adherence to air bubbles. Although

Anaulus australis accumulations are generally closely associated with rip currents, cells are continually being added to and eroded from patches as a result of water currents.

Anaulus australis fuels three distinct food chains (Brown and McLachlan 1990), namely the interstitial system foodchain (small organisms living between the sand grains), the microbial foodchain (the bacterial component) and the macroscopic foodchain (organisms retained on a sieve with a mesh aperture of 0.5 - 1.0 mm). Of the total primary production by *Anaulus* along the Sundays River beach, about 40% enters the microbial foodchain, about 20% is consumed by the interstitial system, while macrofauna account for 10-15%. Approximately 30% is exported to the marine nearshore, much of it as detritus (fragmented organic matter).

The macrofauna consists of a large number of animals, although the number of species is relatively low. The foodweb is centred in the surf zone and comprises the benthic community living in the sand and a pelagic community present in the water column. Generally, molluscs dominate the finer-grained beach sands of Algoa Bay, with biomass largely attributed to sand mussels and plough snails. Both the benthos and pelagic community respond to the physical dynamics of the inshore zone that also regulates the accumulation of phytoplankton. Surf zone phytoplankton and suspended organic detritus form the basis of the entire macrofaunal foodweb, since attached plants are not able to withstand the dynamic nature of the surf zone.

Benthic organisms include the filter feeding sand mussels, *Donax* spp., scavenging snails of the genus *Bullia* and the three-spotted swimming crab, *Ovalipes trimaculatus*. *Donax serra* is the larger of two sand mussel species, attaining a length of about 70 mm. It usually occupies a band near the mid-tide level while the smaller *Donax sordidus* (maximum length about 35 mm) occurs around the low water mark. Being filter feeders, the two sand mussel species attain maximum population densities where phytoplankton production is relatively high. Consequently, biomass declines to the west of Sundays River. Sand mussels are key organisms in the foodweb and are preyed on by a variety of organisms including gulls, oystercatchers, crabs, sandsharks, rays, fish and humans. Small waders, such as sanderlings, nip off the tips of *Donax* siphons, but these rapidly regenerate.

The plough snails *Bullia rhodostoma*, *B. pura* and *B. digitalis* all have conical shells. *B. rhodostoma* dominates in the intertidal zone while the other two species are subtidal. *Bullia* spp. are important scavengers, feeding on almost any animal cast up on the shore.

The three-spot swimming crab *Ovalipes trimaculatus* is an important invertebrate predator on Eastern Cape beaches, feeding predominantly on sand mussels and plough snails. *Ovalipes* is essentially subtidal in distribution, occurring to depths greater than 40 m in Algoa Bay. Crabs also bury themselves in the sand, where they spend much of their time. Peak breeding occurs in winter, and although most settlement occurs in deeper water, crabs move progressively further inshore as they grow bigger.

The mysid shrimp *Gastrosaccus psammodytes* is extremely abundant in the subtidal breaker zone forming an important link between the primary food supply and higher levels of the macrofaunal foodweb. During the day, *Gastrosaccus* remains buried in the sand, undergoing periodic excursions into the water column to feed on *Anaulus*. The non-availability at night of phytoplankton in the inner surf zone results in a concomitant change in the feeding behaviour of *Gastrosaccus*. The more active swimmers in the population (e.g. non-breeding component) migrate offshore where they exploit the accumulated food source behind the breakers.

A second species of mysid, *Mesopodopsis wooldridgei* also utilises the accumulated food source behind the breakers at night, and seldom ventures into the white-water zone where it would be

vulnerable to physical damage as a result of the generally turbulent conditions. *Anaulus* is therefore not available as a foodsource to *M. wooldridgei* during the day. Instead, *M. slabberi* remains in deeper water at this time where it is less visible to predators feeding in the water column. After dark, there is a general migration onshore where they remain until dawn, feeding behind the breakers. Off the Coega River mouth, densities of up to 1 300 m³ of water have been recorded behind the breakers. This value was amongst the highest recorded over a two-year period at a series of eight stations around Algoa Bay.

Feeding behaviour of fishes on invertebrates in the surf zone is characterised by opportunism. The mullet, *Liza richardsoni* feeds primarily on surf diatoms, but also on mysids when they are abundant. Other important predatory fish include the white steenbras, *Lithognathus lithognathus*, which feeds on *Donax*, and the sandshark, *Rhinobatus annulatus* which predares on *Gastrosaccus* and *Donax*. Lasiak (1983) recorded 30 species of fish using Eastern Cape surf zones as nursery areas. About half of these species were also recorded as adults. All juveniles recorded were zooplankton feeders, consuming large quantities of mysid shrimps. The rich supply of zooplankton food (especially at night) may be an important feature of sandy beach nursery areas. Ultimately, surf zone hydrodynamics and high levels of *Anaulus* production primarily sustain this foodchain.

Phytoplankton accumulations as described clearly present an important food source. Such persistent accumulations are reported from most continents where beaches are typically extensive, have broad dissipative surf zones and are exposed to strong wave action. Since the nearshore ecosystem in the eastern sector of Algoa Bay is unique with regards phytoplankton, community and foodchain dynamics on a local, regional and national level, the area must be accorded a high conservation status.

Nearshore invertebrates

Few general studies have been undertaken on macroinvertebrates beyond the surf zone in Algoa Bay, although some species have received focused attention. The mysid *Mesopodopsis wooldridgei* occurs out to a depth of about 15 – 20 m in large swarms around Algoa Bay, where it moves inshore at night to feed behind the breaker line (Wooldridge 1999). The penaeid prawn *Macropetasma africanus* and *Ovalipes trimaculatus*, are also important species in the nearshore foodweb (Cockcroft and Wooldridge 1987). *M. africanus* and *O. trimaculatus* both use the surf zone as a nursery area, migrating further offshore as they mature, with the latter species being found down to 40 m.

Burrowing urchins are also common in the nearshore waters of sheltered bays and estuaries around the coast of South Africa, although their status is unknown in Algoa Bay. The sand dollar *Echinodiscus bisperforatus* inhabits sandy intertidal and subtidal areas to a depth of about 20 m. Nearshore populations are known from St Francis Bay, but an offshore study in Algoa Bay recorded only one live specimen at Sundays River in 5 m of water (Bentley 1992).

Cockcroft and Tomalin (1987) investigated the distribution of the sandprawns *Callinassa kraussi* and *C. gilchristi* at four localities in Algoa Bay, from Hobie Beach in the west to Sundays River in the east. While densities of up to 350 prawns m² were recorded off King's Beach and Hobie Beach (highest prawn densities in water depths between 5 and 10 m), no prawns were present off Bluewater Bay immediately to the west of the proposed new Coega Port. A fourth transect down to 20 m depth near Sundays River mouth also indicated no prawn burrows.

Malan (1991) investigated the benthic macrofauna (organisms retained by a 1 mm mesh sieve) off Bluewater Bay, King's Beach and Sundays River, and recorded approximately 100 species. If only Bluewater Bay and the Sundays River transects are considered, the total number of species is 72, of which only about 30% are common to both sites. However, most of species at King's Beach,

Bluewater Bay and Sundays River were present in very low numbers and a more intensive sampling programme would probably have shown greater similarity between sites with respect to species composition. Table 3.1 below reflects only the composition of the macrofauna at the Blue Water Bay and Sundays River transects.

In summary, the shallowest stations tended to have fewer species compared to the deepest sites, which appears typical of similar studies done elsewhere (Malan 1991). A transitional community appeared to be represented at intermediate depths just beyond the breakers. At the deepest Sundays River sites a different community, dominated by *Golfingia capensis*, *Phaxas decipiens* and aplacophoran molluscs, was present. Although Blue Water Bay supported a rich community at the deepest station, analysis of community structure along the depth gradient was not undertaken (because of sediment variability manifested in gravel patches along the transect; Malan 1991).

Suspension feeders dominated shallow stations, predators and scavengers were common further offshore and at the deepest sites deposit feeders dominated. These deeper sites therefore reflect calmer conditions where fine food particles are able to settle out. A similar trend is also apparent for sediment particle size along other depth gradients, e.g. at Lamberts Bay where increasing species richness in an offshore direction correlated with increasing clay content (Christie 1976 in Malan 1991).

Marine mammals

Ten species of marine mammals (Southern Right whale, Bryde's whale, Minke whale, Humpback whale, Humpback dolphin, Common dolphin, Bottlenose dolphin, Striped dolphin, Risso's dolphin and the South African Fur Seal) are relatively common in Algoa Bay, although some only seasonally (Wooldridge *et al.* 1997). All of these will be affected should they be in the vicinity when any blasting occurs, but two species are of particular concern regarding environmental disturbances, namely the Southern Right whale and Humpback dolphin. Bottlenose dolphins and the Cape Fur Seal are common residents in the Bay, even in the existing Port Elizabeth harbour, with the remaining species usually only encountered further offshore but still within the area under consideration (Wooldridge *et al.* 1997).

Table 3.1 Macrofauna species composition and abundance (numbers m⁻²) at transects off Blue Water Bay and Sundays River Beach. Numbers along the transect lines represent the depth at which samples were collected (adapted from Malan 1991).

Species	<i>Blue Water Bay</i>							<i>Sundays River</i>							
	1	4	6	8	10	13	15	1	5	7	9	11	13	15	20
Turbellaria	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
Euchiroidea	-	-	-	-	-	-	140	-	-	-	-	-	-	-	-
Sipunculoidea															
<i>Golfingia capensis</i>	-	-	-	-	-	-	43	-	-	-	-	-	10	120	165
Polychaeta															
<i>Antinoe lactes</i>	-	-	-	-	5	-	10	-	-	-	-	-	-	-	-
<i>Arebella mutans</i>	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-
<i>Capitella capitella</i>	-	-	-	-	-	-	17	-	-	-	-	-	-	-	-
<i>Cirriformia tentaculata</i>	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-
<i>Diopatra c. punctifera</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5
<i>Diopatra n. capensis</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5
<i>Diopatra n. neapolitana</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20
<i>Dispio magna</i>	-	-	-	-	-	-	-	-	-	3	-	-	10	-	15
<i>Glycera papillosa</i>	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-
<i>Glycera unicornis</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-
<i>Glycinde kameruniana</i>	-	-	-	-	-	-	10	-	-	-	-	-	-	-	-
<i>Goniodopsis incerta</i>	-	5	-	-	-	-	-	-	3	10	30	33	-	3	-

Species	Blue Water Bay							Sundays River							
	1	4	6	8	10	13	15	1	5	7	9	11	13	15	20
Polychaetae cont.															
<i>Harmothoe lunulata</i>	-	-	-	-	-	-	10	-	-	-	-	-	-	-	20
<i>Nephtys capensis</i>	-	-	10	-	-	-	-	-	3	3	-	-	-	-	-
<i>Nephtys sphaerocirrata</i>	-	-	-	-	-	-	10	-	-	-	-	-	-	-	-
<i>Orbinia bioreti</i>	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-
<i>Ophelia roscoffensis</i>	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-
<i>Ophelia acumiata</i>	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-
<i>Onuphis eremita</i>	-	-	-	-	-	-	3	-	-	-	-	-	-	-	5
<i>Pherusa swakopiana</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
<i>Sigalion capense</i>	-	-	-	-	-	-	-	-	3	10	-	3	-	25	-
<i>Stenelais limicola</i>	-	-	-	-	-	-	-	-	-	3	3	10	-	-	-
<i>Syllis ferrugina</i>	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-
Ostracoda															
-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-
Amphipoda															
<i>Cunicus sp.</i>	-	-	3	-	-	-	20	-	-	-	-	-	-	-	-
<i>Lysianissidae</i>	-	-	7	-	-	-	-	-	-	-	-	-	-	-	-
<i>Mandibulophoxus stimpsoni</i>	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-
Unidentified	-	-	-	-	-	-	3	-	-	-	-	7	-	5	-
Isopoda															
<i>Apanthura africana</i>	-	-	-	-	-	-	-	-	-	-	-	3	5	-	-
<i>Eurydice longicornis</i>	-	-	3	-	7	-	-	-	-	-	-	-	-	-	-
<i>Lepthanthura laevigata</i>	-	-	-	-	-	-	-	-	3	7	-	-	5	-	-
<i>Synidotea hirtipes</i>	-	-	-	-	-	-	1	-	-	-	1	-	-	-	-
Mysidacea															
<i>Gastrosaccus psammodytes</i>	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Decapoda															
<i>Diogenes extricates</i>	-	-	10	1	10	1	1	-	-	-	3	-	1	-	5
<i>Galathea intermedia</i>	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1
<i>Hexapus stebbingi</i>	-	-	-	-	-	-	47	-	-	-	-	-	-	-	-
<i>Hymensoma orbiculare</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
<i>Macropetasma africanus</i>	-	-	-	-	-	-	-	1	-	-	-	1	-	-	-
<i>Ogrides saldanha</i>	-	-	-	-	-	-	-	-	10	-	-	-	-	-	-
<i>Ovalipes trimaculatus</i>	1	-	-	-	1	1	1	-	1	-	-	-	-	-	1
<i>Palaemon perengueyi</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
<i>Penaeus indicus</i>	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-
<i>Phylira punctata</i>	-	-	1	1	1	1	3	-	-	-	-	-	-	-	5
<i>Processa austroafricana</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
<i>Thaumastoplax spiralis</i>	-	-	-	-	43	-	80	-	-	-	-	-	-	-	-
Aplacophora															
-	-	-	-	-	-	1	1	-	-	-	-	-	-	15	220
Pelecypoda															
<i>Abra ovalis</i>	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-
<i>Doxax sordidus</i>	13	1	-	-	-	-	-	1	20	-	-	-	-	-	-
<i>Macoma crawfordi</i>	-	-	-	-	-	-	10	-	-	-	-	-	-	5	1
<i>Mactra glabrata</i>	-	-	-	-	1	-	-	-	-	-	-	-	10	-	-
<i>Phaxas decipiens</i>	-	-	-	-	1	13	-	-	-	-	-	-	15	225	40
<i>Pseudopythina africana</i>	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-
<i>Solen corneus</i>	-	-	-	-	-	3	-	-	-	3	-	-	-	5	-
<i>Tellina alfredensis</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-
<i>Tellina canonica</i>	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-
Gastropoda															
<i>Ancilla albozonata</i>	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
<i>Bullia annulata</i>	-	-	-	-	1	1	1	-	1	-	-	-	-	-	5
<i>Bullia callosa</i>	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
<i>Bullia digitalis</i>	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
<i>Bullia laevissima</i>	-	-	-	1	-	-	1	-	-	-	-	1	-	-	-
<i>Bullia pura</i>	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
<i>Clavatula kraussi</i>	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-
<i>Cyclichna tubulosa</i>	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-

Species	<i>Blue Water Bay</i>							<i>Sundays River</i>							
	1	4	6	8	10	13	15	1	5	7	9	11	13	15	20
Gastropoda cont.															
<i>Fusinus ocelliferous</i>	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-
<i>Nassarius speciosus</i>	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Asteroides															
<i>Astropecten g. natalensis</i>	-	-	-		1	1	1	-	-	-	-	-	-	-	-
Ophiuroidea	-	-	-	-	1	1	20	-	-	3	-	10	40	20	190
Echinoidea															
<i>Echinocardium cordatum</i>	-	-	1	1	-	-	7	-	-	-	-	-	-	-	15
<i>Echinodiscus bisperforatus</i>	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
Number of species	3	2	10	5	14	10	32	3	11	8	5	9	9	12	21
% Suspension feeders	98	1	1	1	1	10	4	25	18	59	1	1	1	16	1
% Deposit feeders	1	-	3	25	22	20	91	-	10	7	-	58	99	83	96
% Predators/Scavengers	1	99	96	74	77	70	5	75	71	34	99	41	-	1	3

Southern Right whales appear in the Bay from June, with numbers peaking between August and October, when they use the shallow waters to give birth and nurse their calves. As many as 40 individuals have been counted in the Bay on a single occasion. These whales leave the bay as summer approaches, with the last few vacating the area by the end of January. Their incredible size and slow cruising speeds (0.25 – 2.2 knots) make them a hazard to the trailing suction hopper dredgers which are underway at all times, either dredging or en route to the disposal site. This species is protected under the Bonn Convention on Migratory Species (CMS) of which South Africa became a signatory in 1991.

The humpback dolphins are probably under the greatest threat. Between 200 and 400 individuals of southern Africa’s estimated population of less than 1 000 animals live in Algoa Bay (Karczmarski 1996), with the highest concentrations located west of the Sundays River around inshore rocky reefs. The surf zone off the Coega Estuary and around the St Croix Island Group are used as feeding grounds and for social interaction. Klages (1997) estimates that the development at Coega would exclude humpback dolphins from approximately 10 percent of their habitat in Algoa Bay. This species is also listed in the CMS, and it is anticipated that its status in the 1990 IUCN Red Data Book will soon be listed as endangered.

All whales, dolphins and seals are protected against disturbance by legislation (Sea Fishery Act 1988 and Seabird and Seal Protection Act 1973), and the responsibility lies with the dredger captain to avoid collisions and with the contractor to ensure that all marine mammals are cleared from the immediate vicinity prior to blasting. The provisions of the law in the relevant Acts above will be applicable during dredging operations.

Marine ichthyofauna and squid

The more than 70 species of bony fish, sharks, skates and rays, which have been recorded in the surf and nearshore zone in Algoa Bay (Romer 1986) comprise both endemics and wide ranging species. While some species are endemic to the East coast, none are endemic to Algoa Bay alone. The ichthyofauna of the region is considered unique as Algoa Bay falls within the transition zone between the warm sub-tropical waters to the north-east and the cool temperate waters of the south and west coasts (Smale 1992). Twenty-eight of these species can be considered common residents.

Studies at the proposed development site have not been conducted, but an understanding of possible effects can be obtained from studies in nearby areas (Wooldridge *et al.* 1997). Studies on

ichthyofaunal communities from the intertidal zone (Beckley 1985), subtidal gullies (Smale and Buxton 1989), subtidal surf zone (Lasiak 1982), shallow subtidal soft sediments (Wallace *et al.* 1984) and anglers' catches from shallow subtidal reef areas (Coetzee and Baird 1981) in close proximity to the Coega area revealed no rare or endangered species. Similarly, a study on teleost fish larvae of both pelagic and benthic species in Algoa Bay (Beckley 1986) revealed no rare or endangered species. Due to their poor swimming capabilities, larval fish are highly susceptible to hydraulic entrainment and thus high levels of mortality. The southern mullet *Liza richardsoni* makes up 50 percent of the surf zone community, while other common species include blacktail (*Diplodus sargus capensis*), sand steenbras (*Lithognathus mormyrus*), white steenbras (*L. lithognathus*), olive rock-grunter (*Pomadasys olivaceum*), white stumpnose (*Rhabdosargus globiceps*) and strepie (*Sarpa salpa*) (Lasiak 1982). The ray (*Myliobatus aquila*) and sandshark (*Rhinobatus annulatus*) are the dominant benthic feeders. The sandshark is especially common in summer when the females give birth in the surf (Rossouw 1983). The bronze whaler (*Carcharhinus brachyurus*) and the dusky shark (*Carcharhinus obscurus*) frequently enter the surf zone at Sundays River Beach as evidenced by angling catches, while abundant blue stingrays occur just behind the breaker line (Romer 1986). Migratory species such as elf and kob may be present in the dredging area during some months of the year. While the Bay, including the area off Coega, appears to fulfil an important role as a nursery area for juvenile elf and kob, amongst others, the nurseries for these species are not restricted to Algoa Bay alone (Smale 1984).

The chokkasquid has 26 known spawning sites within Algoa Bay, most of which are fished by recreational and commercial fishers during the peak season between November and February. None of these sites, however, fall within the proposed dredging sites and as such should not present a problem.

The 500 m marine reserve radius around each of the Algoa Bay Islands provide a sanctuary for many fish species and are important for protecting (even on a small scale) both biodiversity and exploited species. The paucity of marine reserves in the region makes each one of the island reserves potentially very valuable. Studies on the fish communities associated with the Islands are lacking, and as such we must consider the possibility of rare or endangered endemic species in the vicinity. In addition, it is thought that ragged tooth sharks utilise the reefs surrounding the islands in summer for mating and pupping.

Marine avifauna

The St Croix group of islands lie within Algoa Bay between the Coega and Sundays rivers. Jahleel Island covers an area of 2 hectares and is the closest to the dredging site, approximately 1.3 km from shore. These islands are designated nature and marine reserves and are considered highly sensitive areas in terms of ecosystem functioning. They hold a particular interest for several marine associated bird species which utilise these sites as breeding areas.

Fourteen seabird, 3 shorebird and 33 terrestrial bird species have been recorded for the St Croix and Bird Island groups in Algoa bay (Eastern Cape Nature Conservation 1996). Two of the breeding seabird species, the African penguin and Roseate tern, are considered as being of critical importance with regards to the proposed Coega Port development. La Cock and Cohen (1997) believe that any impacts and mitigation measures associated with these two species would adequately cover concerns regarding the other island group bird species. The African penguin and Roseate tern are listed in the Aouth African Red Data book (birds) as Vulnerable and Endangered respectively (Brooke 1984).

The African penguin is endemic to southern Africa, with the eastern-most breeding site being Bird Island on the edge of Algoa Bay. Since the beginning of the 20th century, there has been an approximately 70% decrease in population size, with an estimated population size of 179 000

individuals (Crawford *et al.* 1995), 43% of which reside on the islands in Algoa Bay. Jahleel Island specifically had the 11th highest population of 1 757 birds, recorded between 1991 and 1994. The breeding colonies in Algoa Bay were the only ones to show an increase in population size (37%) between 1980 and 1994, while other colonies around the country contributed to the overall decline. This is evidence of the importance of the islands to the continued success of the African penguin. African penguins have a prolonged breeding season from January to September, during which they are particularly vulnerable. This is specially evident during January when heat stress makes the birds highly vulnerable and any disturbance can lead to nest desertions (Randall and Randall 1981). Annual moulting takes place immediately after the breeding season from late October to early November, and represents a period when the birds are least equipped to handle environmental disturbances. La Cock and Cohen (1997) concluded that increased levels of mortality could be expected from disturbances related to the dredging operation as a result of reduced reproductive output.

The Roseate tern is among the five most threatened bird species in South Africa, and the third rarest seabird, with an estimated 400 individuals on the sub continent. These birds have a breeding range restricted to Dyer Island and the Algoa Bay Group. Most breed at Bird Island and St Croix Island but there are records that Jahleel Island is also utilised on occasion. They are rarely seen outside of their breeding season between May and October, and breeding success is largely dependent on the lack of disturbance by mammalian predators and man (Brooke 1984), the latter of which may be responsible for the disappearance of the colony that used to breed at Cape Recife until 1968. The infrequent use of Dyer Island means that the survival of the South African population is dependent on the protection of the Algoa Bay island breeding sites (Adams 1992). It is clear that any disturbance will impact negatively on this species, with the probability that Jahleel Island would be abandoned as a breeding and roosting site (La Cock and Cohen 1997).

3.2 PROJECT DESCRIPTION AND ACTION

3.2.1 TIMING OF BREAKWATER CONSTRUCTION

The main breakwater will be 2 530 metres in length, with the secondary breakwater extending 1 186 metres. The total length of time required for construction of the breakwaters is anticipated to be 22 months. There are four main phases, the first being site establishment, which will take 12 weeks. Timing of construction for each breakwater appears in Table 3.2.

Dredging of the approach channel will begin in Month 4, 2002 when the main breakwater is at 707 metres (*) chainage and the secondary breakwater at 402 metres. Dredging of the entrance channel and basin will begin in Month 7 when the main breakwater is at 1 109 metres (**) chainage and the secondary breakwater at 600 metres.

Table 3.2: Timing of breakwater construction.

Main Breakwater			Secondary Breakwater		
Date	Cum Tons	Chainage	Date	Cum Tons	Chainage
Month 1	0	0	Month 1	0	0
Month 4	609 650	707*	Month 4	195 978	402*
Month 7	1 239 850	1109**	Month 7	398 562	600**
Month 10	1 870 050	1405	Month 10	601 146	728
Month 13	2 500 250	1702	Month 13	811 458	795
Month 16	3 109 900	1989	Month 16	1 007 436	1028
Month 19	3 740 100	2286	Month 19	1 048 163.9	1077
Month 21	4 225 214	2510	Month 21	1 210 020	1186
Month 22	4 370 300	2530			

3.2.2 DREDGING WORK

The dredging of the port approaches, entrance channel and basin will require the removal of some 14.2 million m³ of material (11.2 million m³ from the entrance channel and basin area, and 3 million m³ from the approach channel). Dredging work will extend from the -18.0 m CD contour offshore at the beginning of the approach channel to the +5.0 m CD contour onshore at the inland side of the river channel. The approach and entrance channels will be dredged to -18.0 m CD and the basin to -16 m CD. Work will be undertaken in exposed and protected waters. Dredging may also supplant dry excavation where this proves more economical. Mobilisation of dredgers is expected to take 3 months, the dredging of the approach channel will take 3 months, and the dredging of the entrance channel and basin 21 months. Together with demobilisation (2 months), total time for the dredging programme will be 26 months (this includes areas of overlap), but may vary depending on whether dry excavation is used or not.

It is anticipated that a Trailing Suction Hopper Dredger (TSHD) will be used to dredge the approach channel and two thirds of the basin, while a Cutter Suction Dredger (CSD) will be used for the remainder of the basin. Furthermore, the TSHD will have a system whereby the overflow water from the hopper is collected and discharged from the bottom of the ship's hull, and is thus not discharged on the sea surface. If the overall cost of the operation is not affected significantly, the use of overflow system equipped with an Eco-valve to prevent air bubbles from mixing with the overflow discharge should be investigated. Details concerning the turbidity plumes associated with the dredging activity, namely settlement and resuspension of sediments and monitoring guidelines, are dealt with in detail in the Monitoring Guidelines section and will not be dealt with in any more detail here.

Dredging of the approach channel by the TSHD will take 3 months and should be completed by the time work on the entrance channel and basin begins in Month 7, when the main breakwater reaches 1 109 metres and the secondary breakwater reaches 600 metres. (see timing of breakwater construction table earlier, and note that timetable may alter depending on contractors' schedule.)

3.2.3 BLASTING

If hard rock is encountered, this will have to be removed using underwater drilling, blasting and dredging. It is expected, however, that very small volumes of hard material occur within the dredge area, which means only minimal blasting will be required. There is no specific timetable for blasting, as this will be performed on an *ad hoc* basis whenever the rock deposits are encountered. It has been recommended that the aim of the contractors should be to reduce marine vertebrate mortality (with the exception of fish) to zero (Wooldridge *et al.* 1997).

3.3 ENVIRONMENTAL IMPACTS OF DREDGING

3.3.1 DREDGING IMPACTS ON BIOLOGICAL RESOURCES

Dredging operations result in the physical removal or destruction of benthos and habitat along the operational path, and the subsequent smothering/burial of nearby substrata and organisms when sediments disturbed by the dredgers settle once more. Dredging can typically result in a 30-70% reduction in species richness and a 40-90% reduction in biomass and numbers in the dredged trail (Table 3.3).

Despite the immediate impact, recovery of the community probably begins soon after the operation ceases. In the fine sediments found in a South Carolina estuary, substantial recovery occurred after

3 months (Van Dolah *et al.* 1984). In this study, no long term disruption to the macrobenthos was recorded. The impact of sand dredging at Port Stanvac was such that dredging had a significant and immediate pulse disturbance on epibenthic communities, but within 12 months, the recovery of the system was such that no evidence of the impact was discernable on average community structure (Cheshire *et al.* 1996). These authors considered the term ‘average community structure’ appropriate, given the high spatial and temporal variability of natural systems. Hall *et al.* (1990, quoted in Cheshire *et al.* 1996) obtained similar results at a dredged site in a Scottish Loch. However, rates of recovery are variable, depending on the habitat type. Table 3.4 below summarises rates of recovery following dredging in various habitats – in fairly liquid muds, recovery can occur within weeks. Much longer periods are required for coarse sediments. In general, a 2-4 year period is realistic for gravels and sands, but this may increase to more than 5 years in coarser deposits. This would also imply that variability of particle size along the dredge path would also influence the rate of recovery.

Recovery at the dredge site therefore appears to be linked to the granulometric properties of the sediments (e.g. particle size) and the different communities associated with them. The recovering community usually goes through a series of successional stages following cessation of dredging activities. This allows some predictions on the likely recovery of benthic communities (Newell *et al.* 1998). The rate of colonisation by the fauna is determined by the persistence of organisms in undredged areas, immigration of mobile taxa, larval supply and post-settlement processes.

Table 3.3: Impact of dredging operations on benthic community composition from various habitats. Data are from different sources, summarised by Newell *et al.* (1998).

Locality	Habitat type	Species	% reduction after dredging	
			Individuals	Biomass
Chesapeake Bay, USA	Coastal embayment, muds – sands	70	71	65
Goose Creek, Long Island, NY	shallow lagoon, mud	26	79	63-79
Tampa Bay, Florida	Oyster shell	40	65	90
Moreton Bay, Queensland, Australia	Sand	51	46	-
Dieppe, France	Sand – gravels	50-70	70-80	80-90
Klaver Bank, Dutch Sector, North Sea	Sand – gravels	30	72	80
Lowestoft, Norfolk, UK	Gravels	62	94	90
Hong – Kong	Sands	60	60	-
Lowestoft, Norfolk, UK	Sand – gravels	34	77	92

A typical recovery phase is characterised by an initial colonising community of opportunists (relatively few species, but densities may be high), followed by a transitional community before the equilibrium component becomes established. During this process, species number increases to a

maximum during the transitional phase. Although permanent changes to the infaunal benthic community at the disposal site is possible, the apparent similarity of dredged sediments compared to the sedimentary regime at the disposal site (sand dominated) would suggest that the community should ultimately not differ substantially from the community presently there. However, response to some parameters is very difficult to predict, e.g. biotic responses to sediment compactness (temporal and spatial) over time and species interactions.

The impact of dredging activities can also affect communities differentially, when the influence extends to areas outside the immediate boundaries of dredged areas. This can be brought about by lateral transport of some of the material by various means, e.g. spillage and subsequent transport by currents. Filter feeding species appear to be more sensitive than deposit feeders, and larval forms are more sensitive than adults. Many of the species are able to burrow back to the surface following burial. Some benthic species can migrate through 30 cm of deposited sediment, while Kukert (1991, quoted in Newell *et al.* 1998) found that approximately 50% of the macrofauna were able to burrow back to the surface through 4-10 cm of rapidly deposited sediment. In general, however, most recent studies of filter feeders that live in coastal waters (e.g. the sand mussel *Donax serra*, which is particularly abundant along the stretch of Sundays River surf) indicate that these animals are highly adaptable in their response to increased turbidity such as can be induced by storms, dredging or sediment disposal, and can maintain their feeding activity over a wide range of phytoplankton concentrations and inorganic particulate loads (numerous authors quoted in Newell *et al.* 1998).

In summary, the impact of dredging can have a major effect on benthic community composition within dredged areas, but there is little evidence that deposition from outwash during the dredging process has a significant negative impact on the benthos outside the immediate dredged area (Newell *et al.* 1998).

Increased turbidity as a consequence of dredging will have some impact on phytoplankton. No seagrasses are present in the Coega area, and no impact assessment on attached plants is therefore necessary. Higher turbidity levels in the plume associated with the activity will obviously reduce light penetration and hence phytoplankton production, but the effects are likely to be very localised and temporary. More motile organisms that encounter patches of increased turbidity have the capability to move vertically in the water column to more suitable levels, or move away from the area. It should also be remembered that turbidity levels in inshore bay waters also attain high levels after river flooding or severe storm events.

Table 3.4 Rates of recovery for the benthic fauna following dredging in various habitats. Highly disturbed sediments that are dominated by opportunistic species (r-strategists) have a very rapid rate of recovery. Rates of recovery increase in stable habitats (shells and gravel) where longer-lived animals with complex species interactions dominate. Data are from different sources, summarised by Newall *et al.* (1998).

Locality	Habitat type	Recovery time
Coose Bay, Oregon	Disturbed muds	4 weeks
Gulf of Cagliari, Sardinia	Channel muds	6 months
Mobile Bay, Alabama	Channel muds	6 months
Chesapeake Bay, USA	Muds – sands	18 months
Goose Creek, Long Island, New York	Lagoon muds	>11 months
Klaver Bank, Dutch Sector, North Sea	Sands – gravels	1 –2 yrs, exc. Bivalves
Dieppe, France	Sands – gravels	>2 yrs
Lowestoft, Norfolk, UK	Gravels	>2 yrs
Dutch Coastal Waters	Sands	3 yrs
Tampa Bay, Florida	Oyster shell (complete defaunation)	>4 yrs
Tampa Bay, Florida	Oyster shell (incomplete defaunation)	6 – 12 months
Boca Ciega Bay, Florida	Shells – sands	10 yrs
Beaufort Sea	Sands – gravels	12 yrs

3.3.2 INTRODUCTION OF EXOTIC SPECIES

The movement of species from their native habitats to new geographical areas is one of the most common and dangerous human effects on the natural world. Introduced species vary in their impact, some having catastrophic effects on native communities, marine resource-based industries and structures built by man. Some invaders arrive by accident, while others are deliberately introduced. These introduced species may have the following impacts on the new environment:

- they may disrupt complex ecosystems, alter foodweb structures, reduce biodiversity, jeopardise endangered biota and degrade habitats;
- they may hybridise with native species and alter native genetic diversity and integrity;
- they may transmit exotic diseases to native species, against which the natives may have no defence.

A primary method of introducing marine associated alien species has been in ballast water of shipping vessels. In order to maintain stability during transit along coasts and on the open ocean, ships fill their ballast tanks with water. Taken from coastal port areas, this water (and associated sediments) is home to multiple marine organisms. The ships, in loading ballast, also load the living organisms, ranging in size and phyla, from tiny microorganisms to larger species, including schools of fish. Scientists estimate that as many as 3 000 alien species per day are transported in ships

around the world. However, not all transported species survive and become established in new areas. It is therefore not surprising that exotic or introduced species are often first discovered around shipping ports. In any event, large sums of money are now spent in trying to eradicate introduced species that have become problematic. Exotic species are not new to South Africa and there are many examples from our coastal waters.

3.3.3 MARINE ARCHAEOLOGY

The following has been taken from a section of the Revised Coega Port EIA (CEN 2000):

“According to the Historical Shipwrecks Database maintained by the National Monuments Council, 264 vessels are listed as having been lost in Algoa Bay. Three of these ships, the *Oaklands* (1860), the *Portsmouth* (1866) and the *Gerhardine* (1888), are known to have been wrecked at the Coega River Mouth. These ships are all protected by legislation and may not be disturbed unless the authority of the National Monuments Council has been obtained.

National Heritage Resource Act (Act 25 of 1999) stipulates the protection of any vessel or part of a vessel, which was wrecked in South Africa, whether on land, in the internal waters, the territorial waters or in the maritime culture zone of the Republic. Any cargo, debris or artefacts found or associated with the wreck, which is older than 60 years or which South African Heritage Resources Agency considers to be worthy of conservation, receives protection under the Act.

A survey was undertaken by a Marine Archaeologist of the proposed dredge area. Sonar scans of the dredge area were used to determine if any ships were present in the area. The archaeologist confirmed that it was unlikely that any ships were present in the area to be dredged. Based on the survey undertaken it is concluded that the probability of any shipwrecks being disturbed by the proposed dredging are low and no significant impacts are predicted.”

On further investigation, it would appear that this initial work was founded on a professional opinion, and further work may be required to meet the standards required by the South African Heritage Resources Agency (SAHRA). The CDC has taken it upon itself to address this matter further.

3.3.4 ISSUES, IMPACTS AND MITIGATION

Impacts were evaluated according to standardised criteria defined by CES guidelines (Appendix 8), and are discussed below and summarised in Table 3.5.

ISSUE 1: THE EFFECT OF NOISE AND LIGHTS ON MARINE MAMMALS, SEABIRDS AND FISH

Cause and comment: The dredging operation at the Coega Port site will be active 24 hours a day unless extreme weather conditions force a stoppage. Ship noise and lighting (at night) will need to be considered for their effects on marine and island fauna, which would not be accustomed to such disturbances, which could affect breeding success through nest desertion and hence hatching failure. Jahleel appears to be a roosting site for the African penguin and Roseate tern, but there are also records that indicate that the island has been used as a nesting/breeding site on a few occasions. The group of marine birds known as Tubenosed birds, which include Petrel and Albatross species, visit Algoa Bay during the winter months. In other areas (Southern Ocean) these birds have been known to be attracted to lights on vessels and fly into them, resulting in high levels of mortality. Sustained levels of noise in the vicinity of Jahleel Island may impact on the birds inhabiting the island,

causing them to desert roosting and nesting sites. A similar impact could be expected if the island is exposed to artificial light sources on a frequent basis.

Marine mammals and fish could either be scared away or attracted to the area by excess ship noise and lighting. Attraction towards the dredging operation may lead to unnecessary encounters, which could result in maiming or even mortality due to collisions and hydraulic entrainment. Observation during the revised EIA study (CEN 2000) showed that dolphins and sea birds were not visibly disturbed by the dredging operation in Port Elizabeth harbour, where they were seen to be feeding and diving in close proximity to the dredger.

Further impacts related to the noise from blasting could be expected. Excessive noise could lead to temporary stress amongst marine mammals and possibly permanent nest desertion by island avifauna.

All the impacts related to noise and lights that are discussed below are associated with Jahleel Island. There should be very limited impact on birds roosting and nesting on the more distant islands, namely St Croix, Brenton and the Bird Island Group. It must be remembered that dredging operations are only a small part of the overall construction work on the Coega Harbour and the associated onland infrastructure. As such, the contribution of the dredging operation toward the overall noise and light pollution will be relatively small.

Impact 1: The effect of dredger noise on island avifauna

Significance statement: The noise factor emanating from the dredgers is not normally excessive, but will increase when hard rock is encountered. When softer sediments, which are in the majority at Coega are dredged, noise levels will be similar to that of other vessels of the same size (Bray 1990; Hubrich 1993). In addition the TSHD will mostly be operating a fair distance from Jahleel, while the CSD will operate in the basin and will be shielded from the island by the breakwater. It is **possible** that *slight*, short term impacts on breeding success may occur within the *dredge area*. Due to the conservation status of the African penguin and Roseate tern, this impact can be considered to be of MODERATE to HIGH significance even though nesting on Jahleel Island may not be a major occurrence.

Impact 2: The effect of blasting noise on island avifauna¹

Significance statement: While sound from a blast will travel great distances underwater very quickly, it is uncertain as to the extent the sound will travel to birds resident on Jahleel Island. If this noise level is too high and frequent, it is **possible** that nest desertion by birds may occur. As this would impact on breeding success, and based on the conservation status of the African penguin and Roseate tern, this *localised*, short term impact, while considered *slight*, can be considered to be of MODERATE to HIGH significance even though nesting on Jahleel Island is not a major occurrence.

Island birds that are in the water at the time of the explosion will feel the effects far greater than if they were on land. This would typically be applicable to penguins, which spend the majority of the time in the aquatic environment. The noise would **probably** chase them away from the immediate vicinity for a short period after the blast, such that the impact that may occur would be *slight*, short term, *localised* and of LOW significance.

Mitigation and management: In order to reduce the possible impact of noise on penguins in the water, it is recommended that where possible, blasting be carried out between 12h00 and 14h00

¹ See Issue 3 Impact 5 for physical effects of blasting.

when the fewest numbers of this bird will be in the water in the vicinity of the St Croix Island Group.

While blasting may be done a reasonable distance from Jahleel Island and some within the confines of the breakwaters, the only reasonable mitigation measures would be to restrict the number of blasts over a specified time period (single blast per day). It is expected that blasting will be an infrequent occurrence, and as such it is **possible** that any impact may be reduced to *slight* and of LOW significance.

Impact 3: The effect of lights on island avifauna

Significance statement: It is **probable** that the African penguin and Roseate tern may be *severely* affected within the *localised* area of Jahleel Island over the short term if dredger lights are too bright and the island itself is illuminated. Due to their conservation status, if this disrupts their breeding cycle, the impacts could be of MODERATE to HIGH significance.

Mitigation and management: If correct mitigatory measures are utilised, namely shielded lights or deflectors to ensure that the island is not constantly illuminated, then it is **probable** that only a *slight* negative impact of MODERATE significance will occur, i.e. breeding may only be partially interrupted as birds may be disturbed for a short period but not forced to abandon nests or roosting sites. This measure should not be a problem to enforce, as apart from normal navigational lights, only lights providing enough illumination to carry out normal work duties are used, and these are not usually trained on areas beyond the vessel itself.

Impact 4: The effect of lights on other marine bird species

Significance statement: Although Albatross and Petrel species flock to Algoa Bay during the winter months, they retreat to the outer limits of the Bay at night. As such it is **probable** that the lights used on board the dredgers would be unlikely to cause mortalities amongst these species, and any impact would thus be of LOW significance.

Impact 5: The effect of ship noise and lights on marine mammals

Significance statement: While it is **probable** that certain marine mammals may be attracted towards the lights and noises generated by the dredging operation within the *dredge area*, it is unlikely that there will be negative impacts in terms of collisions, as the CSD will be pivoting slowly in one place, and the TSHD advancing at a slow rate (1 – 3 knots). Combined with the escape responses of dolphins and seals it is **probable** that maiming or mortalities are unlikely to occur. On the chance that a few encounters may occur, any impact would be *slight*, short term and of LOW significance.

Impact 6: The effect of ship noise and lights on marine fish

Significance statement: A few species of fish (adults and larvae) may well be attracted to the noise and lights. It is **possible** that a percentage of these may suffer mortality through hydraulic entrainment. Entrainment rates for fish tend to be low, even for demersal species, however, mortality rates of entrained fish are high (generally >70 – 80%). As a result of the low entrainment rates, and the absence of rare and endangered species in the immediate vicinity (Wooldridge *et al.* 1997), it is **probable** that a *slight* negative impact may occur which would be short term, *localised* and of LOW significance.

Impact 7: The effect of blasting noise on marine mammals and fish

Significance statement: The noise emanating from an underwater blast will both attract and scare off mammal and fish species. Based on the assumption that blasting will be an infrequent occurrence, it is unlikely that fish or mammals would be permanently chased away, and as such any impact would **probably** be *slight*, short term, within the *dredge area* and of LOW significance.

Those species which are attracted to the blast noise would only be negatively impacted upon if another blast followed shortly after, or if sea mammals were to be involved in collisions with dredging vessels. Impacts after any subsequent blasting may occur and would **definitely** have a *severe*, short term, *localised* impact. This would be of LOW significance for marine fish, and as a result of their protected status, would be of HIGH significance for sea mammals. Collisions with vessels are unlikely. On the chance that a few encounters may occur, any impact would be *slight*, short term and of LOW significance.

Mitigation and management: Blasting should only take place once a day at most and must be monitored by the PAD environmental officer and a member of the Department of Economic Affairs, Environment and Tourism. This would preclude subsequent mortalities in those animals attracted to the blast zone as a result of an earlier explosion. This would ensure that the only impact may still be collisions and as already stated, collisions with vessels are unlikely, and on the chance that a few encounters may occur, any impact would be *slight*, short term and of LOW significance.

ISSUE 2: THE EFFECT OF DREDGING IN THE APPROACH CHANNEL AND HARBOUR BASIN ON INVERTEBRATES AND GENERAL ECOLOGY

Impact 1: Destruction of marine organisms in the sandy sediments in the area to be dredged

Cause and comment: Dredging operations will result in the physical removal or destruction of benthos and habitat along the operational path. This impact represents a significant pulse disturbance in the immediate area. However, recovery of the community probably begins soon after the operation ceases, passing through a series of 'successional' stages before an 'equilibrium' community is established. This may take up to 2-4 years. The 'equilibrium' community may assume different characteristics compared to the initial community present, due to natural variability in communities and/or modifications to key environmental variables that structure them (e.g. slight changes in depth, light penetration, sediment characteristics, slope etc). Recovery success will therefore be very difficult to measure, aggravated by the absence of a detailed database for bottom communities in Algoa Bay (incorporating temporal and spatial information).

Significance statement: Dredging will **definitely** result in the physical removal or destruction of most of the benthic community. This will **probably** have a *severe* negative effect in the short term in the *dredge area*. The environmental significance of the impact would be LOW.

Mitigation and management: Because of the localised and severe impact of dredging on bottom sediments and the associated benthic communities, mitigation measures are not practical. Recovery of a bottom community will occur, usually within 2 years, although the 'equilibrium' community may assume slightly different characteristics to the original one or to the community immediately adjacent to the dredged channel. This is because the interactive environmental variables that influence community dynamics will be slightly different in the two environments as a result of the dredging operation.

Impact 2: Impact of sediment settling outside the immediate boundaries of dredged and disposal areas

Cause and comment: Some dredged material will settle on the bottom outside the immediate boundaries of the dredging and deposition sites, brought about by dredger outwash, overflow, prevailing currents etc. In general, the benthic community appears to have a relatively wide tolerance to limited smothering (centimetres) as sediment settles on the bottom. In such cases, recovery is predicted to be relatively rapid (weeks to months). The area affected by this settling sediment is thought to be small, probably not more than 500 m (see Monitoring Guidelines).

Significance statement: The benthic community immediately adjacent to the dredging area will **possibly** be affected by smothering as material filters from dredging operations. A **moderately severe** negative impact on most species in the short term in the *dredge area* may occur, but have no significant impact at the district or regional scale. The environmental significance of the impact would be LOW.

Mitigation and management: Incidental spillage that has the potential to affect areas adjacent to dredging and disposal sites must be kept to a minimum. Events must be carefully monitored and solutions sought should it be deemed necessary by the monitoring officer.

ISSUE 3: THE EFFECT OF DREDGING AND BLASTING IN THE APPROACH CHANNEL AND HARBOUR BASIN ON MARINE MAMMALS, SEABIRDS AND FISH

Cause and comment: Marine mammals and fish could either be scared away or attracted to the area by disturbance of the sediment around the immediate dredge site. As is the case for noise and lights, attraction towards the dredging operation may lead to unnecessary encounters with vessels.

Blasting during the dredging phase could impact marine mammals, seabirds and fish in the immediate area. The effects of underwater blasting on seabirds, marine mammals and other marine vertebrates have been well studied. Cetaceans, seals and fish are all at risk from the effects of underwater blasts, which can cause sub-lethal injuries due to pressure or shock waves rupturing tissues. Cooper (1995) states that experimental work has shown that underwater blasts cause air bladder, intestinal and organ ruptures and broken ribs in fish, lung haemorrhages, gastrointestinal lesions and ruptured eardrums in mammals and pulmonary haemorrhages, coronary air embolisms and ruptured airsacs, eardrums, livers and kidneys in birds. A number of studies have been undertaken to predict the distance at which mortalities of marine mammals will occur (Aplin 1947; Goetner *et al.* 1982; Cooper 1995). The variables that have to be taken into account for determining a safe distance for both birds and mammals are many and without details of each blasting event, it is not possible to make a firm recommendation. The possible impact of blasting, if it is required at all, demands careful analysis before blasting takes place.

Impact 1: The effect of dredging on fish in the area of operation

Significance statement: Bony fish (larvae, juveniles and adults) and sharks, skates and rays (juveniles and adults) will be in the immediate vicinity of the dredging operations, and may well be attracted to the disturbance area in search of food. It is probable that a percentage of these may suffer mortality through hydraulic entrainment. Entrainment rates for fish tend to be low, even for demersal species, however, mortality rates of entrained fish are high (generally >70 – 80%). As a result of the low entrainment rates, and the absence of rare and endangered species in the immediate vicinity (Wooldridge *et al.* 1997), it is **probable** that only a **slight** negative impact may occur that would be short term, *localised* and of LOW significance.

Impact 2: The effect of dredging on marine mammals in the area of operation

Significance statement: It is **probable** that cetaceans will be present in the area of the dredging operations on occasion. They are unlikely to be affected by the dredging operation itself but the movement of the dredger to and from the disposal site will impact on their movements and pose a risk of collision. Due to the slow speed of the dredger (while actively dredging) and the escape responses of dolphins and seals, it is likely that any negative impact that may occur will be of LOW significance, and the issue of maiming or mortalities should be limited.

Impact 3: The effect of blasting on marine mammals

Significance statement: It is **possible** that certain marine mammals may be in the area prior to a blasting event and that they would **probably** suffer maiming or mortality as a result of the concussion. This impact would be short term and within the *dredge area*, but due to the conservation status of marine mammals in general, this impact can be considered to be **moderately severe** and of HIGH significance.

Mitigation and management: Suitable mitigation would probably decrease this impact to *slight* and one of LOW significance. Mitigation should ensure that underwater blasting only take place during daylight hours, with a visual survey of the area 30 minutes before the blasting to determine whether marine mammals are, as a guideline, within 1 000 metres of the blast area (2 000 metres for cetaceans, unless the breakwater is shielding the mammals from the blast). The exact distance should be calculated once the nature of each blasting operation is finalised. If there are any marine mammals present the blasting must be delayed until they have vacated the area on their own accord. Blast monitoring should include a detailed account of layout of blast, charge, delays and PPV measurements of the blast.

Impact 4: The effect of blasting on marine fish

Significance statement: It is **probable** that teleosts (bony fish) and chondrichthyans (sharks, skates and rays) will be in the immediate vicinity of the blasting operation, and that a percentage of these may suffer mortality. The absence of rare and endangered species in the immediate vicinity (Wooldridge *et al.* 1997) and restricting blasting to a maximum of once per 24-hour period should result in the negative impact being *slight*, short term, *localised* and of LOW significance.

Impact 5: The effect of blasting on seabirds

Significance statement: Any seabirds in the vicinity of a blast will be vulnerable, whether they are underwater, e.g. penguins, or on the surface, as their lungs and air sacs which could be ruptured by the concussion, are directly exposed to the effects of the blast. The resultant sub-lethal rupturing of tissues will probably result in mortality. Due to their conservation status, African penguins provide the worse case scenario, where it is **probable** that any impact that may occur would be **moderately severe**, *localised*, short term and of HIGH significance. The impact on other seabirds would be similar but of LOW significance.

Mitigation and management: The impact would be reduced if blasting took place between 12h00 and 14h00 when the fewest number of penguins would be in the water around Jahleel Island. A patrol of the area should be done to determine whether any seabirds are present in the water, and if any are detected, an effort should be made to scare them from the area. This should ensure that any impacts that may occur would **probably** be *slight*, *localised* and short term. If a few penguin mortalities still occur, this can be regarded as being of MODERATE significance.

ISSUE 4: THE EFFECT OF INCREASED TURBIDITY LEVELS ON ECOSYSTEM FUNCTIONING

Cause and comment: Increased suspended solids (SS) levels during dredging means that turbidity plumes will be evident in the area throughout the operation. The dynamics of these plumes and the recommended SS levels and mixing zones are dealt with in detail under the Monitoring Guidelines (Chapter 4).

Elevated turbidity levels will negatively impact on phytoplankton production. This reduction in the primary food source will in turn have a negative effect on the food web. Higher than usual SS levels may also cause a disturbance and impact on the nearshore fish breeding grounds, and may affect egg and larval survival rates. This in turn may impact on the availability of food for the birds utilising the area as a feeding ground. The local fish communities are adapted to short term increases in turbidity levels, for example, when rivers come down in flood. These episodic events are of short duration, whereas the construction of the port and the associated turbidity levels will be sustained over a longer period. This may result in changes to the local fish community structure and may reduce recruitment.

Increased SS levels will probably impact on seabirds from the nearby St Croix Island Group, which utilise visual cues and diving in their feeding strategy, for example penguins and cormorants. Because penguins rely on vision for feeding and orientation, an increase in turbidity may also increase predation on the penguins, which would be unable to successfully avoid those predators that are not affected by the turbid water. If elevated levels persist in an area for long periods (years), birds which feed at specific locations or feeding grounds may abandon the region altogether.

Impact 1: The effect of increased turbidity levels on primary production

Significance statement: Increased SS levels may occur and will **possibly** have a *severe* negative impact on *localised* (dredge area and vicinity around Jahleel Island) primary production over the short term. This will have the effect of a chain reaction with regards to the foodweb, and any impact can be considered to be of HIGH significance.

Impact 2: The effect of increased turbidity levels on the fish community

Significance statement: It is **possible** that aspects such as breeding, hatching rates, larval survival, feeding and escape responses may be affected by the turbidity levels. Impacts on these aspects may occur, and would be *severe*, *localised* and short term. Due to the possible presence of rare or endangered endemic reef fish species around Jahleel Island, any impact must be considered of HIGH significance.

Impact 3: The effect of increased turbidity levels on the marine avifauna

Significance statement: Increased turbidity levels will **possibly** affect feeding in birds such as cormorants and penguins. The impact will be *severe*, *localised* and short term. For most species, which are highly mobile and capable of finding alternative feeding sites, the impact would be of MODERATE significance. The only possible exception to this may be the endangered African penguin, which may not be as quick to find alternative sites. Due to its conservation status, any possible impact, no matter how slight, should be regarded as being of HIGH significance.

Overall mitigation and management: Guidelines for environmentally acceptable dredging procedures with regards to turbidity levels have been covered in detail under the Monitoring Guidelines for the dredging operation at Coega (see Chapter 4). The immediate site of dredging and

a 500 m mixing zone around that site have been set aside as the so called sacrificial zone where elevated turbidity levels are acceptable. In terms of the total area of Algoa Bay, these sacrificial zones are a minor proportion. In addition, much of the dredging will take place within the basin and behind the breakwater, which removes some of the risk associated with Jahleel Island. Furthermore, if the TSHD is equipped with a sub-surface overflow system, then surface waters should not be too adversely affected by elevated SS levels. As such, phytoplankton production as well as birds and fish would not be as severely affected. Adherence to the monitoring guidelines should remove any threat from the nearby Jahleel Island and its associated fauna, and all impacts would be reduced to *slight* and of LOW significance. The exception to this would be the African penguin where the significance of an impact post mitigation, would be MODERATE.

ISSUE 5: THE EFFECT OF EXOTIC SPECIES INTRODUCED BY DREDGERS

Impact 1: Introduction of exotic species

Cause and comment: While the major threat of introduced species will be during the operational phase dredgers move rapidly between different parts of the world and may translocate exotic species between different geographic regions. The potential risk of such translocations is potentially high and strict measures must be enforced to ensure that exotics are not introduced when dredgers arrive in Algoa Bay. Besides ballast water, dredgers may also have pockets of trapped sediment transported from their previous area of operation. Consequently there is a risk of introducing a different suite of exotic species from those carried in ballast. The seriousness of this issue should not be underestimated as the introduction of a single pest species could cause a much more serious and longer-lasting impact than dredging itself.

Significance statement: The introduction of new exotic species to South African coastal waters is unlikely, but if it occurs and that species survives, it will **definitely** have a medium to long term and **very severe** negative effect on native communities and/or marine resource-based industries at the *local, district and regional scale*. The environmental significance of the impact to organisms in the region would be VERY HIGH.

Mitigation and management: It is recommended that a risk assessment of the likelihood of introductions from the dredgers be undertaken well before the dredger leaves its previous dredging location. This assessment should consider the climatic similarity of the location of the previous dredging project compared to Port Elizabeth. Mitigation of this impact by thorough cleaning of dredgers would probably reduce the risk to a level where introductions are unlikely to occur. Although this would be the ideal scenario, it is likely that the dredging contractors would not know the origins of the dredgers to be used before they are underway to Coega, making the proposed risk assessment impractical.

It is safest to assume that there will be a risk of species from the previous dredging operation surviving in Algoa Bay waters, and special precautions should be taken to minimise the risk of possible introductions. These precautions should include:

- Cleaning of the dredgers at sea, and cleaning and emptying of ballast while en route to, and still outside of South African territorial waters.
- Upon arrival, the dredgers should still be considered a risk and inspected before dredging commences in South Africa. The inspection may be undertaken in Algoa Bay. If exotic animals are found during inspection of the hopper upon arrival in South Africa, considerable costs will result from delays to the dredging while they are removed. Consequently it is important that the need for necessary precautions is made clear at the tender stage.

Unfortunately it cannot be guaranteed that no invasives will be introduced and management programmes can only reduce the probabilities of occurrence. Due to the *very severe* nature of any introductions, the impact is of VERY HIGH significance but is **unlikely**.

ISSUE 6: DESTRUCTION OF THE PHYSICAL ENVIRONMENT

Impact 1: Removal of sediment and destruction of benthic community

Cause and comment: The actual practice of dredging is inherently destructive. The operation at Coega will be removing vast quantities of sediment for disposal elsewhere, and as such the physical environment will be forever altered.

Significance statement: As it is highly unlikely that the physical environment will ever return to its original state, it is **definite** that a permanent change will occur. The impact will be *very severe* and *localised*, but as a result of the small area will be of LOW significance.

ISSUE 7: AESTHETICS

Impact 1: The visual impact of the dredging operation

Cause and comment: There may be concern about the visual impact of the dredgers operating in close proximity to the shore. This will be exacerbated if turbidity plumes are visible from the shore.

Significance statement: Algoa Bay already services a high load of ship traffic, and it is unlikely that the mere sight of two more vessels is going to make much of an impression. The turbidity associated with the CSD will probably be restricted largely to the bottom, and below the surface with the TSHD. A plume will still be visible around the dredging operation. It is **possible** that the visual impact will be *moderately severe*, *localised* and short term in nature. The overall significance of this impact will vary from person to person, but on a precautionary basis is regarded as being MODERATE. Due to the lack of residential housing near the dredging site and the limited view from the National Road the dredging area and associated plume should not be visible to large numbers of people.

3.4 MAINTENANCE DREDGING

This chapter has dealt with the potential environmental and social impacts of the capital dredging operation at the site for the development of the new Coega Port. Due to the dynamic and often unpredictable nature of the ocean, the majority of harbours have maintenance dredging operations in place to deal with the accumulation of sediment within approach channels and harbour basins over time. For example, maintenance dredging at Richards Bay amounts to 1 million m³ on average per year.

The scale and frequency of the maintenance dredging operation will differ between locations, and would depend on the size and infrastructure of the port, physical oceanographic conditions, sediment type and financial implications. Analysis of sediments in and around the harbour revealed a predominance of fine sands, with other sediment types such as clay, shell, pebbles and gravel making up smaller proportions of the whole. These fine sediments, which are moved along by longshore drift under normal circumstances, would normally pose a threat to a port such as Coega, which is being positioned directly in the path of the natural longshore pathway of sediment movement. Research indicates that net longshore movement of sand around Algoa Bay continues in a northeasterly direction, i.e. directly into the harbour entrance. Due to the disruption to the longshore transport of sand by the harbour breakwaters, and the danger of sediment accumulation to the south and within the port, as well as the danger of erosion north of the port, a permanent sand

bypass system in the form of a jet pump system will be installed in order to transfer 150 000 – 200 000 m³ yr⁻¹ of sand to the northern side. The sand bypass system will consist of a fixed row of jet pumps deployed from a jetty, a pump house, a slurry pipeline, booster pump stations, and a discharge point. The system will be designed to maintain the current dune and beach forms on the adjacent beaches by artificially maintaining the longshore drift.

Due to this precautionary measure, siltation within the harbour confines will be very limited, and as a result, a large scale ongoing maintenance dredging operation will not be necessary, but rather it is anticipated that occasional, and limited maintenance will be required. The cost involved will determine both the frequency and extent of such an undertaking. In most cases the majority of impacts identified for the capital dredging operation would also apply during the maintenance phase, although the biological communities being affected may differ from those originally in place before the initial disturbance. The extent to which they differ would depend on scale of the capital operation, time period until maintenance phase is introduced, the degree to which recolonisation has taken place and the faunal and floral composition of the new community.

The maintenance operation will have to be considered as an entirely new undertaking, separate from the capital operation, and this would entail an entirely new permit application. It is unlikely that a separate EIA will be required as the anticipated volumes will be small. As part of the permitting procedure, the sediments earmarked for dredging will need to undergo testing for contaminants. Although the sediments to be dredged during the initial developmental phase have been tested and declared clean (Appendix 2: Connell and Parsons 1999), subsequent sediment build-ups will require further testing. It is possible that accumulated sediments within the harbour will become contaminated with a variety of toxic substances, in particular hydrocarbon based fuels and oil emanating from ships entering and leaving the port, as well as those found in the Coega River and stormwater system. A host of land based activities associated with the port may also inadvertently introduce toxins into the water, which could become locked up in the sediment. If the sediment is found to exceed the specifications for contaminants specified in the Guidelines for the Management of Dredged Spoil in South African Coastal Waters, the implications can be serious, and open water disposal offshore will not be approved. Impacts resulting from contaminated spoil are potentially more serious than those caused by clean sediments. Their disposal becomes problematic and the monitoring guidelines become more detailed and complex than those prescribed for the capital operation.

Table 3.5: Summary of issues and impacts, before and after mitigation, resulting from the dredging operation.

ISSUE/IMPACT	WITHOUT MITIGATION						WITH MITIGATION	
	RISK	TEMPORAL	SPATIAL	CERTAINTY	SEVERITY	SIGNIFICANCE	SEVERITY	SIGNIFICANCE
Issue 1: The effect of noise and lights on marine mammals, seabirds and fish								
Impact 1: The effect of dredger noise on island avifauna	May occur	Short term	Dredge area	Possible	Slight	Moderate – High*	*	
Impact 2: The effect of blasting noise on island avifauna (on islands & in water)	May occur	Short term	Localised	Possible	Slight	Moderate – High	Slight	Low
	May occur	Short term	Localised	Probable	Slight	Low	Slight	Low
Impact 3: The effect of lights on island avifauna	May occur	Short term	Localised	Probable	Severe	Moderate – High	Slight	Moderate
Impact 4: The effect of lights on other marine bird species	Unlikely			Probable		Low		
Impact 5: The effect of ship noise and lights on marine mammals	May occur	Short term	Dredge area	Probable	Slight	Low		
Impact 6: The effect of ship noise and lights on marine fish	May occur	Short term	Localised	Possible	Slight	Low		
Impact 7: The effect of blasting on marine mammals and fish (initial & subsequent blasts and collisions)	Unlikely	Short term	Dredge area	Probable	Slight	Low	Slight	Low
	May occur	Short term	Localised	Definitely	Severe	Low (fish) High (mammals)	Slight	Low
	May occur	Short term	Localised	Possible	Slight	Low	Slight	Low
Issue 2: The effect of dredging in the approach channel and harbour basin on invertebrates and general ecology								
Impact 1: Destruction of marine organisms in the sandy sediments to be dredged	Definite	Short term	Dredge area	Probable	Severe	Low		
Impact 2: Impact of sediment settling outside the immediate boundaries of dredged and disposal areas	May occur	Short term	Dredge area	Possible	Moderate	Low	Slight	Low
Issue 3: The effect of dredging in the approach channel and harbour basin on marine mammals, seabirds and fish								
Impact 1: The effect of dredging on fish in the area of operation	May occur	Short term	Localised	Probable	Slight	Low		
Impact 2: The effect of dredging on marine mammals in the area of operation	Unlikely	Short term	Localised	Probable		Low		

*High for species of special concern.

Table 3.5 continued

ISSUE/IMPACT	WITHOUT MITIGATION						WITH MITIGATION	
	RISK	TEMPORAL	SPATIAL	CERTAINTY	SEVERITY	SIGNIFICANCE	SEVERITY	SIGNIFICANCE
Impact 3: The effect of blasting on marine mammals	Possible	Short term	Dredge area	Probable	Moderately severe	High	Slight	Low
Impact 4: The effect of blasting on marine fish	May occur	Short term	Localised	Probable	Slight	Low	#	#
Impact 5: The effect of blasting on seabirds	May occur	Short term	Localised	Probable	Moderately severe	High (penguins) Low (others)	Slight	Moderate
Issue 4: The effect of increased turbidity levels on ecosystem functioning								
Impact 1: The effect of increased turbidity levels on primary production	May occur	Short term	Localised	Possible	Severe	High	Slight	Low
Impact 2: The effect of increased turbidity levels on the fish community	May occur	Short term	Localised	Possible	Severe	High	Slight	Low
Impact 3: The effect of increased turbidity levels on the marine avifauna	May occur	Short term	Localised	Possible	Severe	High (penguins) Moderate (others)	Slight	Moderate (penguins) Low (others)
Issue 5: The effect of exotic species introduced by dredgers								
Impact 1: Introduction of exotic species	Unlikely	Medium - long term	Local - regional	Definite	Very severe	Very high	Very Severe	Very High
Issue 6: Destruction of the physical environment								
Impact 1: Removal of sediment and destruction of benthic community	Definite	Permanent	Localised	Definite	Very severe	Low	#	#
Issue 7: Aesthetics								
Impact 1: The visual impact of the dredging operation	May occur	Short term	Localised	Possible	Moderately Severe	Moderate	#	#

Limited mitigation possible.

CHAPTER 4: MONITORING GUIDELINES FOR THE COEGA PORT DREDGING OPERATION

4.1 INTRODUCTION

The objective of this chapter is to provide the contractors with a set of guidelines for acceptable levels of water quality with respect to turbidity, and to propose a monitoring programme to ensure compliance with these guidelines. This will aim to achieve minimal impact on the immediate and nearby environment as well as the sensitive ecosystem associated with Jahleel Island. In order to accomplish this goal, the dynamics of turbidity plumes resulting from dredging and disposal operations need to be addressed, then coupled with a turbidity maximum at the edge of a mixing zone, which may not be exceeded by the dredging contractor.

It should be noted that the monitoring guidelines are a trade-off between dredging cost and ecological impacts. The guidelines aim to reduce the impacts associated with the dredging operation to an acceptable level, while not unnecessarily increasing the costs of the operation. The dredging operation will cost approximately R500 000 per day and as this is a primarily government funded project, mitigatory actions and guidelines need to be practical.

4.1.1 THE ENVIRONMENTAL CONSEQUENCES OF INCREASED TURBIDITY

The development of a deepwater port located at the Coega River mouth north of Port Elizabeth, requires extensive dredging of an approach channel, entrance channel and port basin. It is anticipated that the majority of dredged sediment will be disposed of at an offshore site. Both the activities of dredging and disposal of spoil cause increases in turbidity well above ambient levels. These increases in levels of suspended solids (SS – all particles, organic and inorganic, in suspension – DWAF 1995) are cause for concern from an environmental perspective, both in the immediate vicinity of the activity as well as around the nearby Jahleel Island. In addition to the primary concern of increased turbidity, the disruption of the sediment can unlock nutrients and organic matter leading to algal blooms and reduced levels of dissolved oxygen (LaSalle *et al.* 1991; Probyn 2000). Furthermore, there are indirect effects on the bioavailability of heavy metals, although this should not be a point for concern as tests could not detect significant levels of heavy metals in the region (Appendix 2: Connell and Parsons 1999).

Turbidity levels at the site of dredging are influenced by the sediment type, class of dredger and ambient currents (Johnson and Parchure 1999). The cutter suction dredger (CSD) influences levels of SS depending on cutter head type, diameter and speed of rotation, swing speed and depth of cut, while a trailing suction hopper dredger (TSHD) affects SS levels through hopper filling speed, overflow rates and speed of vessel. Finer sediment types, such as silt, result in higher SS loads for both dredger types, while coarser sediments such as sand and gravel settle quickly and contribute less to the long term overall SS load.

The structure and functioning of aquatic ecosystems responds negatively to higher than ambient levels of SS in the following ways:

1. Primary production and prey detection by predators is affected due to reduced light penetration.
2. Respiratory and excretory functions of fish, crustaceans and molluscs is adversely affected due to abrasion and mechanical failure.
3. Feeding rates are reduced and most exposed organisms undergo behavioural changes, which may, for example, impact on breeding success.

4. Smothering by settling SS may affect sessile organisms and their habitats as well as the habitats of motile organisms.

One of the primary concerns from an environmental perspective is the close proximity of Jahleel Island to the dredging operation and Brenton Island to the proposed disposal site. These islands, together with the nearby St Croix Island, are designated Provincial Nature Reserves, and are categorised as Category Ia Protected Areas in the management plan compiled by the provincial Directorate of Nature Conservation. A 500 metre radius marine component around each island is also proclaimed as part of the reserve. Although the protection status of the St Croix group of islands was originally to afford a breeding sanctuary to the African penguin, a more holistic approach to the islands' associated fauna and flora exists at present (La Cock and Cohen 1997), making them particularly sensitive from an environmental impact point of view.

Organisms in the vicinity of the proposed development site are exposed to turbid conditions resulting from natural activities such as currents (tidal, wind and pressure induced), increased wave action and surface runoff into rivers, and have evolved mechanisms to cope with these events. It must be remembered, however, that dredging or disposal-induced turbidity will differ from the natural order in scope, timing, duration and intensity. The Sundays and Swartkops rivers deliver approximately 600 000 m³ of mud into Algoa Bay each year, most of which is delivered over a short period of time. Resuspension due to dredging operations will take place over the entire dredging period and the effect will thus not be as acute, and any effects will be localised around the immediate dredge or disposal site. In addition, dredging displaces existing deposits within the Bay and does not introduce new sediments as is the case with river input. In Algoa Bay, sand is moved longshore by waves, both northward and southward, although net movement is north. While a total of as much as 3 400 000 m³ may be displaced per annum (Delft Dredging Consultants Report 2001) the net volume transported northward and eastward past the Coega mouth is estimated at between 150 000 and 200 000 m³ per year (Watermeyer *et al.* 1986; Illenberger 1993; McLachlan *et al.* 1994). Together with the sediment load from rivers, it is clear that organisms living in this moderate to high energy coastal zone (Schumann 1984) should be predisposed to dealing with elevated SS concentrations.

For all dredging and disposal operations, a mixing or exclusion zone is established within which turbidity levels may exceed those specified as being environmentally desirable in the guidelines, i.e. an area where environmental criteria are not protected. This zone extends from the site of dredging or disposal where turbidity levels are highest to a distance over which SS levels should decrease to levels equal to or less than those prescribed in the guidelines. This distance depends on local physical processes such as currents, waves and tides, such that in medium to high energy coastal zones, the zone may be small due to rapid dilution and dispersal, i.e. sediment plume is far more dynamic and prone to disturbance.

This document describes the modelling procedure for SS settlement and resuspension, addresses plume dynamics and proposes monitoring guidelines for maintaining a level of water quality. The impacts of dredging, disposal and elevated levels of SS or turbidity on organisms at the dredging and disposal sites have been addressed by the specialists in the relevant sections.

4.2 TURBIDITY ASSESSMENT FOR DREDGING AT THE COEGA HARBOUR

4.2.1 TURBIDITY GUIDELINES AND RESULTS FOR ALGOA BAY

There are very few recorded ambient turbidity levels in Algoa Bay. Schumann and Campbell (1999) reported on a series of measurements mainly north of the Port Elizabeth harbour and to a distance of 13 km offshore. Water samples were taken at the surface and approximately 1 m above the seabed on a grid of 23 stations on 24 cruises over a period of 2½ years. The samples were analysed for total suspended solids (TSS) with a detection limit of 5 mg/l. 5% of a total of 390 surface samples were above 5 mg/l, with a corresponding 10% of 373 bottom samples being above 5 mg/l. 0.5% of surface samples and 3% of bottom samples had TSS values above 30 mg/l, while the highest recorded value was 142 mg/l at the bottom at an inshore site.

Turbidity measurements were also made in terms of the scattering of light by particles in water: this is governed not only by the concentration of undissolved substances, but also by their size, shape and refractive index. The results show that the highest concentrations occur off the New Brighton Pier and Papenkuils Canal mouth, with the highest overall values near the bottom off the Papenkuils Canal.

Churchill (1995) used a D & A Instruments OBS-3 optical backscatter sensor to measure turbidity over a grid of 12 boat stations north of the Port Elizabeth harbour. It should be noted that the measurements were taken from a small ski boat, which meant that results were only obtained when conditions were relatively calm, i.e. reported wave heights were generally less than 1 m. As a consequence the turbidity profiles were fairly homogeneous over the water column, at values less than 4 Nephelometric Turbidity Units (NTUs). On one cruise, when wave heights were around 3 m, the turbidity values showed a marked increase to a maximum of 32 NTUs within 5 m of the bottom. It was therefore apparent that such waves will lift sediment into suspension near the seabed; however, the system soon returned to normal when the waves decreased in size.

Probyn (2000) recommended absolute SS guideline levels of below 80 mg/l outside of a 500 m mixing or exclusion zone around the dredger. An analysis of his proposal by Delft Dredging (2001) indicted that these guidelines were unrealistic and too restrictive for the type of coastline (exposed, unpredictable and high energy) in question. Based on the total natural yearly sediment released by rivers in the area (Sundays and Swartkops), the total longshore sediment transport due to wind, waves and currents, and the probable high sediment loads during storms and extreme sea conditions, the following recommendations were made:

1. Many organisms in the area will be predisposed, both behaviourally and physiologically, to dealing with above ambient levels of SS.
2. Negative impacts on the Coega environment should only occur when total SS (ambient plus dredge induced) exceeds that experienced during the most adverse weather or river inflow conditions.
3. The allowable SS for dredging operations should be based upon ambient levels during heavy storms or river flooding minus ambient levels during normal weather. In the opinion of the Delft Dredging Consultants, this margin would be higher than the 80 mg/l proposed by Probyn (2000).
4. Suspended solids induced by dredging operations will be contained in a localised area when compared to the spatial scale of ambient SS levels during bad weather.

For the proposed operation, a level of 150 mg/l above ambient will be assumed. This is thought to be realistic in terms of the medium to high-energy coastline, high natural sediment loads from river outflow and the maximum SS concentrations measured during extreme weather conditions. In addition, as mentioned by Probyn (2000), the turbidity levels are based upon the environmental

thresholds of bivalve molluscs and fish. Concentrations of 100 mg/l appear to delay egg hatching in some marine species, but lethal effects are only observed at concentrations approaching 500 mg/l. During dredging operations at Saldanha, where bivalve molluscs were present in vast quantities close to the site, SS levels were also set at 150 mg/l with no undue adverse affects.

4.2.2 DREDGING SPECIFICATIONS AND SCHEDULE

There are two distinct harbour areas where dredging is required, namely the approach channel and the basin area. The channel will be dredged to -18 m Chart Datum (CD), requiring the removal of 3 million m³, and the basin to -16 m CD, requiring the removal of 11.2 million m³.

It is anticipated that a Trailing Suction Hopper Dredger (TSHD) will be used to dredge the approach channel and part of the basin, while a Cutter Suction Dredger (CSD) will be used for the remainder of the basin. Furthermore, the TSHD will more than likely have a system whereby the overflow water from the hopper is collected and discharged from the bottom of the ship's hull, and is thus not discharged on the sea surface. In addition it is a possibility that the overflow system will be equipped with a so-called Eco-valve to prevent air bubbles from mixing with the overflow discharge (Entech Consultants (Pty) Ltd). The precise specs regarding dredger types will only be finalised once the tender process is completed.

Construction goals in the proposed dredging schedule are depicted in Figure 4.1 (Entech Consultants, pers comm.). It will require three months to dredge the approach channel, by which time the main breakwater will have been constructed to chainage 707 m. The approach channel will be completed when the breakwater has reached chainage 1 109 m, and dredging of the basin will begin. Dredging of the basin will take 21 months, by which stage the main breakwater will already have been completed six months earlier.

4.2.3 SEDIMENT CHARACTERISTICS

A number of boreholes have been drilled in the area, and the geotechnical characteristics of the sediments established. Figure 4.1 shows the positions of the boreholes where information has been given on sediment characteristics, and Table 4.1 details this information (all data supplied by Entech Consultants).

In accordance with standard nomenclature, the sediment grain size terminology used is as follows (Bremner 1991):

Gravel:	> 2 mm	(< -1 φ)
Sand:	0.0625 to 2 mm	(-1 to 4 φ)
Silt:	0.004 to 0.0625 mm	(4 to 8 φ)
Clay:	< 0.004 mm	(> 8 φ)

In overall terms, Entech Consultants have calculated the composition of material to be dredged from the basin and approach channel given in Table 4.2.

In terms of surficial sediment distribution, Bremner (1991) found that there was mainly medium sand (0.18 to 0.25 mm, or 2 to 2.5 ö) from the Coega Estuary mouth to beyond Jahleel Island. This sand was also composed of more than 60% quartz.

These results show that sand is the dominant component of the material to be dredged. This sand is composed primarily of quartz, though with a substantial percentage of shell fragments in places giving rise to the higher levels of calcium carbonate. These shell fragments form minor gravel beds within the region to be dredged.

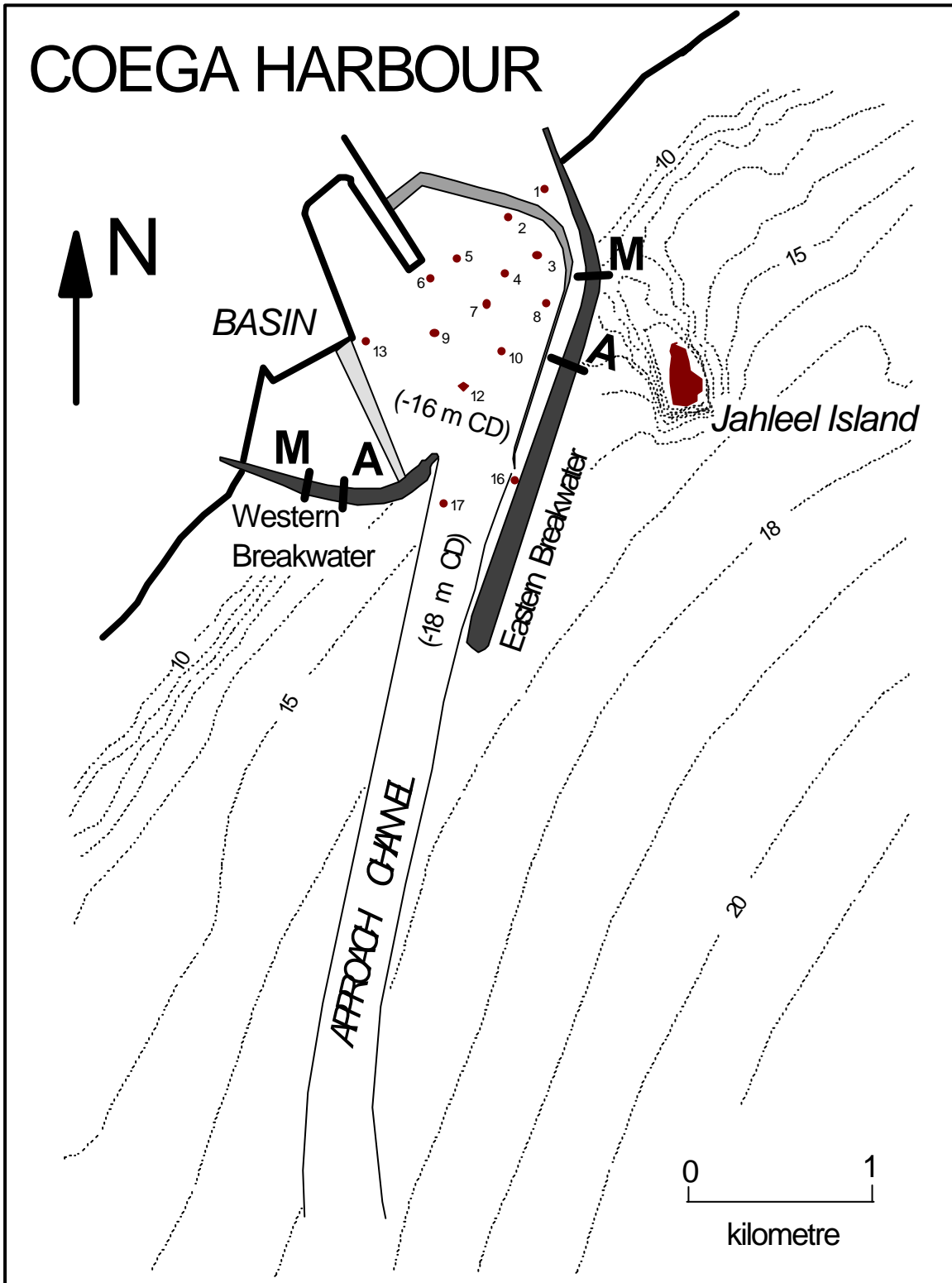


Figure 4.1: Details of the proposed Coega Harbour. All depths are given relative to chart datum (CD), the position of boreholes discussed in the text are indicated and numbered, and the cross lines shown on the breakwaters give the positions to be reached in Month 4 (M) and Month 7 (A) (See Table 3.2).

Table 4.1: Available information supplied by Entech Consultants on sediment characteristics from the boreholes shown in Figure 4.1. Percentages of gravel, sand, silt and clay and calcium carbonate (CaCO₃) are given.

Borehole	Depth Range (m)	Gravel	Sand	Silt	Clay	CaCO ₃
1	-0.92 to -3.47	1	94	5	0	-
2	-2.64 to -3.44	0	95	5	0	-
	-11.41 to -12.99	0	57	27	16	-
3	-13.18 to -13.63	0	78	12	10	-
4	-9.5 to -11.46	4	93	0	3	26
	-15.51 to -15.96	0	84	10	6	-
5	-1.81 to -2.81	0	95	5	0	-
	-8.31 to -10.26	0	87	13	0	-
	-17.31 to -19.27	1	77	16	6	3.5
6	-6.25 to -6.69	0	90	7	3	50
	-8.74 to -9.19	14	79	4	3	52.7
	-10.74 to -14.19	0	95	2	3	36.9
	-17.29 to -17.74	0	53	25	20	-
7	-10.23 to -14.33	0	81	13	6	-
	-17.78 to -18.23	1	70	20	9	-
8	-14.2 to -14.74	0	87	7	6	33
	-15.79 to -16.24	0	86	6	8	5
9	-10.73 to -11.18	2	57	21	20	-
	-12.23 to -14.18	1	80	13	0	-
10	-16.33 to -18.73	0	81	13	6	13.5
12	-14.9 to -15.4	0	81	6	13	3.5
13	-3.0 to -4.0	7	69	18	6	-
	-10.6 to -10.9	4	63	21	12	13.5
	-15.0 to -15.5	8	71	9	12	-
	-18.0 to -18.25	3	28	37	32	-
16	-16.58 to -17.03	1	80	13	6	17.5
17	-21.04 to -21.49	0	82	18	0	-

Table 4.2 Volumes of material to be dredged (Entech Consultants 2001).

Material	Basin (m ³)	Approach Channel (m ³)
Beach Sand	2 400 000	2 250 000
Marine Sand	3 200 000	
Marine Silty Sand	3 800 000	700 000
Estuarine Silty Sand	1 000 000	
Estuarine Sand	100 000	
Estuarine Clay	100 000	
Fluvial Gravel	500 000	50 000
Kirkwood Mudstone	100 000	
Total	11 200 000	3 000 000

In addition to this, a total of 23 cores were obtained by vibrocoreing in the region of the approach channel (Lord *et al.* 1997 – see Chapter 3). Analysis of the cores showed most to comprise fine sand

overlying pebbles, shells and clay in the upper layer. Below this interface, cores further offshore at the outer extremity of the approach channel were predominantly clay with some shell, sand and pebbles. Closer to the Coega mouth, the lower layers were once again predominantly sand, pebbles and shells with small amounts of hard clay. Some nearshore sites (e.g. site 20) exhibited larger sediment types below the interface, with rough shells and stones being recorded.

It is evident that silt and clay percentages increase with depth, though nowhere do they comprise more than 50%; note that the high values at stations 6 and 13 are actually below the proposed dredging levels. The outermost stations 16 and 17 in the approach channel have high percentages of sand, noting that the depths given in Table 4.1 are actually not far below the seabed.

4.2.4 SETTLING VELOCITIES

Sediment released in a water column will settle down at a rate dependent on grain size, density and shape, and the degree of turbulence in the water. A typical curve for settling velocities is given in Figure 4.2. In a practical situation in the sea, settling velocities are likely to deviate substantially from values determined under idealised conditions in still water. Thus a non-spherical shape of particles will decrease the settling velocity compared to spherical particles with the same volume, while temperature and salinity also affect the settling speed. Most flows in the ocean are turbulent, and as such there are vertical components of this turbulent velocity. If the upward speed of flow within the turbulent eddies exceeds the settling speed, then particles will remain in the flow. A rough rule of thumb is that upward speeds are about 1/12 of the forward speeds in turbulent currents (Friedman and Sanders 1978). For fine sand, such resuspension velocities need to be of the order of 0.5 m/s or more, and such velocities are unlikely to occur here as ambient ocean currents (see section 4.2.5).

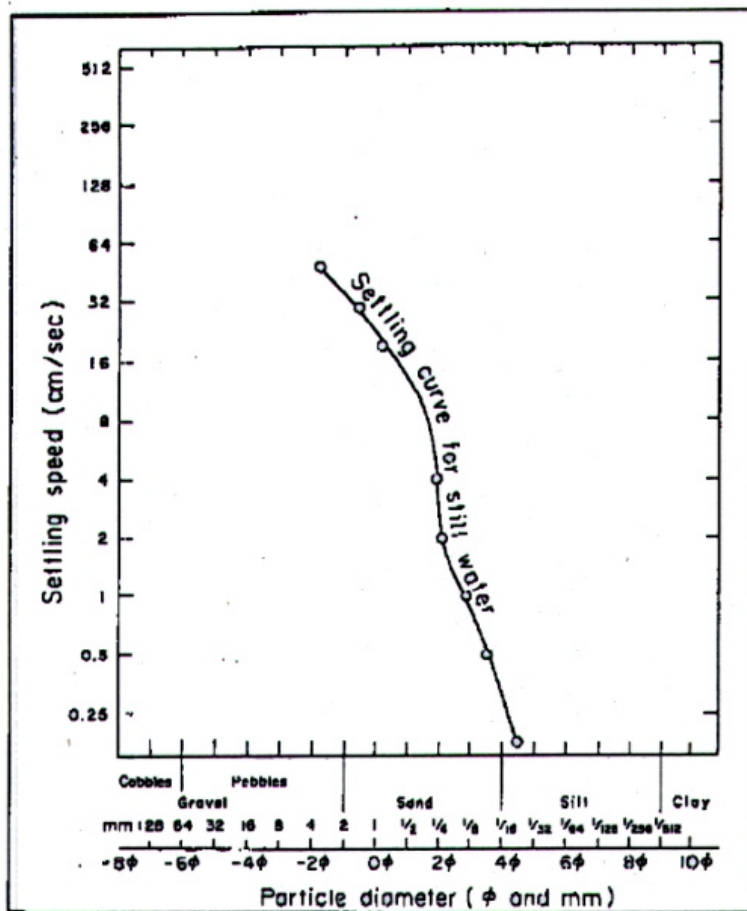


Figure 4.2: Graph of settling speed versus particle diameter for quartz spheres in still water (Friedman and Sanders 1978).

However, very fine silt and clay particles can easily be kept in suspension by turbulence, though flocculation can also occur, resulting in an increase in settling velocity. If sufficient particles are put into the water column, an aqueous suspension can result, effectively increasing the density of the water/sediment mixture. This in turn may set up a density current which would increase the settling rate of the particles as a whole compared to each one if it were in isolation. However, under high wave conditions the associated orbital velocities will increase instantaneous current velocities and turbulence, and will therefore increase the probability that sediment will remain in suspension even in the presence of a density current.

4.2.5 OCEAN CURRENTS

Schumann and Campbell (1999) have discussed current measurements made to the north of the Port Elizabeth harbour, as well as at a position farther into Algoa Bay in a water depth of 42 m. These data were obtained at fixed mooring positions, with the current metres generally deeper than 5 m. The results show that close inshore, the currents are sluggish, with some evidence of tidal and inertial oscillations. In deeper water the currents become stronger, with a marked southerly tendency.

It has generally been assumed in the past that currents in Algoa Bay were predominantly northeastward, and being driven by the dominant southwesterly wind (e.g. Harris 1978). The current meter results show that below the direct influence of the wind, the southwestward-flowing Agulhas Current probably has a major influence.

Schumann (1999) analysed data from the *InterOcean Systems S4* current meter moored at a position about 1 km south of Jahleel Island. Seven deployments covering a period of approximately eight months were included. Considerable variability was recorded, and the overall current rose for all deployments is given in Figure 4.3. An overall average current speed of 4.9 cm/s was found, with a maximum speed in excess of 30 cm/s towards the east-northeast. The maximum current to the north-northwest was only 8 cm/s. More recently, PRDW have analysed currents from more deployments, and their results show that only 1.3% of currents had speeds greater than 20 cm/s.

A rotary spectral analysis shows that both M_2 tidal and inertial oscillations are present at Coega (A rotary spectral analysis resolves a vector time series spectrum into clockwise and anticlockwise rotating components. Thus a linearly polarized vector, i.e. varying along a line, would have the two counter-rotating components equal, while a circularly rotating vector would have one component much larger). This means that currents at the M_2 period move backwards and forwards, probably along the line of the isobaths, with a period of 12.42 hrs, while inertial currents move in an anticlockwise circle with a period of about 21.5 hrs (Tides generally propagate mainly as Kelvin waves, in which the currents are in geostrophic equilibrium and vary in one plane – the two rotary spectral components will therefore be equal at the particular tidal frequency – in this case, the semidiurnal M_2 tide. Such oscillations will normally be parallel to the isobaths. On the other hand, inertial motion is circular and anticlockwise in the southern hemisphere, and at about 34° S, has a period of about 21.5 hours. For this motion the rotary spectrum will therefore have a much greater anticlockwise component at a period of 21.5 hours).

It is important to recognise that at the sea surface the situation is probably different, with currents being influenced to a large extent by winds. Thus surface currents would probably be driven by the dominant southwesterly winds, though east-northeasterly winds increase in summer, with offshore land breezes also prevalent.

Ocean density structures are probably not significant in water depths less than 15 to 20 m. Schumann and Campbell (1999) show that intense thermoclines are present in summer, but seldom at depths less than about 20 m; in winter isothermal conditions prevail. With very limited fresh water input from the nearby rivers (Swartkops and Sundays), salinity structures are also not significant.

4.2.6 SEDIMENT PLUMES

Using the above information, it is possible to make estimates of the anticipated sediment plume structures resulting from dredging operations at Coega. As discussed in section 4.2.2, it is likely that the overflow from the hopper on the TSHD will be collected and discharged at a depth from the bottom of the ship's hull. For the CSD, turbidity arises mainly from the cutting action, with sediment resuspension increasing with speed of rotation, swing speed, cutter diameter and depth of cut (Probyn 2000); such sediment would then be put into the water column at the dredging site. The CSD may also dump its spoil in the basin area where it would be accessible to the TSHD for pumping and subsequent offshore disposal.

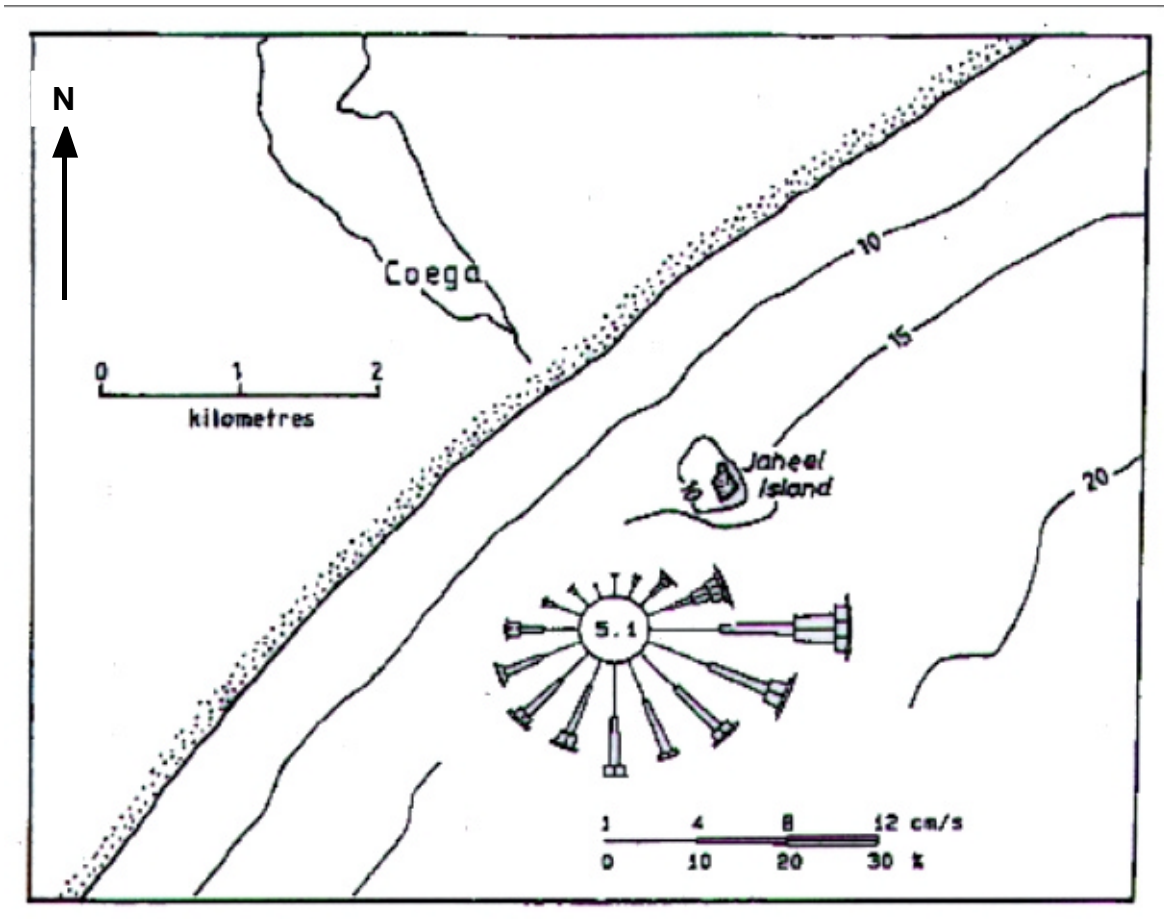


Figure 4.3: A current rose for seven S4 current meter deployments, superimposed on the site map. The value at the centre designates the percentage of speeds less than 1 cm/s.

The given turbidity levels generated by the dredgers to be used at Coega have been specified as 1 000 to 1 500 mg/l (Entech Consultants 2001). Figures quoted in Probyn's report mention plumes, with maximum dimensions of 500 m for a CSD and up to 1 200 m for a TSHD. For the most part, however, SS levels appear to decrease to 10 to 20 % of their maxima within 50 m of the dredge site, with ambient levels recorded outside of a 500 m zone even at sites where fine sediments (mud) made up the majority of dredged material. Dredging operations in the Espirito Santo Estuary in Mozambique (Monteiro and Gregorio 1999), and off Nome, Alaska (Garnett and Ellis 1995), also

utilise a 500 m mixing zone. A mixing zone of 150 m was proposed for dredging operations at Saldanha, with a turbidity maximum of 150 mg/l (Carter 1995). The small mixing zone was required as the sediment was comprised of at least 50 % mud and the immediate area had a number of commercial mussel farming ventures². The situation at Coega with respect to sediment composition and faunal make-up is different, with the large proportion of sediment comprising sand and fluvial gravel, and no large commercial farming venture being close to the sites of dredging or disposal.

Based on the vertical settling distances of various sediment types, and the proportions of these sediments at Coega, a mixing zone of 500 m has been proposed. Apart from the 150 m radius at Saldanha, which was due to the potential ecological impact on nearby mussel beds, many other dredging operations utilise the 500 m zone. Within this zone, turbidity levels will be allowed to rise above the recommended environmental level of 150 mg/l above ambient. This mixing zone is specified as 500 m from the dredging area, i.e. within the approximate lines given in Figure 4.4 (the dredging area has been assumed to lie within the breakwater walls). The extent of this mixing zone should also provide sufficient protection for the fauna and flora associated with Jahleel Island, which is an average distance of 2.5 km from the channel. Although dredging within the basin takes place closer to Jahleel, the construction of the breakwaters should prevent any turbidity plumes from posing a threat. If Cape Recife and Woody Cape are taken as the boundaries, a rough estimate of the surface area of Algoa Bay is $1.442 \times 10^9 \text{ m}^2$. Consideration must be given to the fact that the area to be dredged and the area of the offshore disposal site together add up to between 23.25 and $25.99 \times 10^6 \text{ m}^2$ or 1.61 to 1.8% of the Bay area as a whole.

Table 4.3 gives guideline vertical settling distances for different sediment types while traversing 500 m at current speeds of 5 cm/s and 20 cm/s, the average and near-maximum currents measured near the end of the main breakwater position. For example, gravel particles have a settling velocity of $> 30 \text{ cm/s}$, and with a horizontal current of 20 cm/s will settle a vertical distance of 750 m through the water column before reaching 500 m from the source and thus will easily settle out in a depth of less than 50 m. As discussed already, these calculations are probably optimistic, and in practice sediment can be expected to settle at slower speeds, except for consolidated clays.

All gravel and the majority of sand particles will have settled out within a 500 m horizontal distance at the dredge sites. It is only the smallest sand particles at the highest current velocities which would still be in suspension. Larger silt particles should have settled out within 500 m, but the majority of silt and all clay particles will still be in suspension. While these calculations may be optimistic, they describe the dynamics of particles in isolation. In reality high densities of similar particles would form density currents and settle at faster rates. Even so, silts and clays would need a far greater distance than 500 m to settle out. However, their respective contribution to the overall sediment and diffusive forces in the water column should ensure that the 150 mg/l SS concentration is not exceeded.

Dredging in the approach channel and in the harbour basin will result in different scenarios, and will be discussed separately.

².Mussel embryo development is seriously impeded at levels $> 188 \text{ mg/l}$ (Davis and Hidu 1969).

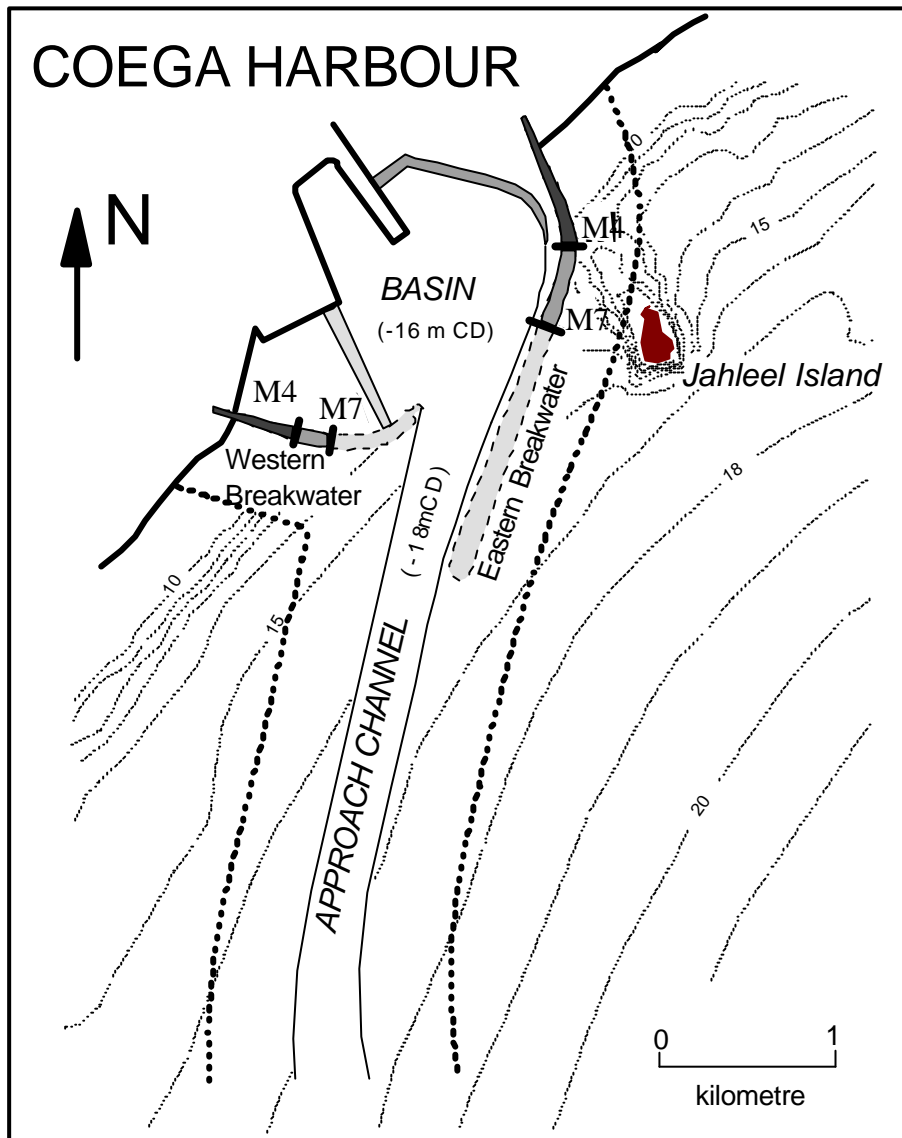


Figure 4.4: Breakwater positions in Month 4 (M4) and Month 7 (M7) are shown, as well the approximate 500 m limit of the mixing zone (dark dotted line).

Table 4.3: Calculated vertical settling distances over 500 m at current speeds of 5 cm/s and 20 cm/s for the different sediment types to be dredged/disposed at Coega Port.

Sediment Type	Settling Velocity Range	Current Speed (cm/s)	Vertical settling Distance for 500 m
Gravel	> 30 cm/s	5 cm/s	> 3 000 m
		20 cm/s	> 750 m
Sand	30 cm/s to 0.2 cm/s	5 cm/s	3 000 m to 20 m
		20 cm/s	750 m to 5 m
Silt	0.2 cm/s to 0.002 cm/s	5 cm/s	20 m to 0.2 m
		20 cm/s	5 m to 0.05 m
Clay	< 0.002 cm/s	5 cm/s	< 0.2 m
		20 cm/s	< 0.05 m

The Approach Channel

Only the TSHD will be used in dredging the approach channel. According to the isobaths in the region, the present depth of the area of the approach channel varies from about 14 m to its specified depth of 18 m, i.e. the maximum depth to be dredged here is about 4 m. According to the borehole

characteristics given in Table 4.1 (stations 16 and 17), over 80% of the dredged material will be sand, there will be a minimal amount of gravel, some 15% will be silt, with around 5% of clay.

The dredging of the approach channel will take place while the breakwater constructions progress from positions M4 (Month 4) to M7 (Month 7) (Figure 4.4). The channel lies well away from these limits, and it can therefore be assumed that the construction and breakwaters will not change ambient current structures markedly, or provide any protection.

According to Bremner (1991), the sand is predominantly of medium size, comprising more than 60% quartz. Such sand has diameters of 0.18 to 0.25 mm, with settling velocities in the range from about 2 to 3 cm/s, although irregular less dense shell fragments will settle more slowly. These fall within the ranges given in Table 4.3, with settlement distances of 200 to 300 m with a current of 5 cm/s, or about 50 to 75 m with a current speed of 20 cm/s. With the shallow depths in the vicinity, the maximum depth below the TSHD overflow discharge point is approximately 10 m³, and even with the uncertainties in settling velocities, it is unlikely that this sand will still be in suspension outside of the mixing zone.

On the other hand, from Table 4.3, silt will only settle a distance between 0.2 and 20 m with a current speed of 5 cm/s, and between 0.05 and 5 m for current speeds of 20 cm/s. It is not specified what is meant by 'silt' in Table 4.1, but Table 4.2 indicates that the silt is likely to be on the larger size. Nonetheless, it depends on the structure of the sediment layers encountered on site how much sediment actually penetrates outside of the mixing zone. On a very simple proportional basis, if silt comprises 10% of the discharged sediment load then out of an original loading of 1 500 mg/l, only silt will still be in suspension at a turbidity concentration of 150 mg/l at the edge of the mixing zone. This is a worse case scenario, as diffusion due to physical processes should ensure lower concentrations at the limit of the mixing zone.

The Harbour Basin

Dredging in the harbour basin is scheduled to begin when the breakwaters are at the position A in Figure 4.4, and will still be ongoing when the breakwaters have been completed. As a consequence, and particularly in the later stages, the ambient ocean currents will be severely impeded by the construction; in fact the CSD is only able to operate in relatively calm waters.

Many of the conclusions for the approach channel also apply to the harbour basin, particularly at the start of this dredging stage. In the later stages, the ambient currents should be less than those in the open ocean, and therefore a longer time will be available for the sediment to settle out.

Possible tidal currents in and out of the harbour basin can be calculated approximately by considering the area of the basin and entrance, and the tidal amplitudes. Maximum change occurs at mid-tide and at this time the rate of change of sea level can be calculated to be about 0.3 mm/s for a 2 m spring tide. If the area of the harbour is taken to be 1 km², then about 300 m³/s needs to exit through the harbour mouth at this time. For a width of 300 m and a depth of 16 m, this translates to current speeds of about 6 cm/s. At neap tides these speeds should decrease to around 1.5 cm/s. Such maximum speeds should have little additional impact in moving suspended sediments out of the harbour basin and beyond the demarcated mixing zone. Despite this, it is recommended that monitoring should take place during the ebb tide each day as this is when the possibility exists of SS loads being washed out of the basin into the adjacent ocean.

The effect of wave orbital velocities associated with surface gravity waves bring an unknown into the calculations, and several additional factors need to be considered. Firstly, the additional currents and turbulence will keep sediment in suspension, but at the same time will disperse it both

³ Depth of discharge depends on the size and draft of the dredger.

horizontally and vertically. Secondly, if the waves are large enough then sediment will be lifted into the water column from the seabed, thus increasing the ambient turbidity; this increase will tend to be concentrated near the bottom.

4.3 TURBIDITY ASSESSMENT FOR DISPOSAL OF DREDGED SPOIL AT OFFSHORE SITE 1

This site, located offshore from the Coega River mouth, lies in 25 to 39 metres of water and is demarcated by the following grid references⁴ (Figure 4.6):

33 50.55 S; 25 44.42 E
33 50.55 S; 25 45.51 E
33 51.39 S; 25 45.10 E
33 52.23 S; 25 44.30 E
33 52.91 S; 25 42.87 E

The site measures approximately 2.7 nautical miles (nm) at the longest axis and 0.9 nm at its widest axis, with the long axis parallel to the 30 metre depth contour.

Ocean currents are likely to be stronger than at the inner site described in section 2.4. Currents tend to flow parallel to isobaths, and as a guide, the currents measured by the SAN at two sites in 17 and 40 m to the northeast of the Port Elizabeth harbour are pertinent (Schumann and Campbell 1999). The measurements show a dominant south to southwestward flow, with the currents at the inner mooring having a greater southward tendency. Average speeds here were 5.9 cm/s, with all being less than 20 cm/s. At the outer mooring, the bottom currents (35 m depth) were slower than those 10 m higher up in the water column: average speeds at the top metre were 9.7 cm/s with maxima greater than 40 cm/s, while at the bottom metre the average was 7.6 cm/s with maxima greater than 35 cm/s.

Currents at the disposal site are therefore likely to also have a dominant southward to southwestward flow, with speeds in the range given above. Note that nearer the surface, the currents probably come more under the influence of the wind, and since the major wind component is from the southwest, these surface currents will probably flow counter to those deeper down.

A slight complicating factor is the thermocline which occurs in summer, generally at depths greater than 20 m. Though fairly intense, with temperature changes greater than 6° C, they will only have an impact on fine sediment by inhibiting movement through the density interface.

The same general criteria will apply at the disposal site, as were applied for the dredging process to assess movement of sediment in the water column (see Table 4.3). The spoil will be dumped from the TSHD or barge (if spoil from the CSD is dumped offshore) through bottom doors, which open suddenly to dispel the load as quickly as possible. This method of disposal means that the spoil will probably resemble a density current, with the mass reaching the seabed very quickly. In addition, this method of disposal suggests that the turbidity plumes will not be affected to any great extent by the wind driven surface currents.

As a result of the dominant oceanic currents, the preferential movement of sediment will be towards the south and southwest. There is a much greater range of material being dredged out of the harbour basin than from the approach channel, including a substantial proportion of silt (Table 4.2). This fine material should be dispersed widely, since it will be released more than 20 m above the seabed – at a settling speed of 0.2 cm/s (fine sand/silt) and in a current of 8 cm/s, the sediment will travel a horizontal distance of 800 m while settling through 20 m vertically. The coarser sediment will settle

⁴ The reference points are for the recommended site (see chapter 5).

out first, and it can be expected that the dumped sediment will disperse widely, especially the finer sediments such as silt and clay, although settlement may occur faster due to the density current effect mentioned above. This is observed during flood events in Algoa Bay when large quantities of sediment are spilled into the Bay from the Sundays and Swartkops Rivers. Finer sediments tend to be dispersed further and settle out in the deeper and stiller parts of the Algoa Bay seafloor (Illenberger 1998).

It is anticipated that disposal will take place over the whole of the proposed disposal site, and that the sediment impact will be the greatest soon after the disposal takes place. Because of the likely ambient currents, the greatest impact will also be to the south-southwest, away from the sensitive area surrounding Brenton Island to the northeast. However, since the disposal site is several kilometres long and in the direction of the dominant flow, it is unlikely that disposal in the north will have an appreciable impact to the south outside of the disposal and mixing zone.

4.4 TURBIDITY ASSESSMENT FOR DISPOSAL OF DREDGED SPOIL AT OFFSHORE SITE 2

This site is also located offshore from the Coega River mouth, but lies in deeper water between 43 and 49 metres of water and is demarcated by the following grid references (Figure 4.6):

33 52.69 S; 25 51.68 E
33 53.65 S; 25 51.82 E
33 55.64 S; 25 49.31 E
33 55.53 S; 25 47.96 E

The site has a northeast to southwest orientation along its long axis, and measures approximately 4.05 by 0.81 nautical miles at its longest and widest axes.

The site lies considerably further into Algoa Bay than the first site, and as such the currents can be expected to be stronger. Goschen and Schumann (1994) have measured southwest currents throughout the water column in the central areas of Algoa Bay in excess of 50 cm/s. These strong currents were, however, associated with an intrusion of the Agulhas Current and should be considered unusually strong for the area.

The majority of statements made for site 1 are also applicable here, though dispersal currents may be considerably greater. In the most extreme situation, e.g. a current of 50 cm/s, fine silt/sand with a settling speed of 0.2 cm/s will travel a horizontal distance of approximately 8.8 km while settling through 35 m vertically. Waves and their associated wave orbital velocities can also be expected to be greater at this site, leading to greater turbulence and maintenance of sediment in the water column. However, due to the dimensions and orientation of the site, if disposal occurs in the northeast section of the site with the accompanying southwesterly ambient currents, there is a distance of close to 8 km (4.05 nm) for the sediment to settle out of suspension.

In conclusion, the majority of the sand and gravel should be confined to within the specified disposal area if cognisance is taken of conditions at the time. However, for the silt fraction it will be very difficult to confine the disposal precisely to the designated area, since the finer material may be carried considerable distances and thus fall outside. This is likely to be a small fraction of the total, and may not have any greater impact than a natural flood from the Sundays River (Illenberger 1998). In fact, the disposal site lies near to an existing muddy sediment seabed, and existing marine life may then be able to cope easier with an additional volume of mud.

4.5 MONITORING GUIDELINES FOR THE DREDGING AND DEPOSITION OPERATION AT COEGA PORT

Three major aspects of the Coega dredging operation will need to be monitored viz. suspended solids (turbidity), blasting and dispersion of disposed material.

4.5.1 SUSPENDED SOLID MONITORING

Four sampling techniques may be employed to monitor turbidity plumes originating from dredging and disposal practises, namely *in situ* sampling, acoustic monitoring, remote sensing and dye tracer studies (Puckette 1998). Each of these techniques was assessed by Probyn (2000), and we concur that *in situ* collection of water samples for the determination of SS levels would be the most appropriate⁵.

Equipment specifications

A contractor shall be appointed who will undertake monitoring measurements to ensure that SS concentrations as a result of dredging and disposal operations adhere to the criterion that turbidity levels do not exceed the specified maximum concentration above ambient. The contractor shall make a vessel, crew and all necessary instrumentation available. The vessel should be capable of sampling during adverse weather conditions to determine ambient SS concentrations under these circumstances. All SS measurements shall be taken once daily by the contractor in the presence of the PAD Environmental Officer or a designate for the duration of the dredging operation. The vessel shall be equipped with a GPS capable of fixing the monitoring positions to an accuracy of 5 m. Measurements shall be taken with a Grant YSI or OBS turbidity probe with data logger or similar approved instrumentation. The cable shall be long enough to allow for measurements in 50 m water depth if the first choice disposal site is approved (if the secondary site is utilised, cable for measuring in 70 m of water should be sufficient). Additional probes shall be provided to measure salinity and temperature at the same time. The turbidity probe shall be calibrated once per week, or as directed by the PAD Environmental Officer, to allow accurate correlation of the NTU measurements of the probe with the SS concentrations (mg/l) of the dredged material at Coega. The responsibility for accurate calibrations and measurements rests with the contractor but must be done to the Environmental Officer's satisfaction.

Monitoring and reference sites

For the purposes of this report, a monitoring site refers to any site at which sampling takes place to determine the total SS levels above ambient, and a reference site refers to any site at which sampling takes place to determine the ambient SS level.

All monitoring and reference sites shall be sampled on a daily basis for the first three months. The Ngqura Environmental Committee (NEC) may review this procedure every three months and make amendments as to the frequency of sampling depending on the operational levels of SS during that stage of the operation. For dredging in the approach channel, six monitoring sites shall be evenly spaced along both sides of the line demarcating the 500 m mixing zone. There should be a single site on each of the southern-most corners at the extreme of the mixing zone, with two on both the shoreward and seaward sides of the zone line lying parallel to the approach channel. For dredging within the harbour basin, the monitoring sites shall be fixed at 500 m from the mouth of the breakwaters at either side on the limit of the mixing zone. These positions will be independent of the progress of breakwater construction at the time of sampling. The coordinates of the mixing zone must be established before dredging begins, i.e. the precise position of the dotted line in Figure 4.5 must be established for the dredging operation. Daily SS concentrations must also be collected from two fixed reference sites on either side of the dredging site, which are unaffected by the dredging operation for determination of natural ambient SS concentrations. These reference sites should be

⁵ In situ determination of SS levels will be correlated to NTU for measurement by the prescribed probe.

approximately 3.8 km from the edge of the mixing zone to the northeast and southwest. Two other monitoring sites will be situated 150 m from Jahleel and Brenton islands. The recommended monitoring and reference sites are presented in Figures 4.5 and 4.6. The waypoints for each of these sites are presented in Table 4.4. Measurements at the dredging monitoring sites should be taken while the dredgers are operational, and at the monitoring site at Brenton Island within an hour of disposal. However, at spring tides during harbour basin dredging, whenever possible the monitoring must be done at mid-tide during the ebb tide. It is the responsibility of the PAD Environmental Officer to check that the contractor is following the correct procedure and ensure that measurements are taken at the correct monitoring and reference sites each day. Monthly reports indicating daily results, mitigatory actions implemented, guideline exceedances and subsequent remedies must be submitted to the NEC. The Department of Economic Affairs, Environment and Tourism should also regularly ensure that the guidelines are being adhered to by conducting spot checks and audits.

Turbidity concentrations and mitigatory actions

Due to the design of the overflow on the TSHD and the disposal method, it is unlikely that the sediment plume will reach the surface, and will move closer to the bottom with distance from the dredging/disposal site. Taking cognisance of Probyn's (2000) analysis, where the recommendation is that *absolute* turbidity levels should not be above 80 mg/l, the normal practice of a depth averages SS concentration could allow values much greater than 150 mg/l to occur at the seabed, when the expected low values at the surface and mid-depth are considered. Consequently it is recommended that *profiles* of turbidity, temperature and salinity be measured at all monitoring sites. A maximum value can then be established, and this maximum value should then not be more than 150 mg/l above the maximum concentration along the depth profiles at the fixed reference sites which measure the ambient situation. These maximum values may differ with depth at the respective monitoring and reference sites. It must be clear that 150 mg/l above ambient is the absolute maximum we recommend and any exceedance of this value at any individual monitoring site must result in the suspension of dredging/disposal operations.

Due to the highly sensitive nature of the environment associated with Jahleel and Brenton islands, it is recommended that a maximum of 80 mg/l above ambient be allowed at the islands' respective monitoring sites. The site at Jahleel is far beyond the mixing zone boundary, and the site at Brenton is almost 3 km from the northeast edge of the disposal site. Exceeding the 80 mg/l (above ambient) maximum should not be a concern, but it is included as a backup failsafe due to the sensitivity of the region. It is our opinion that if 80 mg/l is exceeded at these sites, then a serious problem already exists at the disposal site or at the dredging site and its relevant monitoring sites at the edge of the mixing zone.

In an attempt to prevent instituting serious mitigatory measures (cessation of activities) due to the 150 mg/l (above ambient) maximum being exceeded, a graded system of turbidity concentrations is recommended. Instead of relying on a single turbidity concentration maximum at the daily monitoring sites on the edge of the mixing zones, an SS concentration of 100 mg/l (above ambient) should be used as an early warning indicator. The contractor would thus be in more of a position to initiate mitigatory measures to avert exceeding the 150 mg/l (above ambient) threshold if he has sufficient warning that this level is being approached. Once the 100 mg/l (above ambient) level is attained or exceeded, the contractor should ensure that the necessary mitigatory steps are taken and documented to prevent a further increase in SS concentration, which could lead to suspension of the operation when 150mg/l (above ambient) is exceeded. Mitigatory steps that have been proposed for other dredging operations include slowing cutter head speed, a slower rotational speed of the CSD, a different cutter head, a slower rate of progress for the TSHD (slower drag rate of suction head along the bottom means less disturbance), a slower rate of hopper loading to control the overflow, moving the dredger to another sediment type, and disposal over wider area within the disposal site (sediment plume will be more diffuse and diluted from the start). If 150 mg/l (above ambient) is attained or exceeded there should be no debate and dredging operations must be immediately

suspended until levels are reduced to below the threshold mark. A report on the exceedance incident should be prepared and only after the environmental officer is satisfied that the situation has been rectified should the operation be resumed.

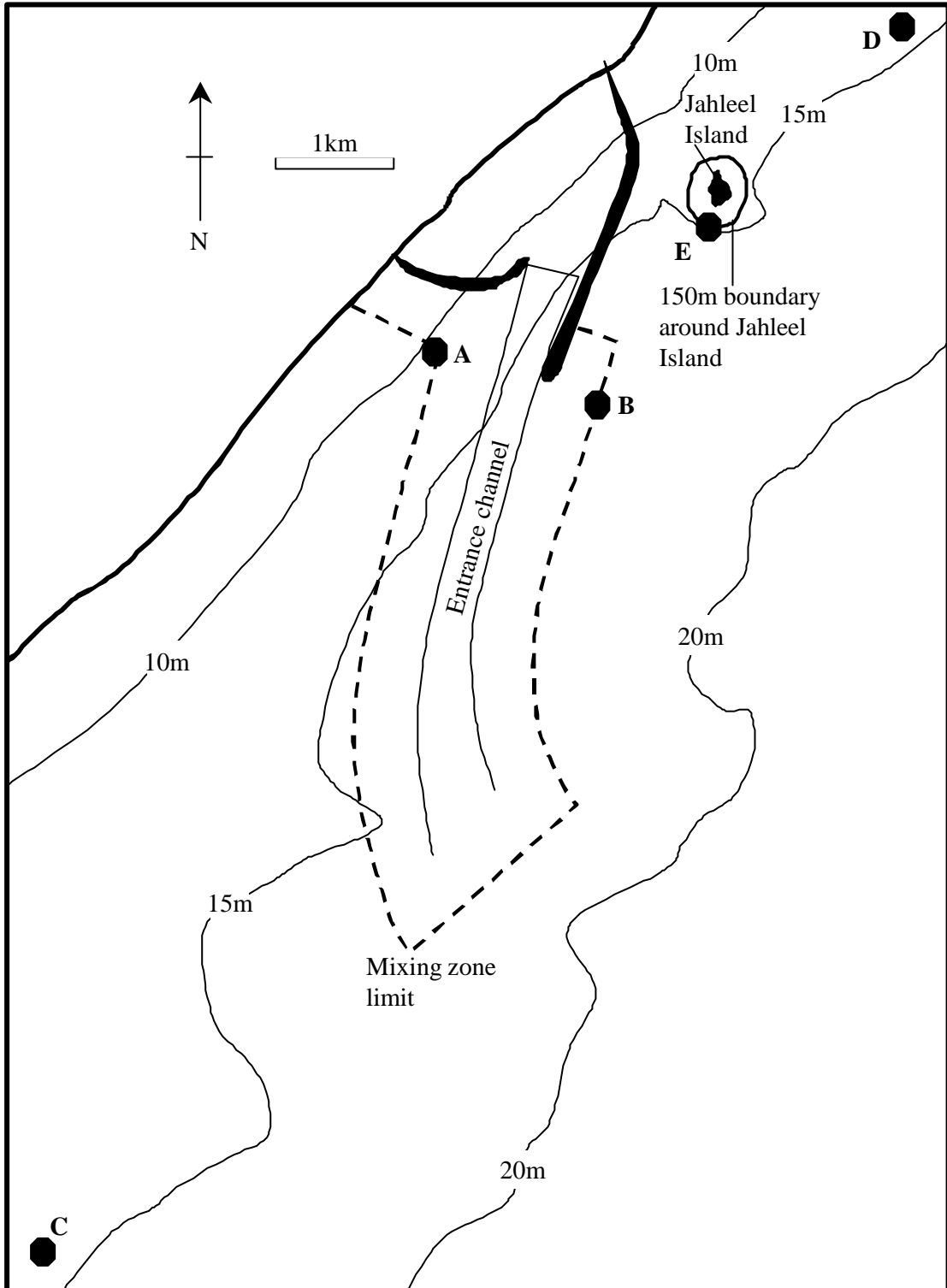


Figure 4.5: Monitoring stations for the dredging operation at Coega Port. The dotted line represents the extent of the 500 m mixing zone either side of the approach channel along which the 6 monitoring sites for the approach channel must be located. A & B are the fixed monitoring sites for the basin dredging operation, C & D are the fixed reference sites to the NE and SW respectively, and E is the fixed monitoring site on the 150 m boundary around Jahleel Island.

Table 4.4: Waypoints for the monitoring and fixed reference sites to be used for the dredging operation at Coega Port (excluding approach channel sites).⁶

Site	Longitude (E)	Latitude (S)
A	33 49.20	25 41.06
B	33 49.40	25 41.72
C	33 53.29	25 38.86
D	33 48.10	25 43.38
E	33 48.80	25 42.30
F	33 49.15	25 45.82

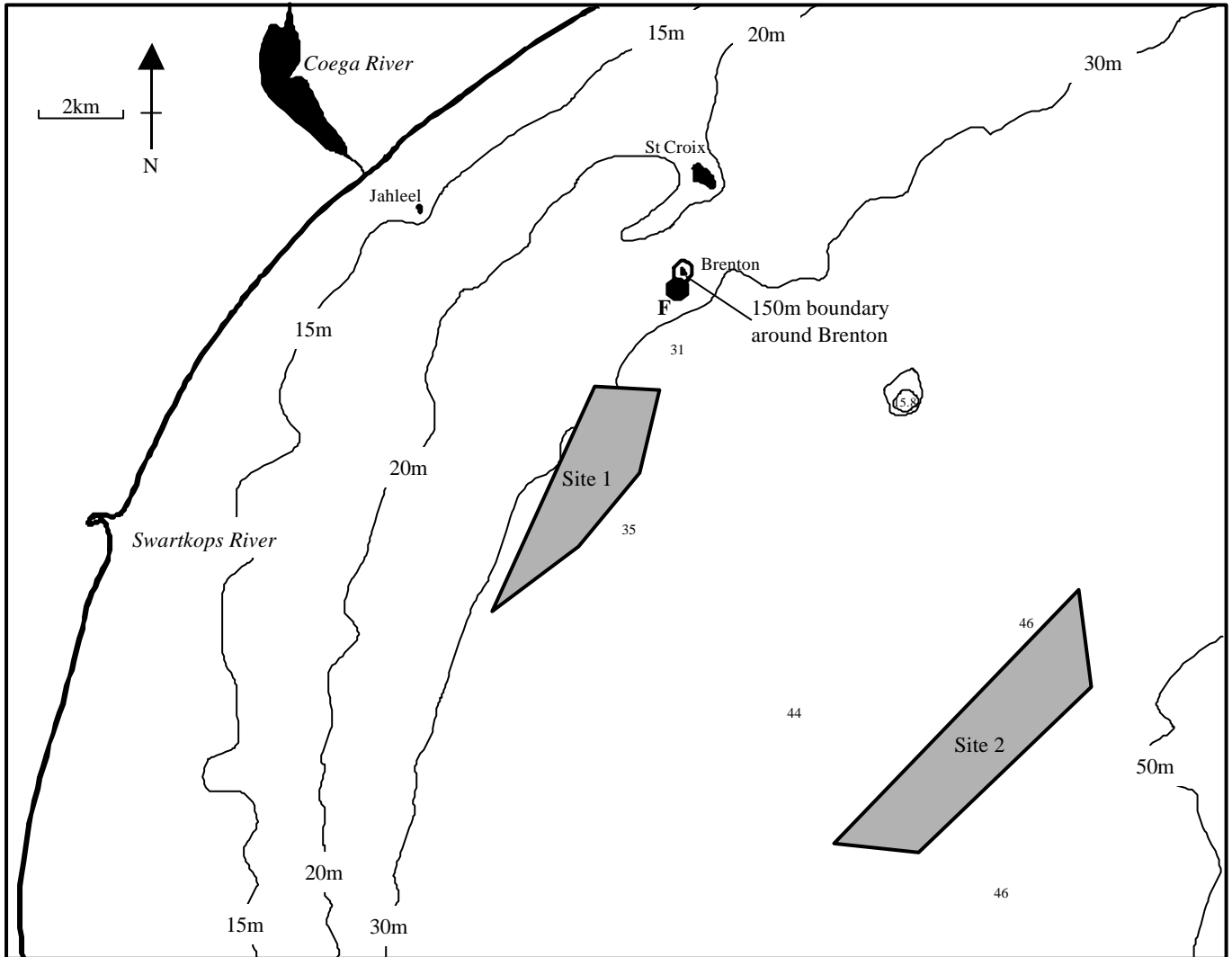


Figure 4.6: Fixed monitoring site (F) 150 m from Brenton Island to the NE of offshore disposal site 1.

⁶ The approach channel sites will be fixed once the precise approach channel is decided upon.

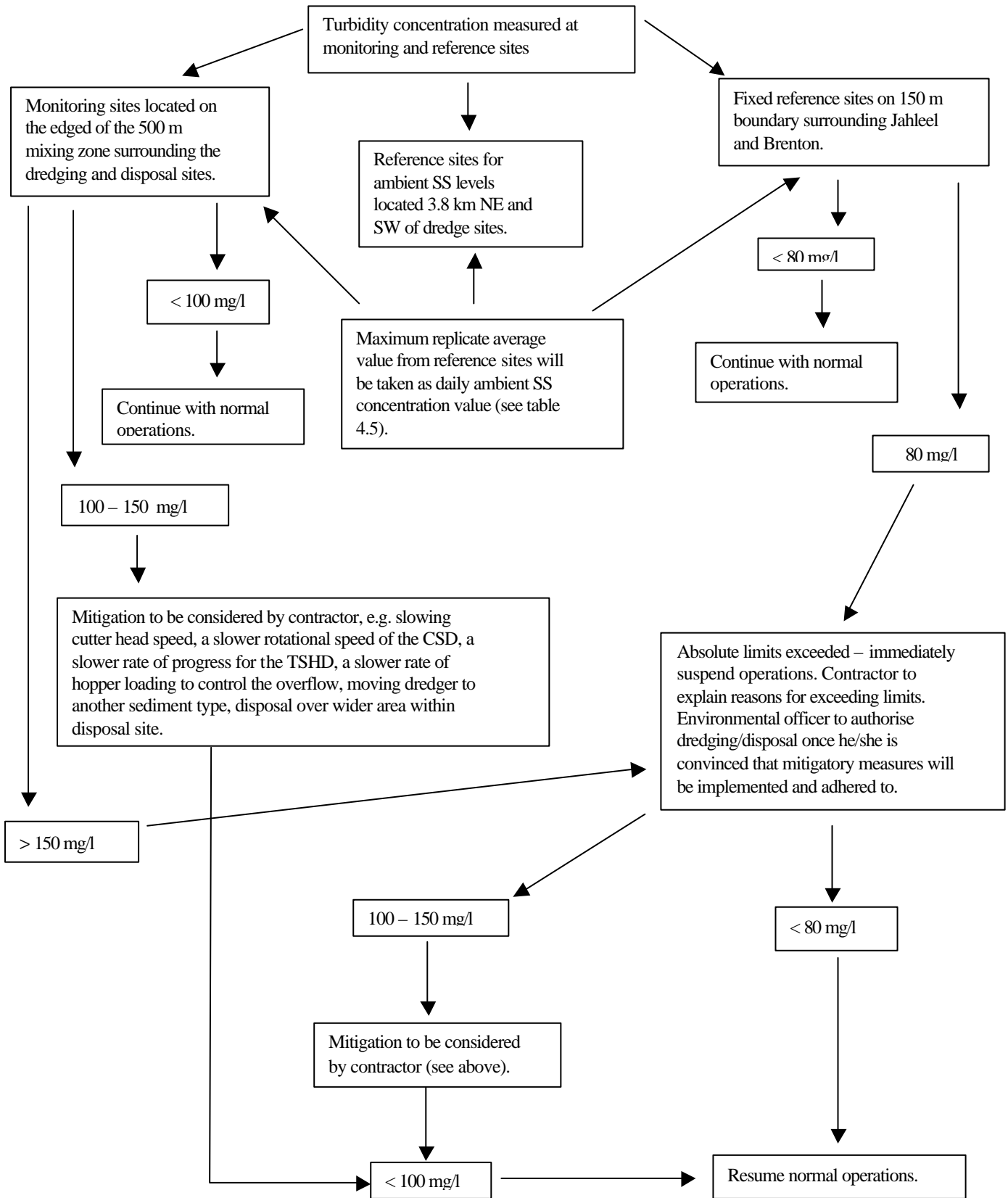


Figure 4.7: Flowchart for monitoring SS concentrations and mitigation (all concentrations are above ambient SS concentrations).

Approach

- 1) At each of the monitoring and reference sites, measurements shall be collected from three different locations (replicates) in close proximity to each other. The measurements shall be in the form of a profile, with the replicate readings averaged at each depth. The highest average value is the ruling ambient or monitoring value for that site (see Table 4.5 for an example).
- 2) The daily ambient value is the higher of the two ambient ruling values from sites C & D.
- 3) If any of the monitoring sites (6 sites around approach channel and sites A & B) ruling value exceeds 150mg/l above the ambient value for that day operations should be stopped.
- 4) If any of the island monitoring sites (sites E and F) ruling value exceeds 80mg/l above the ambient value for that day operations should be stopped.

Table 4.5: An example of how the averaging should be done and reference values should be calculated.

Monitoring Site or Reference Site				
Depth⁷	Profile Replicate 1	Profile Replicate 2	Profile Replicate 3	Average
1	0	0	0	0
4	5	7	9	7
7	13	22	19	18
10	16	28	20	21.33
13	20	36	25	27
16	26	49	32	35.66
19	30	65	38	44.33
22	38	70	47	51.66
25	55	73	54	60.66
28	78	80	73	(Ruling Value) 77
31	65	67	60	64
Continue in 3m intervals				

While mitigatory actions associated with the release of dredge spoil at the deposition site are limited, the selection of the deposition site for each load should take into consideration the approved deposition plan (see below) as well as the prevailing conditions to ensure that the spoil deposited settles within the site and buffer area. In other words, if a strong current is running towards Brenton Island, that load should be deposited in the southern reaches of the disposal site.

4.5.2 BLASTING MONITORING

If hard rock is encountered, this shall be removed using underwater drilling, blasting and dredging.

Hard material shall be drilled and blasted to obtain a size distribution that can be removed by the dredging equipment mobilised for the contract. Blasting shall use delay elements to ensure that a Peak Particle Velocity (PPV) of 25mm/s is not exceeded.

Underwater blasting shall only be permitted once per day during daylight hours, preferably between 12h00 and 14h00. A visual survey of the area shall be done 30 minutes before the blasting is to commence to determine whether marine mammals are within 2 kilometres of the blast. Permission to blast must be delayed until all cetaceans are outside of the 2 km limit. Marine mammals may not

⁷ Care should be taken that the deepest station reading is clear of the substrate.

be disturbed in terms of the Sea Fisheries Act. Any marine birds in the area must be scared off prior to the blast. A member of the Department of Economic Affairs, Environment and Tourism should observe all blasts and permission to blast can only be given by the PAD Environmental Officer or his/her designate.

A visual survey of marine mammal and bird casualties shall be carried out after each blast and reported to the PAD Environmental Officer. In addition, the beaches surrounding the port could be inspected for casualties on a weekly basis.

A dredging method statement shall be submitted with the tender, and shall include specific reference to blasting and provide calculations in this regard. Each blast shall be designed and submitted to the Technical Officer for approval before blasting is to take place. Blast monitoring shall include a detailed account of layout of blast, charge, delays and PPV measurements of the blast.

4.5.3 MATERIAL DISPERSION MONITORING AT THE DISPOSAL SITE

The distribution of the deposited sediment must be monitored to avoid any build up beyond the 2 m cap expected. The even distribution of material is the contractor's responsibility and detailed hydrographic surveys to confirm the dredging results along with the even deposition of spoil material should be undertaken by the contractor and be subject to review by the Port Authority Division (PAD).

To ensure an even spread of materials, the contractor must submit to the NEC, on a quarterly basis, a detailed deposition plan. This plan must contain the following.

- 1) A clear grid pattern which divides the deposition site into 6 equal size areas.
- 2) The previous quarter's dumping statistics (e.g track plots, exact amounts, location and date).
- 3) The results of the latest surveys.
- 4) The proposed deposition plan which takes cognisance of the results of the previous quarter.

The contractor should keep daily records and submit a monthly report to the PAD Environmental Officer, outlining how the objectives stipulated in the quarterly report are being met. The PAD Environmental Officer and/or the NEC must be authorised to stop dumping activities if the deposition plan is not being adhered to.

4.5.4 RESEARCH AND DEVELOPMENT

The Coega Project as a whole, and the dredging component in particular, offers a unique opportunity to examine the effects of a significant engineering operation on the marine ecology in a relatively pristine area. While this research falls outside that required by authorities, PAD, in conjunction with research agencies such as the National Research Foundation, should recognise this unique opportunity and support merit-worthy initiatives. It is suggested that PAD explore these opportunities as soon as possible, as many of them will require baseline information prior to the initiation of activities. Avenues of research could include sediment dispersion (suspended and bed load using systems such as MEDUSA – Multi Element Detector System for Underwater Sediment activity), modelling, and recovery rates of various components of the biotic environment.

4.6 CONCLUSIONS

The assessment of available information on seabed sediment structures, prevalent currents and the proposed dredging scenario indicate that for the most part the dredging plume should settle out within the predefined mixing zone. Problems are only likely to arise during the dredging of silt and possibly clays if they are unconsolidated, which may not settle quickly enough within the mixing zone: this will depend in large measure on the currents and waves present at the time. Available information shows that silt constitutes generally less than 20% of the sediment to be dredged, and it may be that under severe conditions, the dredgers could change their position to more suitable sediments.

Some differences are expected in dredging the approach channel and the harbour basin, with the approach channel completed before the harbour construction has a major effect on ambient currents. Dredging within the harbour will be much more confined, with much slower ocean currents. However, ebb tidal flows, particularly at spring tides, could discharge this sediment into the open ocean although no deleterious impacts are expected outside of the mixing zone. Due to the sensitive nature of the islands' ecosystem, a more stringent turbidity maximum is proposed for their respective reference sites.

CHAPTER 5: THE ENVIRONMENTAL IMPACTS OF OFFSHORE DISPOSAL OF DREDGE SPOIL FROM THE COEGA PORT DREDGING OPERATION

5.1 PROJECT DESCRIPTION AND ACTION

The disposal of dredge spoil should be carried out in such a way as to maximise the beneficial use whilst minimising the impact on the affected environment. In order to ensure that adverse impacts on the marine environment are kept to a minimum, data on the physical and biological aspects of the disposal sites needs to be gathered so that informed decisions can be made (ANZECC 1998). Two options are available for the majority of marine dredging operations, namely offshore or onshore disposal. At present it is envisaged that 1 million m³ will be dumped on the eastern beaches, 3 million m³ onshore for landfill, and 10 million m³ offshore. It is possible that all 14 million m³ will be dumped offshore, and that even a proportion of the 13 million m³ of dry excavated material will be considered for offshore disposal. In light of this, the permit application for offshore disposal will be for 20 million m³.

A number of proposed disposal sites needed to be evaluated and finally selected through a process of elimination. Most of these options were already rejected prior to this report (see below), leaving only a single viable offshore disposal option. A minimum of two offshore sites needed to be evaluated before the final recommendation could be made as to where the disposal operation should be located. Using the assessment framework outlined in the ANZECC Ocean Disposal Guidelines as a basis, the following objectives regarding the disposal of dredge spoil at Coega were identified:

1. To select an alternative offshore disposal site utilising a screening process and sensitivity map.
2. To obtain a representative impression of the benthic environment, physical and biological, within the two proposed disposal sites and the immediate area around them.
3. To assess the issues and impacts associated with offshore disposal of dredge spoil at the sites.
4. To recommend mitigatory measures, which may be practically and cost effectively implemented to decrease the effects of any impacts.

Offshore disposal of dredge material shall be carried out under the conditions set out by the London Dumping Convention (1972). The Special Guidelines as amended in Dredged Material Assessment Framework and adopted at the December 1995 consultative meeting of the London Convention (Ref. Dredged Material Management Guide: PIANC: PEC Special Report, Vellinga 1997 and Handling and Treatment of Contaminated Dredged Material from Ports and Inland Waterways: PIANC 1998) (See also Dumping at Sea Control Act 73 of 1980) will be applied. A permit shall be obtained from the Department of Environment Affairs and Tourism for this purpose. Disposal of material shall be subject to the following guidelines:

1. Offshore disposal will be controlled for quality at the source prior to the start of dredging operations (Appendix 2: Connell and Parsons 1999). Potential disposal sites have been identified and shall be fully assessed before final selection of the site.
2. Offshore discharge from the TSHD is by means of a bottom disposal arrangement. If necessary, the CSD may also discharge via a pipeline onto a barge, which will utilise a bottom disposal arrangement at the offshore disposal site. Alternatively, the CSD may dump

its spoil at a site within the basin where the TSHD will dredge it up and remove it offshore for disposal.

5.2 SITE SELECTION

The number of disposal sites that were originally considered included disposal at the PPC mining concession north of Coega, disposal on the beaches north of Coega and offshore sites in 30 and 80 m of water. The offshore 80 m site was discarded because of the significant costs involved for a return trip by the dredgers. The option of disposal at the PPC site was rejected by PPC as they believed the spoil would create the following problems:

1. The spoil would contain high levels of salt, which would have to be washed from the sediment by freshwater before they could use it. This would prove to be too costly, and the sand they presently use from the dunes has already been washed by rain over the years.
2. They were concerned that the spoil could contaminate the existing dunes on site with excess salts.
3. Environmental problems could arise due to contamination of underground water as a result of wind blown dredge spoil.

Although they did not fully understand the implications of disposal along the northern beaches, PPC expressed the following concerns with this option:

1. The spoil may increase levels of airborne sand, resulting in groundwater contamination and also increase salt levels in the existing dunes.
2. Any modification to the beaches could prevent the development of the beaches for recreational purposes.

A further option of disposal on the eroded beaches and the nearshore zone off Paapenkuils Canal was initially met with a degree of optimism by various sectors of the City Engineer's Department, although there was concern expressed about the impact on sewerage disposal, stormwater outlets and siltation at Swartkops River mouth. Upon further consideration, this option was finally ruled out due to engineering difficulties expected to be associated with the outfall canal and the many outflow pipes entering into the nearshore region. In addition, analysis of borehole and vibrocore samples showed that the dredge spoil would comprise more than just clean sands, with a moderate amount of gravel being detected, and as such significant resistance to this option was expected from the public sector.

The remaining offshore site proposed by the dredging consultants, which is located along the 30 m depth contour directly off the Coega River mouth, appeared to be the most feasible option. However, a second site was needed for evaluation in the event that results from an assessment survey led to the rejection of the 30 m site. The alternative offshore disposal site was selected after a screening process and analysis of a sensitivity map of Algoa Bay. This procedure involved specialists who determined the extent to which various user groups and marine animals utilised the offshore waters in the Bay, and through a process of elimination arrived at the site location, which would provide the least interference for all user groups. The 30 m site was also evaluated in this way to determine that it too would not interfere with other interest or user groups. These users and their activities included Portnet and existing shipping lanes, popular commercial and recreational fishing grounds, marine mammal and bird feeding grounds and migration routes, marine bird nesting sites, fish and squid spawning grounds, recreational boating (sailing) and SCUBA diving sites. The proximity of the operation to the residential areas at Swartkops Estuary and Bluewater Bay was also considered from an aesthetic point of view.

The first site lies in 25 to 39 m of water and measures approximately 2.7 nautical miles (nm) at the longest axis and 0.9 nm at its widest axis, with the long axis parallel to the 30 m depth contour. The alternative site that was chosen lies in deeper water between 43 and 50 m, and like the first site has a northeast to southwest orientation along its long axis, and measures approximately 4.05 by 0.81 nm at its longest and widest axes. Both these sites⁸ are illustrated in Figure 4.6 in the Monitoring Guidelines chapter (Chapter 4).

5.3 SITE DESCRIPTION

General information pertinent to the physical description of the two offshore disposal sites has been included in the Monitoring Guidelines (see Chapter 4), and will not be re-addressed here. The following section provides a biological description of the two proposed sites based on information available for seabirds, sea mammals and fishes. This is followed by a brief summary of the rationale behind the survey that was undertaken to assess both sites. The results describing the macrofauna, bathymetry and topography, and sediments are presented. Based on the findings of the survey, a recommendation is made as to which of the offshore disposal sites is best suited for the disposal operation.

5.3.1 MARINE FISHES AND SQUID

There have not been many studies aimed at describing the offshore fish community in Algoa Bay, but much of what was referred to in Chapter 3 for the dredge sites will be applicable here. A combination of species caught by anglers off St Croix (Coetzee and Baird 1981) and those sampled by otter trawls during research cruises down to a depth of 40 m in the Bay (Wallace *et al.* 1984) would be found at either proposed disposal site. While there are a number of species which are of importance to the linefishery (trawling is not allowed within the confines of Algoa Bay), none are considered endangered or endemic to the Algoa Bay region. Based on these assumptions, there should be no pressing issues regarding impacts on fishes during the disposal operation. Algoa Bay supports approximately 2 300 participants in the commercially important squid fishery, the 4th largest fishery in South Africa. Squid are known to spawn all year round with peaks over the spring/summer period. There are 26 known spawning sites for the chokka squid in Algoa Bay, two of which lie within the confines of disposal site 1. This represents only 7.7% of present area utilised for spawning/egg laying, and as such should probably not be cause for concern, as it is likely that the animals will find alternative sites if needed.

5.3.2 MARINE AVIFAUNA

Seabirds are arguably the most conspicuous component of marine life off the Coega coast and on the islands, which have been identified as an Important Bird Area (IBA), as they are inhabited by threatened and endangered species. A third of all 91 seabird species recorded in southern African waters occur with some regularity in the area. Eight of the 14 South African resident seabird species breed here, either on islands or at the adjacent coast, and their numbers are well documented (Table 5.1).

⁸ Site 1 illustrated in Figure 4.6 is the preferred positioning for this site.

Table 5.1: Resident and/or breeding birds occurring off the coast of the Coega Mouth and around the St Croix group, with conservation status and latest estimates of population numbers around Coega and the Island Group.

Common name	Scientific name	Status	Population
African Penguin	<i>Spheniscus demersus</i>	Threatened	60 000
Cape Gannet	<i>Morus capensis</i>	Near-threatened	140 000
Cape Cormorant	<i>Phalacrocorax capensis</i>	Abundant	500
Whitebreasted Cormorant	<i>Phalacrocorax carbo</i>	Common	350
Kelp Gull	<i>Larus dominicanus</i>	Abundant	2000
Swift Tern	<i>Sterna bergii</i>	Common	600
Roseate Tern	<i>Sterna dougallii</i>	Endangered	420
Damara Tern	<i>Sterna balaenarum</i>	Threatened	30

The African Penguin, Cape Gannet, Kelp Gull and Cape Cormorant are the most numerous (97%) of the resident species at sea, whereas prions, shearwaters, Whitechinned Petrel, Common Terns and stormpetrels dominate the migrants in terms of numbers (87%). The structure of the seabird assemblage in Algoa Bay fluctuates substantially depending on season because of migration and dispersal. It is generally believed that the assemblage is richer in species and more numerous during winter because the Southern Ocean birds remain near their breeding sites during the austral summer.

Three broad foraging guilds are recognisable in the assemblage, based on where seabirds encounter their prey: inshore and benthic, epipelagic, or scavenged (including trawler offal). Members of the first guild are fewest in numbers and overall impact. Most seabirds in the area feed in the top metres of the water column, and largely on epipelagic fish. Anchovy and Pilchard are the most important prey species. Horse Mackerel, Saury and Redeye Herring play a lesser role. Many migrants, but also Cape Gannets, readily take offal provided by fishing boats. Zooplankton and micronekton are important prey constituents for the smaller species, such as prions, storm petrels and terns.

Among the resident seabird species, African Penguins and the two species of cormorants warrant special attention during dredging and dredge spoil disposal operations due to their mode of foraging and their conservation status. Although the Roseate Tern is also an endangered species, the Cape and Whitebreasted Cormorants and African Penguins rely entirely on eyesight for navigation and when diving for food. For these species, successful foraging requires a minimum of 2 metres horizontal visibility.

5.3.3 MARINE MAMMALS

The marine mammal fauna of South Africa comprises about 35 whale, dolphin and seal species. Ten species (Table 5.2) are relatively common in the area, albeit some only seasonally.

The two largest cetaceans are present in winter and spring only, when Southern Right whales give birth and nurse their young in shallow waters, and when Humpback Whales migrate through to their more tropical nursery areas. The productive waters of the Bay are used extensively as feeding areas by the smaller marine mammals. With the exception of Humpback Dolphins, who frequent inshore rocky reefs, these species are highly mobile. All dolphin species, but not the Fur Seal, rely heavily on echo-location to find and catch prey.

Table 5.2: List of marine mammals commonly found near the Coega Estuary and around the St Croix Island Group, with IUCN conservation status and order of magnitude of maximum numbers occurring in Algoa Bay.

Common name	Scientific name	Status	Abundance
Southern Right Whale	<i>Eubalaena australis</i>	Lower risk	10 ¹
Bryde's Whale	<i>Balaenoptera edeni</i>	Data deficient	1 ¹
Minke Whale	<i>Balaenoptera acutorostrata</i>	Lower risk	1 ¹
Humpback Whale	<i>Megaptera novaeangliae</i>	Vulnerable	10 ¹
Humpback Dolphin	<i>Sousa chinensis</i>	Threatened	10 ²
Common Dolphin	<i>Delphinus delphis</i>	Abundant	10 ³
Bottlenose Dolphin	<i>Tursiops truncatus</i>	Data deficient	10 ²
Striped Dolphin	<i>Stenella coeruleoalba</i>	Lower risk	10 ²
Risso's Dolphin	<i>Grampus griseus</i>	Data deficient	10 ¹
South African Fur Seal	<i>Arctocephalus pusillus</i>	Abundant	10 ³

Two broad foraging guilds are recognisable in the assemblage, based on where marine mammals pursue their prey: inshore and reefs, or epipelagic. As is the case with seabirds, Anchovy and Pilchard are the most important prey species for the open-water species of cetaceans, whereas a wide variety of reef fish (such as Seabream, Snappers and Mullet) form the common prey of the inshore feeders.

Among the marine mammal species, Humpback and Southern Right whales warrant special attention during dredging and dredge spoil disposal operations due to their large size, slow swimming speed and vulnerability of their newly-born calves. Dredging and disposal operations take place within the core home area of Bottlenosed and Humpback dolphins as well as Fur Seals. Both their abundance and their behavioural characteristics make interference with dredger operations likely.

5.3.4 RATIONALE BEHIND THE SURVEY OF PROPOSED DISPOSAL SITES

It is often assumed that the stratification of benthic habitats, classified using a combination of depth and bottom-type, can be useful in predicting patterns in macrofaunal community structure. Since there was no evidence to suggest that this link might not hold for the two offshore disposal sites, a sampling programme was designed with the aim of obtaining representative samples of the resident macrobenthic communities using a randomised stratified sampling design.

Unfortunately, because the benthic environment in the region of the proposed disposal sites has not been explicitly mapped, a two-phase sampling design was imperative. Of particular concern was the possible presence of significant areas of reef within the boundaries of the sites and the effect that this might have on estimates of macrofaunal abundance and diversity. The first phase of sampling was designed to address the physical description of the site, and to map the benthic topography within the proposed disposal sites and within a nominal "buffer zone" surrounding each site, both in terms of bottom type and water depth. The second phase intended to use this information to address the biological description of the sites by obtaining representative samples of the resident

macrobenthic community and of the sediment grades housing these fauna. A detailed description of the methods employed during both phases of the survey is contained in Appendix 3.

5.3.5 SURVEY RESULTS

Physical description

Depth and topography

Samples taken at Disposal Site 1 were situated in water depths of 25-39 m, and those taken at Disposal Site 2 were from depths ranging from 43-49 m depth (Appendix 5). Plots extrapolated from the depths recorded at the grab sites indicated that depths at each disposal site seem fairly uniform, without any prominent or high profile pinnacles (Figure 5.1). Echo-sounder traces from each site appeared to indicate a similar trend. In addition, no substantial expanse of reef was detected within either site, although one small patch of reef was detected at about 50 m depth in Disposal Site 2. This was too deep to confirm visually or sample with the SCUBA gear available at the time, and as such no data exists on possible community structure. At each of the prospective dive sites, where echo-traces showed no sign of reef-type profiles (Appendix 7), grab samples indicated the presence of muddy sand, as had been the case for most of the other samples.

Sediments

A total of 12 out of 48 sediment samples remain unsorted, but these should not affect the results (Dave Schoemann, Pers. Comm.), as those that were sorted were sufficient to show that the sediments were medium to fine sands (with the exception of DS 1/14, which was fairly coarse, having a median particle diameter of 432 μm), with high proportions of mud (up to 59%), especially in Dump Site 1. Sediments were moderately to well sorted and were generally coarse-skewed. Sub-sieve fractions ranged from 0.0 – 4.3% (Appendix 7), and there was a tendency toward increasing sediment size from south to north (see Figure A3.2, Appendix 3).

Biological description

Benthic invertebrates

The macrofauna at all grab sample sites were dominated by crustaceans, especially amphipods (Appendix 5). This was particularly true for Disposal Site 2, where large numbers of amphipods were frequently present. An interesting feature of these benthic samples was the presence of small numbers of phyllocarids, which are usually not well represented in the subtidal fauna around the South African coast (Branch *et al.* 1994). Other relatively common representatives of the macrobenthic community were cumaceans, isopods, bivalves, polychaetes, holothuroids and ophiroids, most of which are either deposit feeders or filter feeders (Appendix 5).

The average within-grab sample site coefficient of variation was estimated at 56% (range: 4-144%), which is quite acceptable (Appendix 6). Nevertheless, the 95% confidence intervals for the means frequently (51% of the time) included zero. This high degree of variability at small spatial scales justified our decision to select a simpler analytical design based on a single index of abundance and diversity per grab sample site.

Based on the selected indices of abundance and diversity, Disposal Site 2 had a significantly greater mean abundance of macrofauna than Disposal Site 1 (26.1 vs. 254.5 specimens per grab sample; $t = -11.13$; $DF = 39$; $p < 0.0001$), with a similar trend evident in terms of diversity (6.0 vs. 9.8 taxonomic groups per grab sample; $t = -8.55$; $DF = 39$; $p < 0.0001$). The mean abundance and diversity of the additional grab sites sampled southwest of Disposal Site 1 (Sites C1-C6) were intermediate between estimates from the two main Disposal Sites, but were more similar to those of Disposal Site 1 (Appendix 6).

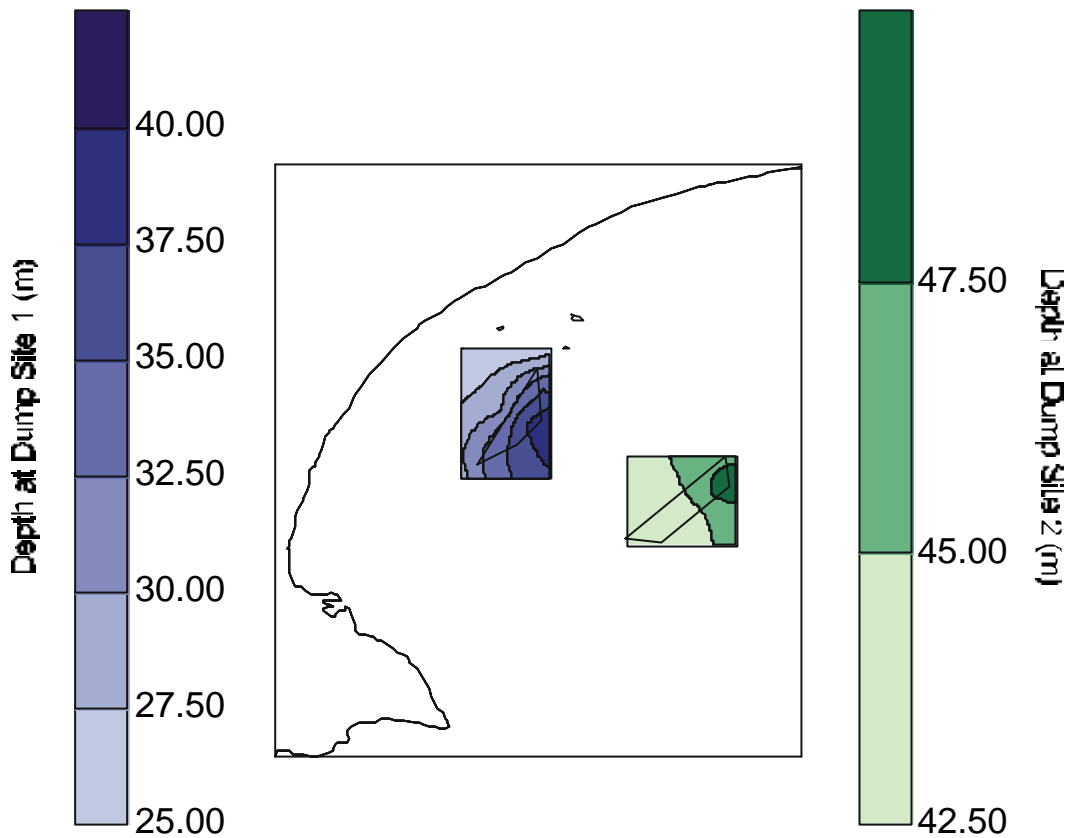


Figure 5.1: Depth contours as extrapolated from the grab sample sites.

Other visible trends in the data were a tendency toward higher abundance and diversity with increased depth and also, apparently, with proximity to the St Croix Island Group (Figures 5.1, 5.2 and 5.3). Also evident from these latter plots is a clear indication of the spatial variability in the indices of abundance and diversity, with extreme concentrations of organisms in very specific areas. The data do not allow identification of factors driving these aggregations, but this type of patchy distribution does have implications for any future sampling programmes that might be conducted. It will be imperative to stratify the area by depth before any sampling takes place.

Multivariate analysis confirmed results suggested by their univariate counterparts (Figure 5.4). Samples from Disposal Site 1 clustered together with each other and also with the additional samples taken southwest of Disposal Site 1 (samples C1-C6). The only exceptions were sites DS 1/11 and DS 1/14, which clustered with samples from Disposal Site 2, although they were separated from this latter group at a similarity level of about 72% (Figure 5.4). These differences seemed to be driven by estimated macrofaunal abundance and diversity.

Although samples were drawn not only from within the proposed Disposal Sites, but also from a nominal buffer zone, it will be assumed here that all samples are representative of the Disposal Sites. This is probably an accurate scenario, as dredge spoil would be expected to drift in the currents and also shift along the bottom (resuspension – see Chapter 4). A rough estimate of likely overall mortality (assuming that all organisms in the disposal sites will die) for each site is presented, based on the estimates of macrofaunal abundance and site area (Table 5.3). While these figures may appear high, the area concerned here comprises a very small percentage of the total Bay, and as such is in fact a small contribution to overall abundance.

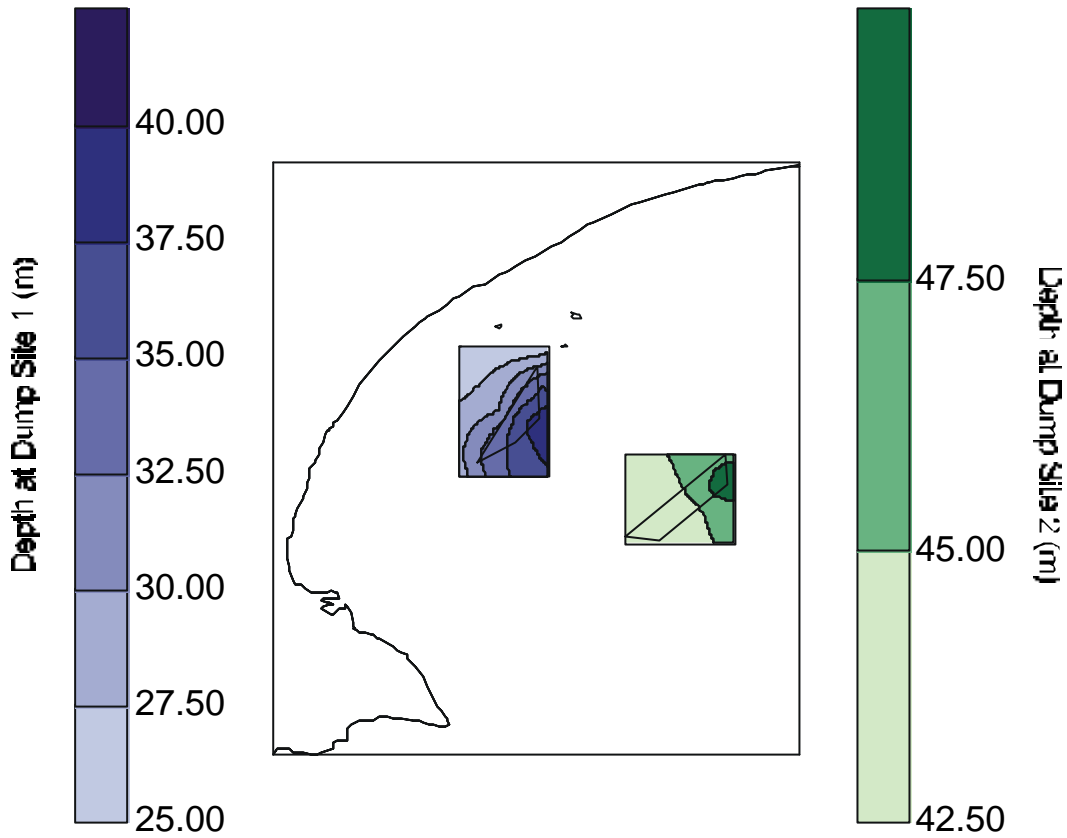


Figure 5.2: Contours in estimates of macrofaunal abundance (maximum number of specimens per grab).

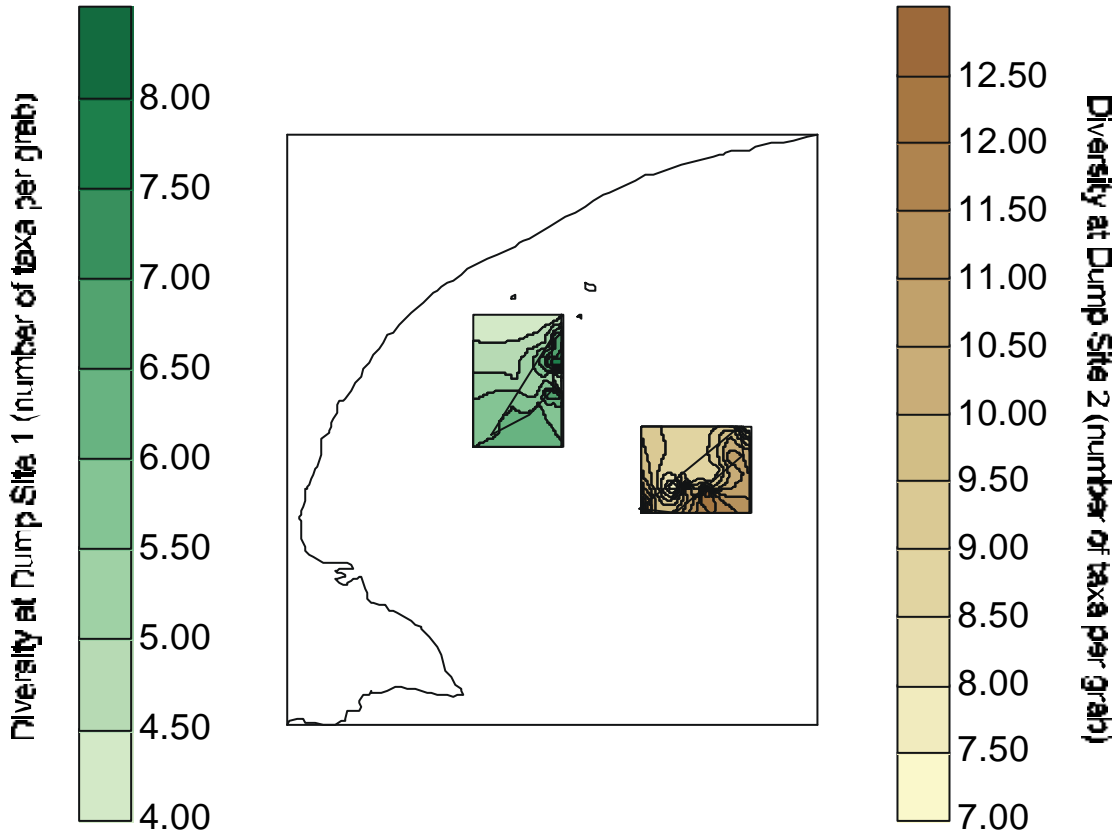


Figure 5.3 Contours in estimates of macrofaunal diversity (maximum number of taxonomic groups per grab).

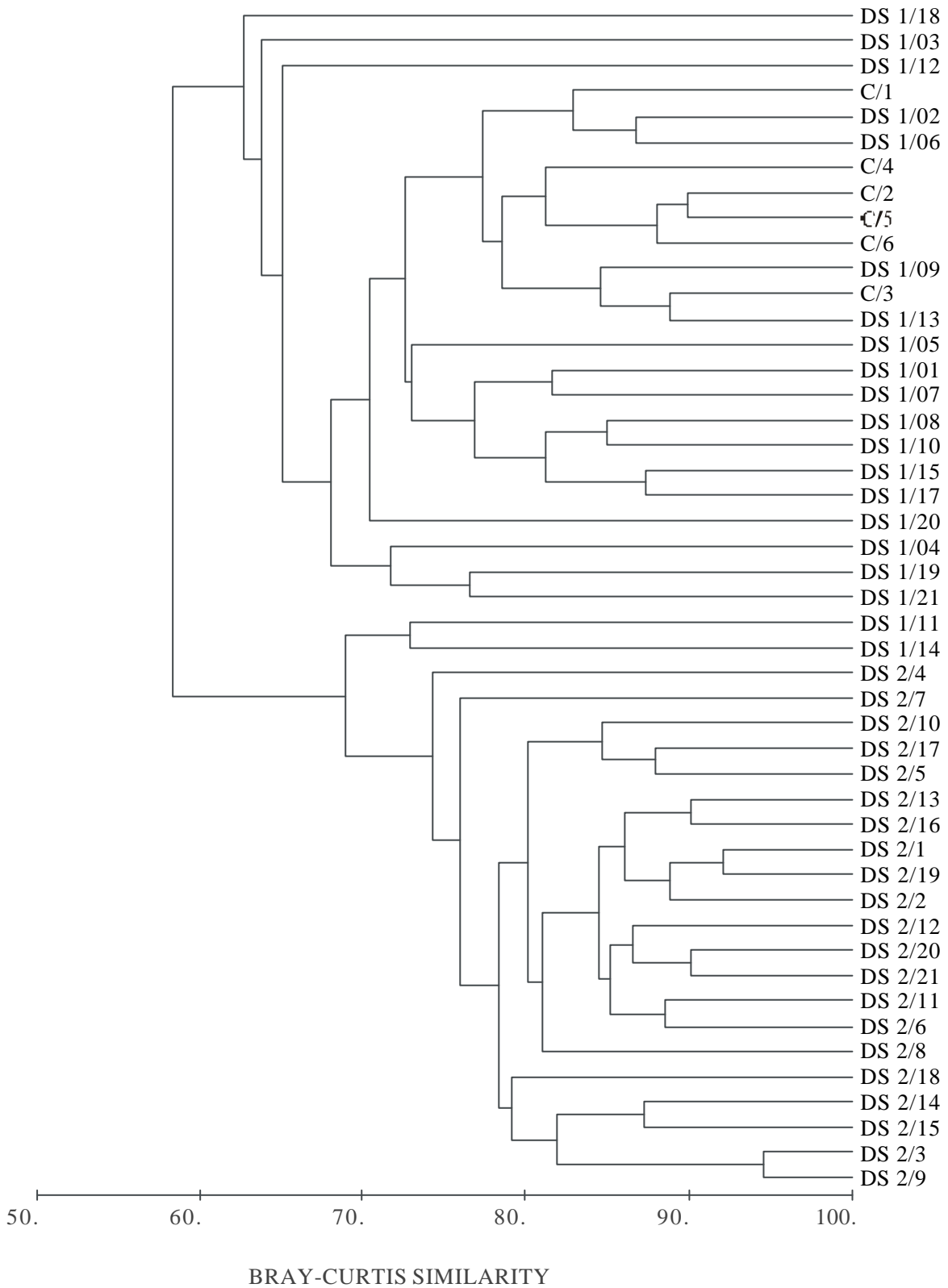


Figure 5.4: Dendrogram relating grab sample sites according to rough taxonomic groupings.

Irrespective of whether or not organisms in the buffer zones are impacted, Disposal Site 1 is preferable to Disposal Site 2. This is also reflected in the organisms of greatest scientific interest, the phyllocarids, which are more abundant at Disposal Site 2 than Disposal Site 1. Phyllocarids are shallow-water suspension feeders, and are believed to represent the most primitive of the Malacostracans, the largest class of the Crustacea.

5.3.6 DISCUSSION AND RECOMMENDATION

There are a few important facts which have been uncovered by the survey, namely:

1. There are no substantial expanses of reef at either proposed disposal site.
2. Abundance of organisms at Disposal Site 2 is an order of magnitude larger than that at Disposal Site 1, with diversity reflecting similar trends.
3. Abundance and diversity increase with depth and proximity to the islands.
4. The tentative identification of at least one species of the crustacean order Phyllocaridae. The only known example of this group in South African waters is *Nebalia capensis*, which is a detritus-feeder conventionally found under loose stones on rocky and mixed shores (Branch *et al.* 1994). A new species of this primitive group is considered to be of great scientific importance.
5. Coarse sediments, such as the ones located in the northern sector of disposal site 1 (Appendix 7), should be avoided, as they take longer to recover from disturbance (see Table 3.4 in Chapter 3 – Dredging Impacts).

The above data, in particular the abundance and diversity issue, in conjunction with the shorter travelling distance and thus lower possible collision probabilities with whales, supports the use of Disposal Site 1. Furthermore it is recommended that Disposal Site 1 be moved 1 nm southwest of its present position and that the shape be slightly modified to move the one corner of the trapezium away from Brenton Island⁹. This change will effectively avoid the coarse sediment around the northeast corner, which is closest to Brenton Island, as well as increasing the distance of the disposal operation from Brenton Island which is viewed as a sensitive area.

For a synopsis of the procedure, based on the Dredged Material Assessment Framework, that was used in determining the site for dredge spoil disposal, see Figure 5.5.

Table 5.3: Estimates of macrofaunal mortality at the proposed disposal sites.

Prospective Disposal Site	Area (km ²)	Macrofaunal abundance (m ⁻²)	Projected mortality (billion macrofaunal specimens ± 95% CI)
Disposal Site 1	6.5	465.2	3.02 (2.29 – 3.76)
Buffer Zone 1	8.8	465.2	4.09 (3.10 – 5.08)
Disposal Site 2	9.1	4526.4	41.19 (34.50 – 47.88)
Buffer Zone 2	7.1	4526.4	32.14 (26.92 – 37.36)

⁹ The exact co-ordinates for site 1, which are outlined in Chapter 4, are the recommended co-ordinates for site 1, and not the original co-ordinates received from Entech Consultants.

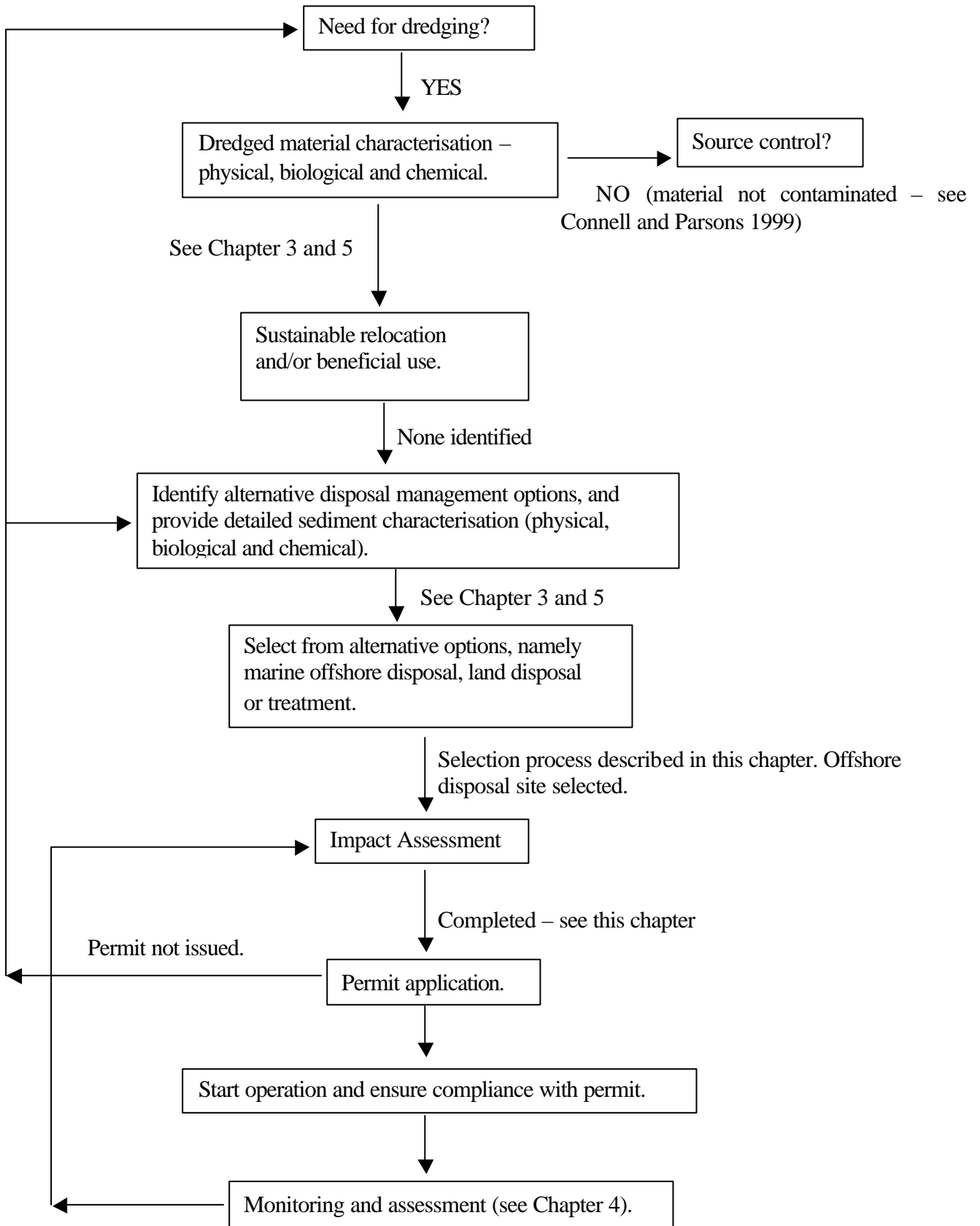


Figure 5.5: Dredging Material Assessment Framework for the Coega Port operation.

5.4 THE ENVIRONMENTAL IMPACTS OF MARINE DISPOSAL OF DREDGE SPOIL

5.4.1 SMOTHERING OF BENTHIC MARINE ORGANISMS

As indicated in Chapter 3 (Dredging Impacts), shallow sample stations in Algoa Bay tended to have fewer species compared to deep sites, a scenario that appears typical of similar studies done elsewhere (Malan 1991). Suspension feeders also dominated shallow stations; predators and scavengers were common further offshore and at deepest sites deposit feeders dominated. These deeper sites therefore reflect calmer conditions where fine food particles are able to settle out. A similar trend is also apparent for sediment particle size along other depth gradients – for example at Lamberts Bay where increasing species richness in an offshore direction correlated with increasing clay content (Christie 1976, quoted in Malan 1991). A similar broad pattern is apparent for the benthic community at the two disposal sites at Coega (located at 30 and 40 m average depth respectively). The shallower disposal site had a lower diversity compared to the deeper locality, while the deeper site also had a greater number of taxa per grab. Consequently, the observed levels of similarity depicted in the dendrogram (Figure 5.4) are more readily explicable.

Recovery at dumpsites is linked to the granulometric properties of the sediments (e.g. particle size) and the different communities associated with them. The recovering community usually goes through a series of successional stages following cessation of activities. This allows some predictions on the likely recovery of benthic communities (Newell *et al.* 1998). The rate of colonisation by the fauna is determined by the persistence of organisms in undredged areas, immigration of mobile taxa, larval supply and post-settlement processes. Vertical migration of benthic organisms through the new substrate is also an important recovery mechanism. The first organisms to recolonise dredged material usually are not the same as those that originally occupied the site; they consist of opportunistic species whose environmental requirements are flexible enough to allow them to occupy the disturbed areas. In general, rapid rates of initial recolonisation are reported for some coastal deposits, where organisms are mainly mobile ‘opportunistic’ species that have a rapid rate of reproduction and growth.

The impact of disposal activities can also influence areas outside the immediate boundaries of disposal areas, affecting communities differentially. This can be brought about by lateral transport of some of the material by various means – spillage, current transport etc. Filter feeding species appear to be more sensitive than deposit feeders, and larval forms being more sensitive than adults. Many of the species are able to burrow back to the surface following burial. Some benthic species can migrate through 30 cm of deposited sediment, while Kukert (1991, quoted in Newell *et al.* 1998) found that approximately 50% of the macrofauna were able to burrow back to the surface through 4-10 cm of rapidly deposited sediment. In general, however, most recent studies of filter feeders that live in coastal waters show that they are highly adaptable in their response to increased turbidity such as can be induced by storms, dredging or sediment disposal, and can maintain their feeding activity over a wide range of phytoplankton concentrations and inorganic particulate loads (numerous authors quoted in Newell *et al.* 1998).

A typical recovery phase at a disposal site follows the same sequence as depicted for a dredged area. Namely, it is characterised by an initial colonizing community of opportunists (relatively few species, but densities may be high), followed by a transitional community before the equilibrium component becomes established (Newell *et al.* 1998). During this process, species number increases to a maximum during the transitional phase. Although permanent changes to the infaunal benthic community at the disposal site is possible, the apparent similarity of dredged sediments compared to the sedimentary regime at the disposal site (sand dominated) would suggest that the community

should ultimately not differ substantially from the community presently there. However, response to some parameters is very difficult to predict, e.g. biotic responses to sediment compactness (temporal and spatial) over time and species interactions.

In monitoring studies conducted on the impacts of dredged material disposal in Galveston Bay, Texas, secondary production was not obviously affected in the longer term (approximately 4-5 years). Two years after placement of the dredged material, macroinvertebrate species richness and total benthic production was highest at the disposal sites while the densities of bivalves increased substantially 1 year after disposal (Wilber and Clarke 1998). In a study undertaken on fine material dredged from a South Carolina estuary (Van Dolah *et al.* 1984), the detrimental effects were considered minimal. The differences recorded were in part due to sampling and natural variability over time. By contrast, long term ongoing deposition of material (13 years) in Liverpool Bay, UK, resulted in a marked change in macrofauna community structure in the vicinity of the disposal site (Somerfield *et al.* 1995). However, the disposal site is shallow (10 m) and exposed to wave action and strong tidal currents up to 0.8 m sec^{-1} .

Rates of recovery reported in the literature suggest that a recovery time of <1 year is very typical of fine muds (e.g. in estuarine environments), but communities in sand and gravels may take 2-4 years to establish, depending on the proportion of sand and the level of environmental disturbance, e.g. waves and currents. As deposits become coarser along a gradient of environmental stability, estimates of up to 10 years recovery time is possible (see Table 3.4; Newell *et al.* 1998). Recent information has also indicated that recovery is not controlled by any one, or a combination of, simple granulometric properties of the sediments, but that complex interactions between sets of chemical and biological factors also play a role. Such interactions are not easily measured.

5.4.2 EFFECTS ON SEABIRDS AND MAMMALS

Five effects on seabirds and marine mammals were identified. The offshore disposal of dredge spoil excavated from the approach channel and basin of the proposed harbour at Coega may:

1. Disturb food chain functioning by depressing primary production through increased turbidity.
2. Displace marine mammals and seabirds from feeding grounds through increased turbidity.
3. Displace marine mammals from their traditional nursery areas.
4. Smother and obstruct their feeding grounds.
5. Frighten marine mammals and seabirds through noise and light pollution.

Although these are five distinct effects¹⁰, they can be grouped into three key impacts *viz.* the effects from an increase of turbidity, the smothering effects of the dumped material and the effects of the operation of the dredger *per se*.

5.4.3 MARINE ARCHAEOLOGY

According to the Revised Coega Port EIA (CEN 2000), a survey of the area to be dredged in the Coega region was undertaken by a Marine Archaeologist. Sonar scans of the dredge area were used to determine if any shipwrecks were present in the area. The archaeologist confirmed that it was unlikely that any ships were present in the area to be dredged. Based on the survey undertaken, it is concluded that the probability of any shipwrecks being disturbed by the proposed dredging are low and no significant impacts are predicted. This survey did not incorporate any areas offshore or the location of the proposed disposal site.

¹⁰ It must be noted that the area affected is very small when compared to the Bay and the adjacent nearshore zone.

It would appear that the report mentioned above was founded on an opinion, and further work may be required to meet the standards required by the South African Heritage Resources Agency (SAHRA). The CDC has taken it upon itself to address this matter further.

5.4.4 ISSUES, IMPACTS AND MITIGATION¹¹

Impacts were evaluated according to standardised criteria defined by CES guidelines (Appendix 8), and are discussed below and summarised in Table 5.4.

ISSUE 1: EFFECT OF DEPOSITION OF DREDGE SPOIL AT THE OFFSHORE DISPOSAL SITES ON BENTHIC MARINE ORGANISMS

Impact 1: Smothering of benthic marine organisms

Cause and comment: Deposition of dredged material will smother organisms at the dump site. Available information suggests that the bottom topography along the 30 m depth contour at the proposed site is relatively uniform, consisting of sand and finer material. The benthic community described by Malan (1991), was dominated by worms, small crustaceans and molluscs at the deepest sites (15 and 20 metres). A similar assemblage was described for the inshore areas to be dredged (see Chapter 3), and based on the findings of the survey described above, a similar community can be found in the deeper waters of the proposed disposal sites. Although permanent changes to the infaunal benthic community at the disposal site is possible, the apparent similarity of dredged sediments compared to the sedimentary regime at the disposal site (sand dominated) would suggest that the community should ultimately not differ substantially from the community presently there. However, response to some parameters is very difficult to predict, e.g. biotic responses to sediment compactness (temporal and spatial) over time and species interactions. The process of recovery is predicted to take up to 2-4 years, with initial colonisation characterised by more motile species. During the process of recovery, activities of the infauna (e.g. creation of burrows) can modify the benthic environment.

Significance statement: Smothering of the benthic community in the proposed disposal areas will definitely occur. This impact will **probably** be *severe* over the short term and within a *localised* area. Considering a rough estimate of $1.442 \times 10^9 \text{ m}^2$ as the surface area of Algoa Bay, the disposal site occupies roughly $1.397 \times 10^7 \text{ m}^2$ or 0.97% of the Bay's surface area, and as such this impact will be of LOW overall significance.

ISSUE 2: THE EFFECT OF INCREASED LEVELS OF TURBIDITY ON ECOSYSTEM FUNCTIONING

Cause and comment: Disposal of dredge spoil will lead to an increase of the amount of suspended particles in the water column, not only in the vicinity of the dredger but also beyond, perhaps in the immediate vicinity of Brenton Island. Depending on the characteristics of the dumped sediment and on the prevailing current and wave action, plumes of cloudy water may persist for time scales long enough (hours to days) that the ability of the visual hunters, e.g. African Penguin and cormorants, to forage successfully is impaired. The lowering of light levels in the water column through an increase in turbidity will also retard photosynthesis of planktonic algae. Prevailing water circulation patterns presently sustain large accumulations of phytoplankton that support a rich and productive foodweb. The area adjacent to Coega and the islands of the St Croix Group is highly productive and an important nursery area for juvenile fish. Many of these species are directly or indirectly

¹¹ The impacts below assume that Disposal Site 1, the preferred site, will be selected.

dependent on the plankton as a source of food. This in turn affects the higher order predators (seabirds and marine mammals) as the depression of primary production reverberates through the food chain. The disposal of dredge spoil is likely to amplify this negative effect. The decrease in visibility is likely to exclude calving and nursing Southern Right whales from the disposal area because it precludes mothers from maintaining visual contact with their calves and defending them against attacks from large sharks or Killer Whales. These whales will thus lose a part of their traditional nursery area.

Impact 1: The effect of increased turbidity levels on primary production

Significance statement: Increased SS levels will **possibly** have a *moderate* negative impact on *localised* (disposal site) primary production over the short term. This will have the effect of a chain reaction with regards to the foodweb, but based on the small area of the site in relation to the remainder of Algoa Bay, any impact can be considered to be of LOW significance.

Impact 2: The effect of increased turbidity levels on the fish community

Significance statement: It is **possible** that aspects such as breeding, hatching rates, larval survival, feeding and escape responses may be affected by the turbidity levels. The absence of rare or endangered endemic fish species in the vicinity of the disposal site, means that impacts that may occur would be *moderate*, *localised*, short term and of LOW significance.

Impact 3: The effect of increased turbidity levels on the marine avifauna

Significance statement: Increased turbidity levels will **probably** affect feeding in birds such as cormorants and penguins. This impact will be *moderate*, *localised* and short term. For most species, which are highly mobile and capable of finding alternative feeding sites, the impact would be of LOW significance. The only possible exception to this may be the endangered African Penguin, which may not be as quick to find alternative sites. Due to its conservation status, any possible impact, no matter how slight, should be regarded as being of MODERATE significance.

Impact 4: The effect of increased turbidity on marine mammals

Significance statement: It is **possible** that the exclusion of some marine mammals species from the disposal area and waters around Brenton Island due to the risk of increased predation upon themselves or their young may occur. This impact would be *moderate*, short term, *localised* and, due to the small area of concern, of LOW significance. It is possible that if they are not excluded from the sites, that some may suffer increased mortality due to predation. Based on the abundance estimates and IUCN conservation status levels, this impact would also be *moderate*, short term, *localised* and of LOW significance.

Mitigation and management: There are no practical mitigating measures which could be implemented to reduce turbidity levels at the disposal site. Bottom dumping is a sudden occurrence in which an entire sediment load is released over a very short period. The above impacts have been assessed based on the assumption that the disposal operation will be confined to the disposal site and that the monitoring guidelines associated with Brenton Island (see Chapter 4) will be adhered to thus protecting this sensitive environment.

ISSUE 3: THE EFFECT OF SMOTHERING ON THE FOOD SOURCE OF SEABIRDS AND MAMMALS

Impact 1: Smothering of important food organisms by dredge spoil

Cause and comment: A small portion of the spawning and feeding grounds for a variety of fish and mollusc species, which are important components in the diets of cormorants, Fur Seals and Bottlenose Dolphins, will be smothered by dredge spoil and will thus be destroyed.

Significance statement: Although it is **probable** that these food organisms will definitely be displaced or destroyed as a result of habitat destruction, the site of operation is small and relative to the rest of the Bay the impact can be regarded as *slight*, short term, *localised* and of LOW significance. However, the actual destruction of the habitat and subsequent loss of important food organisms over the entire disposal site should be regarded as *severe*.

ISSUE 4: THE EFFECT OF DREDGER NOISE AND LIGHTS ON SEABIRDS AND MAMMALS

Cause and comment: Loss of relatively undisturbed nearshore habitat for feeding, resting, nursing and social interaction for a variety of seabirds and marine mammals is an inevitable consequence of the construction of the harbour at Coega. The activity of the TSHD moving to the disposal site and back will present a permanent source of disturbance, due to ship noise at all times and its lights at night. This disturbance at the offshore site will be felt the greatest by Southern Right whales, Cape Fur Seals, Bottlenosed Dolphins, cormorants and African Penguins. However, the continued presence of various whale, seal and seabird species in some areas of Algoa Bay presently supporting heavy ship traffic, indicates a degree of tolerance to ship noise and lights.

Impact 1: The effect of dredger noise on seabirds

Significance statement: The noise factor emanating from the TSHD moving out to the disposal site should be minimal, as they tend to operate relatively quietly (Entech Consultants, Pers. Comm.). In addition, the passage of the dredger does not pass too close to any of the islands, and time spent at the disposal site is a matter of minutes, so exposure to noise will be minimal. It is **possible** that *slight*, short term impacts may occur within the *dredge area*, with a few birds being disturbed while feeding. The small numbers of birds expected to be affected makes this impact one of LOW significance.

Impact 2: The effect of lights on island avifauna

Significance statement: It is **possible** that seabirds in the vicinity of the ship's path, at the disposal site or on Brenton Island, may be *slightly* affected within the *localised* area over the short term if dredger lights are too bright. Once again, the fast turn around time means that the effect of the lights will not be felt in one place for any length of time, and as such the few birds that may be disturbed can be considered to be of LOW significance.

Mitigation and management: Mitigatory measures such as shielded lights or deflectors will decrease the area of illumination around the dredger and ensure that Brenton Island is not directly illuminated. This should ensure that it is **probable** that only a *slight* negative impact of LOW significance may occur over the short term and within a *localised* area. As little can be done in the medium term to improve the conditions for survival of some of the island avifauna (e.g. African Penguins and Roseate Terns) away from their breeding grounds, the protection of roosts and nesting

areas within the St Croix Island Group from disturbance is vital. No dredgers must violate the protected waters (currently 500 m) surrounding Brenton Island during disposal operations.

Impact 3: The effect of lights on other marine bird species

Significance statement: Although albatross and petrel species, which are attracted to lights aboard ships, flock to Algoa Bay during the winter months, they retreat to the outer limits of the Bay at night. As such it is **unlikely** that the lights used on board the TSHD should cause any mortality. As such, it is unsure if any impact would occur. In the event that this does arise, it would probably be *slight, short term, localised* and of LOW significance.

Impact 4: The effect of ship noise and lights on marine mammals

Significance statement: While it is **probable** that certain marine mammals may be attracted towards the dredger lights and noises associated with the disposal operation, it is unlikely that there will be negative impacts in terms of collisions. A relatively slow cruising speed of the TSHD combined with whale lookouts on board and the escape responses of dolphins and seals, it is unlikely that maiming or mortalities will occur. However, the possibility still exists that a few chance encounters may occur, and these could be considered to be *slight, short term, localised* and of LOW significance, but if a few involve the more threatened species (e.g Humpback Whales), it could be of MODERATE to HIGH significance.

Mitigation and management: Moving Disposal Site 1 one nautical mile to the southwest will mitigate against disturbance to birds and mammals in the close proximity of Brenton Island. Avoidance reactions by marine mammals and diving seabirds to cavitation noise from ship propellers (the main source of underwater noise) are not always effective in preventing collisions with vessels. The risk of collision with ships is particularly high for the large whales (e.g. Southern Right whales) when accompanied by calves. The provision of lookouts, and a speed limit and adherence to the Sea Fishery Act 1988 pertaining to whales should reduce the chances of any collisions further and ensure that, while they may possibly still occur, the impacts will be *slight, localised, short term* and all of LOW significance.

ISSUE 5: THE EFFECT OF OFFSHORE DISPOSAL ON SQUID, FISH AND COMMERCIAL AND RECREATIONAL FISHING ACTIVITIES

Cause and comment: More than 70 species of bony fish, sharks, skates and rays have been recorded in Algoa Bay (Romer 1986). The recommended dump site will have a number of species associated with soft sediment, including teleosts and skates and rays. The area is known to be a nursery site for Silver Kob, although the dump site area only covers a small fraction of the available nursery area. The site is not extensively used by either recreational or commercial fishermen. Two areas within the site have been identified as active spawning grounds for squid (Sauer and Booth 1997). Disposal will influence the activity of the species regularly found in the area and will impact on the activities of squid vessels, although the site occupies less than 5% of the area regularly fished.

Impact 1: The effect of disposal on squid and fish in the area of operation

Significance statement: Bony fish, sharks, skates and rays (adults, juveniles and larvae) will be in the immediate vicinity of the disposal operations, and may well be attracted to the disturbance area in search of food. It is **possible** that a small percentage of these may suffer mortality from the released sediment. Furthermore it is **probable** that two of the 26 known spawning sites for squid in Algoa Bay may be affected. Given the size of the disposal site and the absence of rare and endangered fish species, any impact would be *slight, localised* and of LOW significance.

Impact 2: The effect of disposal on fishing activities in the area of operation

Significance statement: Virtually no recreational fishing activity takes place in or around the proposed disposal site, and commercial activity is limited mainly to the squid fishery. As such it is unlikely that any impact will occur. Once again, given the size of the disposal site and the absence of rare and endangered fish species, it is **probable** that any impact would be *slight, localised* and of LOW significance.

ISSUE 6: THE EFFECT OF OFFSHORE DISPOSAL ON RECREATIONAL BOATING (SAILING)

Cause and comment: The Port Elizabeth Yacht Club (PEYC) hosts two regattas a year, which incorporate daytime racing in the vicinity of the St Croix Island Group. Both Brenton and St Croix are included in the race course. A further race includes all three islands in the group and is a day/night event, although it is not strictly an annual event. There is a risk that the disposal operation could interfere with the running of these races.

Impact 1: Collisions between dredgers and yachts in the vicinity of the St Croix Island Group

Significance statement: It is **possible** that chance encounters between the TSHD and yachts may occur, especially while the TSHD is underway to the disposal site at night. A collision of any kind, while unlikely, would have to be regarded as *very severe* and of VERY HIGH significance. The impacts would be short term and *localised*.

Mitigation and management: Communication and co-ordination between the dredging contractor and the PEYC should prevent the occurrence of any collisions. Correct timing can ensure that the TSHD is nowhere near the race area for those few times during the year. As such it would be **definite** that any collisions would be very unlikely, and hence there would be no impact or *no effect*.

ISSUE 7: DESTRUCTION OF PHYSICAL ENVIRONMENT

Impact 1: Change in bathymetry at the disposal site

Cause and comment: The disposal of such large quantities of dredge spoil over the disposal site will result in a change in bottom topography or bathymetry at the site.

Significance statement: It is **definite** that a permanent change will occur, and the impact will be *very severe* and *localised*, but as a result of the small area will be of LOW significance.

ISSUE 8: AESTHETICS

Impact 1: The visual impact of the disposal operation

Cause and comment: There may be concern about the visual impact of a dredger moving to and from the disposal site and the resulting turbidity plume.

Significance statement: Algoa Bay already services a high load of ship traffic. It is unlikely that a single dredger is going to make much of an impression. In addition, the bottom disposal method used by the TSHD should reduce the visible turbidity plume except in extreme weather, when wave action could stir it upwards to the surface. It is **possible** that a turbidity plume will be visible, which

may represent a *moderately severe, localised* impact over the short term. The overall significance of this impact is LOW but may be MODERATE to some people, as visual aesthetic values vary greatly from person to person.

Table 5.4: Summary of issues and impacts, before and after mitigation, resulting from the disposal operation.

ISSUE/IMPACT	WITHOUT MITIGATION						WITH MITIGATION	
	RISK	TEMPORAL	SPATIAL	CERTAINTY	SEVERITY	SIGNIFICANCE	SEVERITY	SIGNIFICANCE
Issue 1: Effect of deposition of dredge spoil at the offshore disposal sites on benthic marine organisms								
Impact 1: Smothering of benthic marine organisms (all possible organisms)	Definite	Short term	Localised	Probable	Severe	Low	*	*
Issue 2: The effect of increased levels of turbidity on ecosystem functioning								
Impact 1: The effect of increased turbidity levels on primary production	Definite	Short term	Localised	Possible	Moderate	Low	*	*
Impact 2: The effect of increased turbidity levels on the fish community	May occur	Short term	Localised	Possible	Moderate	Low	*	*
Impact 3: The effect of increased turbidity levels on marine avifauna	May occur	Short term	Localised	Possible	Moderate	Moderate (Penguins); Low (Otghers)	*	*
Impact 4: The effect of increased turbidity levels on marine mammals	May occur	Short term	Localised	Possible	Moderate	Low	*	*
Issue 3: The effect of smothering on the food source of seabirds and mammals								
Impact 1: Smothering of important food organisms by dredge spoil	Definite	Short term	Localised	Probable	Slight	Low	*	*
Issue 4: The effect of dredger noise and lights on seabirds and mammals								
Impact 1: The effect of dredger noise on seabirds	May occur	Short term	Dredge area	Possible	Slight	Low	*	*
Impact 2: The effect of lights on island avifauna	May occur	Short term	Localised	Possible	Slight	Low	Slight	Low
Impact 3: The effect of lights on other marine bird species	Unlikely	Short term	Localised	Probable	Slight	Low	*	*
Impact 4: The effect of ship noise and lights on marine mammals	May occur	Short term	Localised	Possible	Slight	Moderate to High (all threatened species) Low (other species)	Slight	Low
Issue 5: The effect of offshore disposal on squid, fish and commercial and recreational fishing activities								
Impact 1: The effect of disposal on squid and fish in the area of operation	May occur	Short term	Localised	Possible (fish) Probable (squid)	Slight	Low	*	*

Table 5.4 continued

ISSUE/IMPACT	WITHOUT MITIGATION						WITH MITIGATION	
	RISK	TEMPORAL	SPATIAL	CERTAINTY	SEVERITY	SIGNIFICANCE	SEVERITY	SIGNIFICANCE
Impact 2: The effect of disposal on fishing activities in the area of operation	Unlikely	Short term	Localised	Probable	Slight	Low	*	*
Issue 6: The effect of offshore disposal on recreational boating (sailing)								
Impact 1: Collisions between dredgers and yachts in the vicinity of the St Croix Island Group	May Occur	Short term	Localised	Possible	Very severe	Very high	No effect	No significance
Issue 7: Destruction of the physical environment								
Impact 1: Change in bathymetry at the disposal site	Definite	Permanent	Localised	Definite	Very severe	Low	*	*
Issue 8: Aesthetics								
Impact 1: The visual impact of the disposal operation	May Occur	Short term	Disposal site and surrounds	Possible	Moderately Severe	Low – Moderate	*	*

*Limited Mitigation is available.

CHAPTER 6: CONCLUSIONS

6.1 LAND EXCAVATION

The Neptune Valley site and the salt works were identified as being unsuitable for disposal of land excavated material. Both provide habitats for unique or endangered fauna and flora, although it is recognised that the salt works will be lost in future port related developments. The Tank Farm was deemed to be partly unsuitable due to the presence of Mesic Succulent Thicket and Bontveld, which is particularly threatened and requires full protection. Four sites were seen as being suitable for use as disposal sites, namely the Eastern Headland, Eastern Beach, Back of Breakwater and Back of Quay Walls. Of these, only the Eastern Headland site requires that certain mitigatory measures be fulfilled to protect sensitive vegetation and nearby archaeological sites, and to ensure rehabilitation through colonisation.

The impacts associated with the land excavation and disposal operation were seen to be problematic for the most part. However, with mitigation, the severity of most of these impacts can be drastically reduced. The impact on air quality due to particulate emissions was seen as the most severe impact, but correct management would see this threat reduced to one of only moderate importance. Loss of habitat, threats to sensitive species and archaeological sites were also seen as severe impacts of high significance, but the recommended mitigating measures would ensure only moderate to slight effects of low to moderate significance. After mitigation, all other identified issues and impacts were classed as being slight and of low or no significance.

The following general recommendations were made, over and above those incorporated in the mitigation statements, for each issue and its associated impacts.

1. No dredge material should be disposed onshore, i.e. above the existing onshore highwater mark. Disposal of such material can occur at Site 6, the Back of Breakwater, which is a reclaimed site currently below the highwater mark.
2. No excavated or dredge material should be deposited outside of the area assessed in the Subsequent EIA, i.e. the Core Coega Development Area, without an additional EIA. Potential impacts in these areas have not been considered in this report.

6.2 MARINE DREDGING

The effect of lights and noise, including blasting, associated with the dredging operation were seen to pose a slight threat to marine and island avifauna, but due to the conservation status of a few of the species (African Penguin and Roseate Tern), this was seen to be of moderate to high significance. Mitigation would reduce the significance of these impacts to low to moderate. It was anticipated that high turbidity levels would have severe impacts on various aspects of ecosystem functioning, especially in the proximity of Jahleel Island. However, mitigation which includes compliance with the monitoring guidelines should ensure that any risks are reduced. A severe impact is anticipated with regards to blasting and sea mammals, and this was seen as being highly significant but not unavoidable, as mitigation should significantly reduce the occurrence of any impacts. African penguins could also be severely affected by blasting, but the high level of significance associated with this would be reduced to moderate if correctly managed. The two final areas of concern were related to the introduction of exotic species and the destruction of the physical environment. The impact of alien species has the potential to be very severe, and any consequences would be regarded as being of very high significance. Fortunately, if mitigating measures are utilised, the chance of introductions can be reduced. A direct consequence of dredging

is the destruction of the physical environment. This impact is seen as very severe, but of low significance due to the small area in question, and there are no mitigating measures.

6.3 MONITORING GUIDELINES

The assessment of available information on seabed sediment structures, prevalent currents and the proposed dredging scenario indicate that for the most part the dredging plume should settle out within the predefined mixing zone described in Chapter 4. Problems are only likely to arise during the dredging of silt and possibly clays if they are unconsolidated, which may not settle quickly enough within the mixing zone: this will depend in large measure on the currents and waves present at the time. Available information shows that silt constitutes generally less than 20% of the sediment to be dredged, and under unsuitable current regimes, the dredgers could change their position to more suitable sediments.

Some differences are expected in dredging the approach channel and the harbour basin, with the approach channel being completed before the construction of the breakwaters has a major effect on ambient currents. Dredging within the harbour will be much more confined, with slower ocean currents. However, ebb tidal flows, particularly at spring tides, could discharge this sediment into the open ocean although no significant deleterious impacts are expected outside of the mixing zone.

Reference sites will be used to measure daily ambient SS levels, which will be taken as the minimum value along a depth profile at each site. The daily SS levels at the monitoring sites will be taken as the maximum value along a depth profile at each site.

An absolute limit of 150 mg/l above ambient has been set as the maximum turbidity level allowed at the monitoring sites along the edge of the mixing zone. An intermediate level of 100 mg/l has also been proposed to act as an early warning to the dredging contractor. Due to the sensitive nature of the islands' ecosystem, a more stringent turbidity maximum of 80 mg/l is proposed for the respective monitoring sites around Jahleel and Brenton.

6.4 MARINE DISPOSAL

The majority of impacts associated with the offshore disposal operation at Coega will probably only be slight and of low significance. There were, however, a few impacts that are cause for concern. The smothering of benthic organisms was deemed to be severe, but of low significance due to the size of the area in question in relation to similar habitat in the greater Algoa Bay area. Ship noise and lights may only have a slight effect on marine mammals, but in terms of the threatened species, this was seen to be of moderate to high significance. Increased turbidity levels were not cause for concern within the disposal site, and it was assumed that the reference site near Brenton Island would protect this sensitive area. As was the case in the dredging operation, the disposal offshore will result in the destruction of the physical environment. This is seen as a very severe impact, but because of the small area, it is considered not to be significant. The chance of an encounter between dredgers and recreational yachts is seen as a possibility and one which could develop into a very severe impact of very high significance. However, with correct management, this scenario would be totally avoidable. The visual impact will vary from person to person but is thought to be of low to moderate significance.

6.5 CONCLUSION

In conclusion, it would appear that there are no fatal flaws, that would prevent the dredging and disposal operation at Coega from taking place. It must, however, be recognised that the proposed dredging operation is very large and that while many of the impacts are of LOW significance, this is due to the *localised* nature of the impact (dredge sites, disposal sites and surrounding areas) in

comparison to Algoa Bay and the nearshore environment. Many of the impacts will be severe within this area.

The sensitivity of the St Croix Island Group and their associated fauna and flora must, however, not be underestimated. Although some of the impacts relating to marine mammals need to be considered carefully, it is of primary importance that interference with the islands' ecosystems is avoided or kept to the bare minimum at all costs. Due to the sensitivity of the islands, it is imperative that the recommended mitigatory actions be implemented and enforced, and regular monitoring of the operation takes place.

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APPENDIX 1: CONCEPTUAL REHABILITATION PLAN

1. INTRODUCTION

The Coega Development Corporation (CDC) is investigating the possible implementation of the Coega Industrial Development Zone (IDZ), which will incorporate a new deepwater port and a 17 000 ha industrial area.

The construction of the port will involve the excavation of the basins and container terminal area, and will require the removal and disposal of approximately 9 million cubic metres of material. Various disposal sites (see Figure 2.1) have been identified in close proximity to the works (East headland, Neptune Valley, salt works, the outer basin reclamation, the tank farm area and limited areas above the high water mark on the eastern beaches) and their suitability has been assessed in this report. In summary, the areas that were deemed to be most suitable were the east headland site and the outer basin reclamation site, with these two sites being able to accommodate the vast majority of the material. All the areas used for disposal will be landscaped and revegetated in order to minimise the environmental impact.

Coastal & Environmental Services prepared a report on the stabilisation specifications and environmental management plan for the back-of-port area (CES 1999). The report was concerned with the stabilisation of the dunes, link roads and the temporary stabilisation around working and marshalling areas at the back-of-port area of the proposed harbour. This section uses information from the CES report (1999) and is concerned with the stabilisation and revegetation of the excavation spoil (or dune). The guidelines provided in this chapter are generic in nature, as there is no detailed site-specific planning at this stage. These guidelines should be developed further in the EMP.

2. OBJECTIVES

The main objective is to return the area to what it was before the disturbance. The natural vegetation should be rehabilitated to a state that resembles and functions the same way as the original community.

3. CONCEPTUAL REHABILITATION PLAN

The conceptual rehabilitation plan will consist of a number of stages/tasks. These include:

1. Site preparation (i.e. vegetation removal and topsoil stockpiling);
2. Landscaping of spoil;
3. Planting of suitable species; and
4. Management.

These stages/tasks are explained in more detail below.

3.1 SITE PREPARATION

The pre-mining phase management will need to address the removal of vegetation and the stockpiling of topsoil for later use. The entire area should not be stripped at once, as it will leave this area exposed to windblown erosion, should only be stripped as required.

The upper approximately 100 mm of biologically active topsoil should be stripped and stockpiled for rehabilitation purposes. These stockpiles should be vegetated with a suitable mixture of grasses to maintain the organic matter and biological activity of the soil, and to prevent erosion. The stockpiles should be convex at the top to promote runoff and should not exceed 2 m in height. Stockpiles must be protected from trampling and vehicular movement. The viability of seeds contained in the soil tends to decrease with time, and therefore soil should be stockpiled for as short a time as possible.

The management of stockpiling will involve the placement of the topsoil and the establishment of a cover crop to prevent erosion and maintain biological activity in the soil. During this phase vegetative material (seed and transplants) should be collected as this will save time and money later. The remainder of the vegetation could be chipped for mulch.

3.2 LANDSCAPING

3.2.1 Introduction

The spoil site must be rehabilitated so that it looks like it is part of the existing and adjacent landscape and topography.

3.2.2 Existing landform

The existing dune landform and topography of the eastern headland generally runs parallel to the coastline, with a trough running from the Coega River behind the foredune in a west–east direction and a number of smaller indentations running south–north. The existing dune rises to 50 metres with the average slope being about 1:10.

3.2.3 Shaping guidelines

The following guidelines should be implemented to blend the spoil into the landscape. These guidelines are illustrated in Figure A1.1.

- The toe of the spoil should follow the natural line of the existing contours and not be a straight line;
- Subsequent contours should more or less follow the toe line, resulting in ‘major’ shaping;
- The dune gradient should vary between 1:4 and 1:8. 1:4 is still accessible for vehicles to place spoil and topsoil material;
- The top of the spoil site should not be as flat and as expansive as it is, but should have more peaks; and
- Further minor irregularities should be created with the use of brushwood barriers being irregularly placed. This will cause wind blown material to be deposited in these areas, resulting in more minor dune undulations.

3.2.4 Further recommendations

The environmental officer needs to assist in the management of the contouring and spreading of topsoil from the stockpiles. It is recommended that the contractor and environmental officer work with a suitable landscape engineer on site during the landscaping phase.

3.3 SUITABLE SPECIES AND PLANTING

3.3.1 Suitable species

The selection of suitable species is critical, especially on the foredune system, as the young plants will be exposed to salt spray, sand movement and wind pruning. They must therefore be adapted to these conditions. If the incorrect species are planted it could limit the establishment and growth of these species. Species that are specifically adapted will accelerate the natural process of dune colonisation (CES 1999).

Species suitable for the stabilisation and rehabilitation of the spoil are presented in the tables below, also indicating moisture requirements, means of propagation and months species can be collected. Table A1.1a lists species that are suitable for initial stabilisation, and Table A1.1b lists species that could be planted once the soil has been stabilised.

Climax tree species that could be considered, once other pioneer species (listed in tables below) have established themselves, are presented in Table A1.1c. These trees should only be planted once the area has been well covered by shrubs and the soil is stable.

Table A1.1a: Species suitable for stabilisation of disturbed area. (L – LOW; P – Plants; S – Seeds; C – Cuttings).

Species	Common name	Moisture requirements	Means of planting	Months to be collected	Notes
<i>Ehrharta villosa</i>	Pipegrass	L	P, S	Oct-Dec	Good in mobile sands
<i>Ammophila arenaria</i>	Marram	L	P	-	Accumulates sand
<i>Ipomoea pescaprae</i>	Dune morning glory	L	P, S	Mar-Apr	Pioneer of open sand

The * symbol in Tables A1.1b and c denotes those plants which are commercially available at the following nurseries:

New Plant Nursery

PO Box 4183
George
6539
Tel: 044 – 889 0055
Fax: 044 – 889 0101

Tzitzikamma Nursery

PO Box 1069
Plettenberg Bay
6600
Tel: 044 – 534 8896
Fax: 044 – 534 8791

Kraaibosch Nurseries

PO Box 4019
George East
6539
Tel: 044 – 889 0092
Fax: 044 – 889 0109

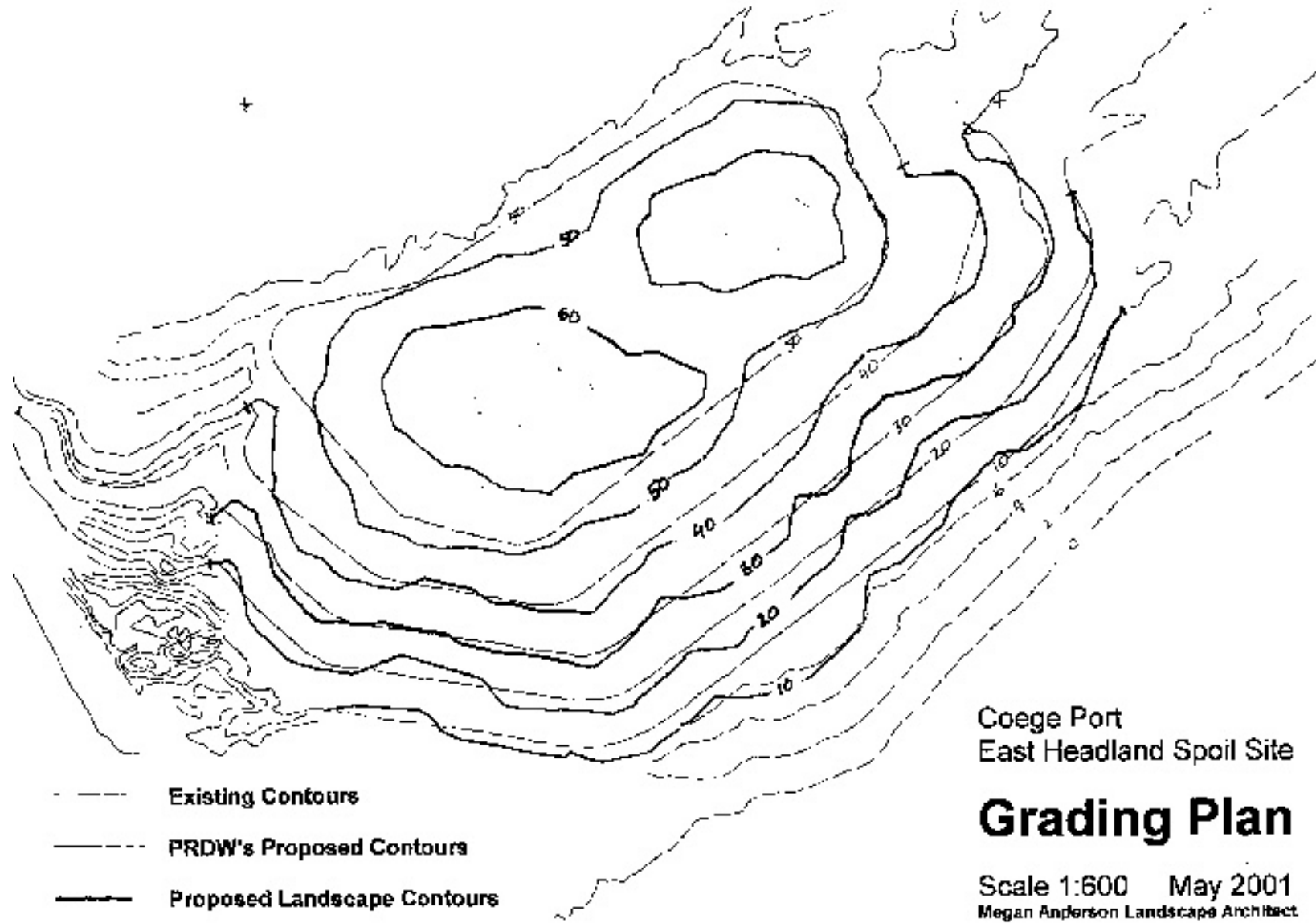


Figure A1.1: Grading plan developed for the east headland spoil site.

Table A1.1b: Species suitable for establishment after soil stabilisation. (L – LOW; M – Medium; H – High; P – Plants; S – Seeds; C – Cuttings).

Species	Common name	Moisture requirement	Means of planting	Months to be collected	Notes
<i>Gazania rigens</i> *	Daisy	M	P, S	-	Good in foredune areas
<i>Gazania uniflora</i> *	Daisy	M	P,S		Good in foredune areas
<i>Chrysanthemoides monolifera</i> *	Bitou	L	P, S	Jun-Jul	Excellent shrub that grows well from seed and spreads rapidly in open areas.
<i>Helichrysum cymosum</i> *	Dune everlasting	H	S	Dec-Mar	Grows well in dune slacks
<i>Helichrysum teretifolium</i> *	Dune scrub everlasting	H	S/C		As above
<i>Rhus crenata</i> *	Dune crow-berry	L	S, C, P	May-Jul	Spreads well over sand
<i>Passerina rigida</i>	Dune-string	L	S	Dec	Very good in open areas and is a pioneer dune forest species, but seeds are slow to germinate.
<i>Metalasia muricata</i>	Blombos	L	S	Jun-Jul	Excellent shrub that grows well from seed and spreads rapidly in open areas.
<i>Salvia africana lutea</i> *	Dune salvia	M	P	-	Good pioneer shrub species, but prefers less exposed areas.
<i>Brachylaena discolor</i> *	Coast silver oak	L	P, C	Aug-Oct	Spreads well over open sand. Useful woody pioneers of dune thicket and forms hedges to protect areas from wind.
<i>Felicia aethiopica</i> *	Blue daisy	M	P		Useful groundcover in fairly stable areas.

Since the seed from most dune plants or seedlings themselves are not commercially available, the following two options could be considered:

1. Collect seeds and germinate species (in greenhouses or under shade cloth). Seeds are then planted in polythene bags with a mixture of 50% beach sand and 50% soil, watered daily for a few months, before transplanting onto the dunes. Plants must be removed from the shade a few weeks before transplantation to allow them to acclimatise; and
2. Contract out the establishment of these species. Elands Nursery (041 – 955 5671) was prepared to grow in bulk the species that are required. However, most large nurseries will probably be prepared to grow species that are required (CES 1999).

Table A1.1c: Trees that could be considered for planting once the soil has been stabilised. (L – LOW; M – Medium; H – High; P – Plants; S – Seeds; C – Cuttings).

Species	Common name	Moisture requirement	Means of planting	Months to be collected	Notes
<i>Harpephyllum caffrum</i> *	Wild plum	M	P		A large, fairly slow growing tree that should only be used if sufficient space is available e.g. parking areas.
<i>Sideroxylon inerme</i> *	White milkwood	M	P		As above
<i>Syzigium cordatum</i> *	Water berry				A small tree or shrub suitable for planting in areas already stabilised.
<i>Celtis africana</i> *	Common Celtis				As above
<i>Apodytes dimidiata</i> *	White pear				As above
<i>Cassine aethiopica</i> *	Kububerry	H	P	Jun-Jul	Large tree that can only be planted once area has been covered stabilised.
<i>Tarchonanthus camphoratus</i> *	Wild camphor	M	P	Jan-Oct	Spreads well over open sand. Useful pioneers of dune thicket.

3.3.2 Planting

Revegetation must be ongoing and not left until the end of the excavation process. The best time to start a stabilisation programme of seeding or planting is during the spring or autumn rainy periods. Germination and seedling establishment is likely to have a maximum chance of success if the sands have been well soaked by rains. However, if irrigation is available, stabilisation can be attempted during the warmer periods. The costs of irrigation will be prohibitive and is not recommended. It is more cost effective to use indigenous species adapted to the local environment. If no irrigation is available, Stocosorb (synthetic polymer) should be used at the time of planting, by saturating 1kg in 200 l of water and then applying 250 to 500ml into the planting cavity (contact Michelle Barnes for more details on 083 630 2842).

For initial stabilisation, a mixture of species listed in Table A1.1a should be used. Seeds (“clean seed equivalent”) should be sown at a total density of 20kg per hectare. “Clean seed equivalent” reduces the cost of producing seed to pure levels.

Once the pioneer grass species have established themselves, various herbs and shrubs should be planted. Not all the species listed in Table A1.1c need to be planted, but at least four woody shrubs and four herbaceous plants should be planted. It is preferable to plant a variety of species, in order to increase species diversity and reduce the risk of sudden die-back of a single species.

Transplanting indigenous seedlings is more costly than sowing seeds, but is much more successful. When transplanting seedlings on foredunes, the plants should be set in deeper than normal to prevent exposure of the roots by wind erosion. Shrubs should be planted about 1.5 to 2 metres apart or one plant per 2.25m² (i.e. a 1.5m x 1.5m area). Groundcovers should be planted at a density of one plant per m². Seeds should be sown at a total density of 20kg per hectare, and shrubs should be planted immediately before seeding. Hydroseeding could be considered and the seed mixture should contain 70% pioneer species and 30% “sure grow” species. At least half of the pioneer seeds should be cheap and easy to collect, e.g. *Ehrharta villosa*, *Gazania rigens* and *Chrysanthemoides monolifera*. The mulch used in the hydroseeding can be milled straw, compost or milled seed husks (derived from the seed collecting process). Compost only becomes “useful” if applied at a rate of 6m³/ha. In sandy areas, *HydroPam* should be considered and applied at a rate of 6kg/ha. This polymer binds the soil and improves germination substantially.

If trees (Table A1.1c) are planted, they should be protected from strong winds by screening them with shade cloth.

3.4 MANAGEMENT

Management will involve a number of tasks. These include:

1. Monitoring (regression of plants, alien eradication)

Regression: If regression of vegetation is noted, it should be addressed. Factors that can cause regression include: a decline in the pH; lack of nutrient recycling; loss of soil structure; deficient drainage system; and failure of biological material. When regression is observed, it is important to identify the underlying causes, and then consider:

1. If the cause can be rectified to enable the objectives to be met; or
2. Whether an alternative vegetation objective is needed.

Plants that are lost due to diseases or any other reason must be replaced. If a tree dies, it must be replaced. However, if a tuft of grass dies, it will not be replaced. (Only replace if a large area regresses.) The survival rate of plants should be monitored by the environmental officer and a programme should be drawn up in order for the environmental manager to monitor the survival rate.

Alien eradication: Alien species (e.g. *Acacia cyclops*) should be removed, as they will tend to colonise and out-compete the indigenous species.

2. Erosion control

The site must be monitored frequently to determine if erosion has occurred, and to initiate erosion control measures if necessary.

3. Irrigation and fertilisation

Irrigation is not recommended and it is more cost effective to use indigenous species adapted to the local environment. If no irrigation is available, Stocororb (synthetic polymer) should be used at the time of planting, by saturating 1kg in 200 l of water and then applying 250 to 500ml into the planting cavity (contact Michelle Barnes for more details on 083 630 2842).

Fertilisation could result in a reduced number of plants, as many of the indigenous species do not favour nutrient-rich soils. However, the addition of fertiliser with low levels of

nitrogen (e.g. 27kg/ha equivalent) could benefit the system. Best results will be obtained by adding 100g of 2:3:2 fertiliser per square metre. This amount is adequate to boost growth but will not burn or weaken the vegetation. The fertiliser should be distributed onto the sand surface and worked in to a depth of 20 – 30cm during the rainy season. The application should be repeated 3 to 4 weeks later, depending on the weather.

4. Measuring success of rehabilitation programme

The success of a rehabilitation programme is not measured simply by the re-establishment of vegetation and the appearance of an environment similar to the original. The initial shortterm objective will be to create a self-sustaining land surface, which is stable against the erosive forces of water and wind, thus preventing localised environmental change (Bell 1987).

Martiniack and Associates (1988) believe that the success of a rehabilitation programme is the establishment of a self-sustaining land surface, which can be measured as:

- The landform exhibits at least three years of stability;
- The successful establishment of self-perpetuating vegetation must be shown or a management programme if commercial vegetation is established;
- Perennial plant species must have survived for at least three summer seasons; and
- The vegetation must have established a plant density that provides for the long term stability of the restored landforms.

Various other methods have been developed and used for assessing restoration success. Westman (1991) uses various parameters (see Box A1.1) of the restored environment to measure success. These parameters must be measured using quantitative measures of the vegetation, and not simply qualitative statements, as is very often done in restoration projects. According to Ewel (1990), it is necessary to determine whether the restored community resembles the original, and whether it contains the same dominant species and a similar structural physiognomy. He provides six criteria (which are rather difficult to measure) for analysis of the success of restoration:

- *Sustainability*, which implies that the community must be capable of perpetuating itself without continuous management. This would mean measuring to see if the species are reproducing and whether the soil buildup is providing nutrients for the restored system.
- *Productivity*, which means that the system must show an increase in abundance or biomass over the growing period. This is measured in terms of biomass and the production of the plants or animals in the system.
- *Invasibility*, which means that there must be evidence of the invasion of new species into the newly formed community. This is easily achieved by carrying out counts of the species in the new community.
- *Nutrient retention*, which implies that there must be a satisfactory build up of a soil system and recycling of nutrients so that the nutrients are not simply lost from the system. This is difficult to measure, as detailed analysis of the soil is required, as well as information on nutrient recycling.
- *Biotic interaction* would complete the picture of restoration, as invasion of other species in a fully integrated ecosystem is the ultimate goal in the rehabilitation regime.
- *Restoration status*. Studying the interaction between species within the ecosystem would require detailed studies to see if this had reached the same proportion as within the natural ecosystem.

What is evident from these studies is that long term monitoring is necessary to show changes in the type and structure of the community. The area needs to be monitored over a long period in order to establish parameters, which may be useful in determining whether or not the restoration has been successful (Box A1.1).

Box A1.1: Some parameters which may be used to assess the success of ecological restoration (from Westman 1991).

ECOSYSTEM STRUCTURE

Biota

- Composition
- Absolute and relative abundance
- Pattern of local and regional distribution
- Gene frequencies
- Height
- Density
- Biomass
- Nutrient pools

Physical Habitat

- Topographic features
- Water quality
- Water quantity
- Energy content (air, water, soil, temperature)
- Soil structure
- Soil/litter nutrient pools

ECOSYSTEM FUNCTION

Biota

- Productivity/growth rates
- Nutrient flux (biota, litter)
- Pollutant flux
- Natality/mortality rates
- Migration
- Fire frequency/intensity

Physical Habitat

- Nutrient flux (air, water, soil)
- Soil movement
- Radiation flux
- Hydrological flow

SOCIAL VALUES

- Recreational opportunity
- Historical or archaeological interest
- Educational or scientific interest
- Aesthetic qualities
- Health and safety
- Psychological environment
- Consistency with government policies

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APPENDIX 2: REPORT ON TRACE METALS IN SEDIMENTS FROM CORES COLLECTED AT COEGA

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Introduction

This report covers a series of drilling cores from within the proposed harbour development at Coega, which, during construction of the harbour, will constitute material that would need to be dredged out and removed from the area. The ultimate fate of the material would depend on its physical and chemical characteristics.

Methods

The cores were collected by drilling contractors and were received at the CSIR laboratories in small plastic jars with labelling as shown in Table 1. The chemical analyses were conducted at the CSIR's marine chemistry laboratory in Durban. A known mass of each sample was digested in sealed digestion vessels, containing nitric acid, according to a standard pressure programme in a microwave oven. The digested sample was then transferred to a volumetric flask and analysed for trace metals. Mercury was analysed by Vapour Generation Atomic Absorption Spectrophotometry (VGAAS), with a pre-concentration step using silver wool. Cadmium, lead, arsenic, tin and selenium were analysed with Graphite Furnace AAS, and copper, chromium, zinc, nickel, iron and aluminium by Flame AAS.

As mentioned above, tin was also measured from 5 of these samples. This was done because we were not able to analyse for tributyl tin; neither can any other laboratory in South Africa. Therefore we decided to analyse for total tin, reasoning that if it turned out to be very low there would be no need to proceed further with tin analysis on the samples. For the analysis of tin, the optimum working range for FAAS is 25 to 100 mg/l, and 15 to 200 µg/l for GFAAS. GFAAS is thus approximately 1000 times more sensitive than FAAS. The low sensitivity of tin analysis by FAAS prompted the decision to analyse the samples by GFAAS. The analysis of tin has not been routinely analysed by this laboratory previously. Initial attempts to analyse for tin were done without considering the possible effect of chemical interferences on the tin in the sample. Results obtained on the digested sample were high with most being greater than 4 mg/l, which converted to a value of greater than 210 µg Tin per gram of dry sample (>210µg/g). An investigation into chemical interferences that may affect the analysis of tin indicated that Sodium Chloride, Potassium, Magnesium, Calcium, Copper and Zinc could cause errors in results. As the presence of these interferences is very likely in sediment samples, their effects had to be minimised, and this was achieved by the use of a chemical modifier, Diammonium Hydrogen Citrate. The addition of this modifier caused a stabilisation of the dissolved tin and facilitated a better analysis.

The pesticide and PCB analysis was performed by extracting a known mass of sediment with dichloromethane. The extract was then filtered through anhydrous sodium sulphate. The whole process was then repeated. The combined extract was rotary evaporated under reduced pressure, dried with a stream of nitrogen gas, reconstituted in dichloromethane and then injected into the gas

chromatograph. Peaks were compared with an extensive library of compounds as well as with standards.

Particle size analysis was performed in a settling column.

Results and Discussion

The chemistry results are shown in Table 1.

Table 1: Coega core sediment samples

Sample		Hg	Cu	Cr	Cd	Pb	Zn	Ni	As	Se	Fe	Al	COD mn
	units	ug/g	ug/g	ug/g	ug/g	ug/g	ug/g	ug/g	ug/g	ug/g	mg/g	mg/ g	mg/g
3 Mixed		0.05 6	4.88	4.88	<0.14	8.78	3.90	<3.80	4.10	0.88	2.44	2.05	0.27
4 Top		0.15 6	3.96	<4.8 0	0.70	7.43	0.99	<3.80	2.77	<0.44	2.67	1.49	0.01
4 Bottom		0.05 7	5.75	<4.8 0	<0.14	12.2	1.92	<3.80	2.49	1.25	2.78	2.11	0.04
5 Top		0.14 2	6.18	14.1	0.19	9.89	9.71	4.41	7.41	<0.44	5.12	9.71	0.58
5 Bottom		0.06 9	5.74	17.2	0.31	13.4	13.4	<3.80	6.31	0.48	4.97	6.12	0.60
6 Top		0.09 0	4.70	6.58	<0.14	9.93	4.70	4.70	2.26	<0.44	2.26	2.92	0.15
6 Bottom		0.06 2	5.97	<4.8 0	1.18	10.9	3.98	5.97	1.19	<0.44	1.79	2.89	0.06
8 Top		24.4 0	6.93	21.8	0.31	15.0	19.8	4.95	7.92	<0.44	6.43	8.91	1.14
8 Bottom		0.21 6	3.73	4.66	<0.14	4.77	5.59	<3.80	2.42	<0.44	2.61	5.69	0.15
9 Top		2.71 7	2.71	<4.8 0	<0.14	4.53	4.51	4.51	1.62	<0.44	2.53	2.62	0.10
9 Bottom		0.18 0	3.71	7.42	<0.14	5.58	7.42	<3.80	2.41	<0.44	3.25	4.73	0.18
11 Mixed		0.25 3	3.71	8.34	0.21	3.80	8.34	<3.80	2.78	<0.44	3.62	4.45	0.22
12 Top		0.11 9	5.96	11.9	0.22	13.5	14.9	7.94	4.96	<0.44	4.57	4.77	0.70
12 Bottom		0.06 8	1.94	4.85	<0.14	9.70	4.85	<3.80	1.36	<0.44	2.91	3.88	0.10
16 Mixed		0.09 8	4.73	6.62	<0.14	11.3	6.62	<3.80	2.65	0.47	2.74	3.59	0.13
20 Mixed		0.32 8	6.78	11.6	<0.14	15.2	6.78	4.84	3.49	<0.44	3.00	3.58	0.31
23 Top		0.07 2	4.77	5.73	<0.14	8.36	3.82	4.77	1.54	<0.44	1.81	1.62	0.15
23 Bottom		0.14 0	4.79	8.62	<0.14	11.0	2.87	3.83	1.92	0.86	1.63	1.53	0.14

While there are no formal guidelines published for use in the assessment of dredge spoil for dumping at sea in South Africa, a draft set of guidelines (DEA&T 1999) has been issued by the Directorate of Marine Pollution Control, Department of Environment Affairs and Tourism in Cape Town. These provide “Action Levels”, “Special Care Levels” and “Prohibition Levels” for a variety of potential contaminants (L Jackson *pers. comm.*).

In addition, a series of papers has recently appeared in the international literature (Long *et al.* 1995), describing a method of evaluating adverse biological effects incidence that is the basis for developing national sediment quality guidelines for Canada and informal sediment quality guidelines for the State of Florida in the USA. Drawing from a wide range of linked sediment chemistry and biological effects data sets from around the world, two guideline values namely "effects range-low" (ERL) and "effects range-medium" (ERM) were established (Long *et al.* 1995). Concentrations below the ERL value represent a minimum effects range; a range intended to estimate conditions in which effects would be rarely observed. Concentrations equal to or above the ERL, but below the ERM (effects range median), represent a possible-effects range within which effects would occasionally occur (DEA&T 1999). Finally, the concentrations equivalent to and above the ERM value represent a probable-effects range within which effects would frequently occur.

All values in the following discussion refer to concentration on a dry mass basis.

Mercury

The DEA&T guideline (DEA&T 1999) for mercury has been set at 0.5mg/g, or 500µg/g, and the prohibition level at anything >5mg/g. The sample from the surface at Core 8 would fall into the Prohibition level and if confirmed, would need to be dealt with in a special manner prescribed by the authorities. In addition the surface sample from Core 9 falls in the Action level and requires special care. In terms of biological impact, the ERL value for mercury has been set at 0.15µg/g (Long *et al.* 1995). Any sediment with a Hg concentration above 0.71µg/g would be above the ERM range and would be regarded as having a high likelihood of causing adverse biological effects, while between 0.15 and 0.71µg/g is regarded as of medium risk and therefore worthy of attention. Thus while most of the samples were well below the ERL, both Cores 11 and 20 were above the ERL value while the surface samples of 8 Top and 9 Top fell above the ERH value, indicating high risk of biological impact.

At the CSIR marine laboratory we have analysed thousands of marine sediment samples, mostly of surface sediments collected with stainless steel samplers, and we have never encountered sediments with this level of mercury contamination. We therefore repeated the analysis and obtained essentially the same result. We then asked for a second sample to be collected from the cores stored in the warehouse, specifically of 8 Top and 9 Top. The results were as follows:-

Station	Mercury µg/g.
8 Top	1.38
9 Top	2.25

The result for 8 Top was lower, but the physical characteristics and colour of the sample were different, indicating perhaps that the previous sample was off the top of the core and the second sample was a few centimetres below the surface. The sample from 9 Top was essentially the same as before. Even though 8 Top was lower than previously both repeat samples were remarkably high in mercury, and fell within the Action range of the DEA&T guidelines.

Subsequent to these repeat samples being analysed, a further set of 6 core samples was sent to our laboratory for mercury analysis. The results as well as the site codes and the depths from which the samples were collected, are shown in the following table:-

Station	Core Depth (m)	Hg in µg/g dry mass
BH211	1.0-1.4	0.015
BH211	–	0.012
BH215	1.2-3.85	0.030
BH217	1.0-1.45	0.026
BH217	1.5-1.95	0.011
BH217	2.0-2.45	0.003

While it would seem as though these samples were collected to verify the high mercury in surface sediments at Stations 8 and 9, their location is presently unknown to us, and none of them is a surface sample. Thus while all the levels are low, these additional results do not add significantly to the data on mercury in surface sediments at Coega.

The question that remains is how and at what point were the offshore sediments from Stations 8 and 9 contaminated with mercury. When plotted on the chart it can be seen that the contaminated stations roughly follow the 15m contour. We felt that it was imperative to resample. We proposed that a diver collect a set of 5-8 samples of shallow cores from which we can analyse for the interstitial water, dissolved fraction as well as the sulphide fraction of the mercury. At the same time the samples will confirm whether the sediments are contaminated or not.

Suitable corers, which could be used by divers were constructed. On 5 October 1999, the cores were collected by Portnet divers, on the 15m contour, where the original samples had been collected. The corers were driven vertically into the seabed to a depth of approximately 30 cm, and then sealed top and bottom and transferred to the ship. The locality was confirmed by Jacques Nel at UPE, who was on board the vessel as an independent observer. The observer also ensured that the samples were handled and stored correctly. Station positions were confirmed by Differential GPS and were regarded to be within 5 m of the previous recorded positions of Stations 8 and 9 (J.M. Nel Pers. Comm.). The samples were sent to CSIR Stellenbosch, for separation into porewater or interstitial water, SEM and total mercury analysis. This detailed analysis was considered necessary to assist in interpretation if these new samples confirmed the presence of high mercury concentrations in the sediments. The results were as follows:

Sample	Dissolved (µg/l)	Organic (SEM-µg/g)	Total Hg (µg/g)	Acid Volatile Sulphides (µg/g)
1	0.232	0.0031	0.0099	1248
2	0.224	0.0027	0.0125	40.9
3	0.136	0.0029	0.0065	54.6
4	0.078	0.0075	0.0077	862
5	<0.025	0.0047	0.0217	988
6	<0.025	0.0066	0.0142	1022

The new results showed that there was no contamination of the diver collected cores. In the expectation that the samples might be contaminated as before, the various fractions were extracted and analysed. From these results it can be seen that the dissolved and organic bound fractions were lower than the total (as has to be expected). The relatively low AVS values indicate that the sediments were reasonably oxygenated. Overall, the results indicate no contamination above the low results recorded in Table 1, and no sign of the contamination found in the surface samples from

Stations 8 and 9 in the borehole cores (Table 1). Thus we must conclude that the borehole cores from Stations 8 and 9 were contaminated during collection, handling, storage or subsequent subsampling.

Copper

Copper is listed as an Annex II substance in the DEA&T guidelines, with the lower limit of the Special Care level set at 50µg/g. All the present samples were well below this level (Table 1). The ERL value for copper is similar at 34µg/g (Long *et al.* 1995). Compliance on both counts is therefore good. There should therefore be no risk from copper, if the sediments were dumped at sea.

Chromium

Chromium is also listed as an Annex II substance in the DEA&T guidelines, with the lower limit of the Special Care level set at 50µg/g. All the present samples were well below this level (Table 1). The ERL value for chromium has been set at 81µg/g (Long *et al.* 1995). There should therefore be no risk from chromium, if the sediments were dumped at sea.

Cadmium

Cadmium is listed as an Annex I substance in the DEA&T guidelines, with the lower limit of the Action level set at 1.5µg/g. All the present samples were well below this level (Table 1). The ERL value for cadmium has been set at 1.2µg/g (Long *et al.* 1995). All the samples analysed were well below this value, except 6 Bottom which was marginal. Nevertheless there should be no risk involved from cadmium, if the sediments were dumped at sea.

Lead

Lead is listed as an Annex II substance in the DEA&T guidelines, with the lower limit of the Special Care level set at 100µg/g. All the present samples were well below this level (Table 1). The ERL value for lead has been set at 46.7µg/g (Long *et al.* 1995). All the samples analysed were well below this value as well. There should therefore be no risk from lead, if the sediments were dumped at sea.

Zinc

Lead is listed as an Annex II substance in the DEA&T guidelines, with the lower limit of the Special Care level set at 150µg/g. All the present samples were well below this level (Table 1). The ERL value for zinc has also been set at 150µg/g (Long *et al.* 1995). There should therefore be no risk from zinc if the sediments were dumped at sea.

Nickel

Nickel is listed as an Annex II substance in the DEA&T guidelines, with the lower limit of the Special Care level set at 50µg/g. All the present samples were well below this level (Table 1). The ERL value for nickel has been set somewhat lower at 20.9µg/g (Long *et al.* 1995). All the samples analysed were well below this value as well. There should therefore be no risk from nickel, if the sediments were dumped at sea.

Arsenic

Arsenic is listed as an Annex II substance in the DEA&T guidelines, with the lower limit of the Special Care level set at 30µg/g. All the present samples were well below this level (Table 1). The ERL value for arsenic has been set quite a bit lower at 8.2µg/g (Long *et al.* 1995), but again all the samples analysed were well below this value. There should therefore be no risk from arsenic, if the sediments were dumped at sea.

Selenium

There is no sediment guideline or ERL value for selenium. Most of the samples were however below detection limits. Offshore sediment studies at Richards Bay rarely exceed 1µg/g (ECP 1998). Thus 4 Bottom would appear to be quite high.

Iron

There is no sediment guideline value for iron, which is generally not regarded as toxic. By comparison with sediments offshore at Richards Bay the values tend to be low (ECP 1998).

Aluminium

There is no sediment guideline value for aluminium, which is also generally not regarded as toxic. By comparison with sediments offshore at Richards Bay the values tend to be average to low (ECP 1998). The main reason for analysing aluminium is to normalise sediment samples with high metals. Aluminium is a common crust material and the amount of aluminium in a sediment is a measure of the amount of metal adsorption surface is present in the sediment. If the sediment has a high clay content, it also naturally has a high capacity to adsorb other metals. Thus the aluminium to metal ratio is a measure of the degree to which the sediment is naturally or artificially contaminated with trace metals. However even at 8 Top, the aluminium level was elevated to about 4x that at most other stations, correction would not bring the relative value of mercury down by more than a factor of four. It thus remains very high even after such a correction. A similar ratio can be seen in the %mud of the sample. Core 8 Top was one of the highest at 22.2%, but all the other stations were in the region of 5-15%, indicating that a correction for muddiness would not compensate for the high mercury in 8 Top.

CODmn

The CODmn values recorded for these sediments were low, confirming the low metals seen in most samples. The exception was 8 Top, which had a CODmn of 1.14mg/g. This is still low compared to most sediments, and indicates a low organic content.

Particle size

The results are presented in Table 2.

Although these results indicate that 8 Top had the second highest mud content this does not explain the extremely high mercury content measured. Generally mercury in sediments on the shelf of the east coast of South Africa would be expected to be in the region of <0.03µg/g, even when % mud is as high as 60% (ECP 1998).

Pesticides and PCB's

The results are presented in Table 3.

Table 2: Coega Core Sediment Particle size Analysis

Sample	%>VCS	% VCS	% CS	% MS	% FS	% VFS	% Mud
3 Mixed	2.5	0.5	7.1	54.9	33.7	0.0	1.3
4 Top	4.2	4.8	26.5	45.3	16.4	0.7	2.1
4 Bottom	20.8	5.6	34.8	27.1	8.3	0.0	3.4
5 Top	3.4	2.1	15.0	28.9	42.2	0.0	8.3
5 Bottom	3.2	0.8	6.3	9.3	40.7	0.7	39.1
6 Top	19.4	7.4	22.2	18.6	27.5	1.1	3.8
6 Bottom	36.9	4.4	29.6	19.5	2.2	0.1	7.3
8 Top	8.3	0.3	2.2	12.5	50.3	4.1	22.2
8 Bottom	0.5	0.1	0.0	12.2	68.5	4.1	14.6
9 Top	0.0	2.1	4.9	27.3	55.8	2.3	7.6
9 Bottom	25.0	0.9	5.3	15.0	41.8	0.0	12.1
11 Mixed	0.3	3.7	26.3	56.8	0.0	0.0	12.8
12 Top	0.4	0.0	3.1	15.8	59.4	7.5	14.1
12 Bottom	0.0	0.1	15.7	65.8	10.2	0.0	8.2
16 Mixed	3.6	0.9	11.8	27.4	42.1	8.8	5.5
20 Mixed	15.3	0.8	12.5	19.9	45.2	2.5	3.8
23 Top	2.2	0.2	8.1	21.6	60.0	5.3	2.6
23 Bottom	21.8	3.5	9.2	13.0	45.7	4.2	2.6

The results of the particle size analysis for the 6 special mercury cores were as follows:

Sample	%>VCS	% VCS	%CS	%MS	%FS	%VFS	%Mud
1	0	0.7	0.6	7.7	61.3	12.1	17.6
2	0	0	0.2	7.7	74	10.6	7.5
3	0	0.2	0.2	12.6	68.6	7.8	10.6
4	0	0	0.6	8.2	71.4	9.5	10.3
5	0	0	1.6	8.6	61.4	9.8	18.6
6	0	0	1.2	11.4	56.6	6.7	24.1

Apart from a trace of DDT and chloroaniline, no chlorinated hydrocarbons, including PCB's were found in the sediments. The DEA&T guidelines (DEA&T 1999) list the Action level for organohalogens in general as above 50µg/g (50ppb). The values given in Table 3 are well below

this. The ERL value for Total DDT has been set at 1.58µg/g (Long *et al.* 1995). Here too the measured value was well below this limit.

The DEA&T guidelines do not give any limits for total tin or tributyl tin. Neither is it listed in the Long *et al.* (1995) paper on ERL's. Langston (1990) mentions a concentration of 1µg/gTBT in spiked sediments as being toxic to clams. Since the current samples had <1µg/g of total tin, it can be safely assumed that TBT will be below this level. Usually, as a check, we would run either of two certified reference materials to validate the results obtained. However, both these reference materials do not have certified values for tin, and thus this means of validation is impossible at this stage. At the same time though, the new process followed gives results that appear more realistic, and the literature used to modify the method is as described by the manufacturers of the Spectrophotometer which we use to analyse our samples (Varian 1992, 1979).

Table 3: Coega Core Sediment Pesticide, PCB and tin Analysis

Core	Chlorinated hydrocarbons	PCB's	Tin
5 Top	chloroaniline 0.0008µg/kg	ND	<1µg/g
8 Top	P,p' DDT 0.0002µg/kg	ND	<1µg/g
9 Top	ND	ND	<1µg/g
18 Top	ND	ND	<1µg/g
23 Top	ND	ND	<1µg/g

Recommendations

Despite the early scare of high mercury in the surface sediments at Cores 8 and 9, further investigation has suggested that these samples were contaminated after collection. A second set of carefully collected samples revealed no mercury contamination above the norm for marine sediments.

We find that all the sediments are suitable for dumping at sea at designated dredge-spoil dumpsites, since they comply to local and international standards with regard to their trace metal and chlorinated pesticide levels as well as being well below levels regarded as giving rise to risk of adverse ecological impact.

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APPENDIX 3: A DESCRIPTION OF METHODS USED DURING THE SURVEY TO ASSESS THE OFFSHORE DISPOSAL SITES AT COEGA.

1. METHODS

1.1 SAMPLING STRATEGY - PHASE 1

Sampling Transects

Seven transect lines were drawn through each of the proposed disposal sites (Figure A3.1). These lines were orientated parallel to the long-axis of each site and were uniformly distributed across each area so that two of the transects fell approximately along the long-axis boundaries of each of the sites. Of the remaining transects at each site, three were placed within the disposal site between the boundary transects, and one was located outside of the site on either side of each boundary transect, but within a nominal buffer zone. Each transect line extended slightly beyond the NE and SW edge of the disposal site, so that the buffer zone completely surrounded that site (Figure A3.1).

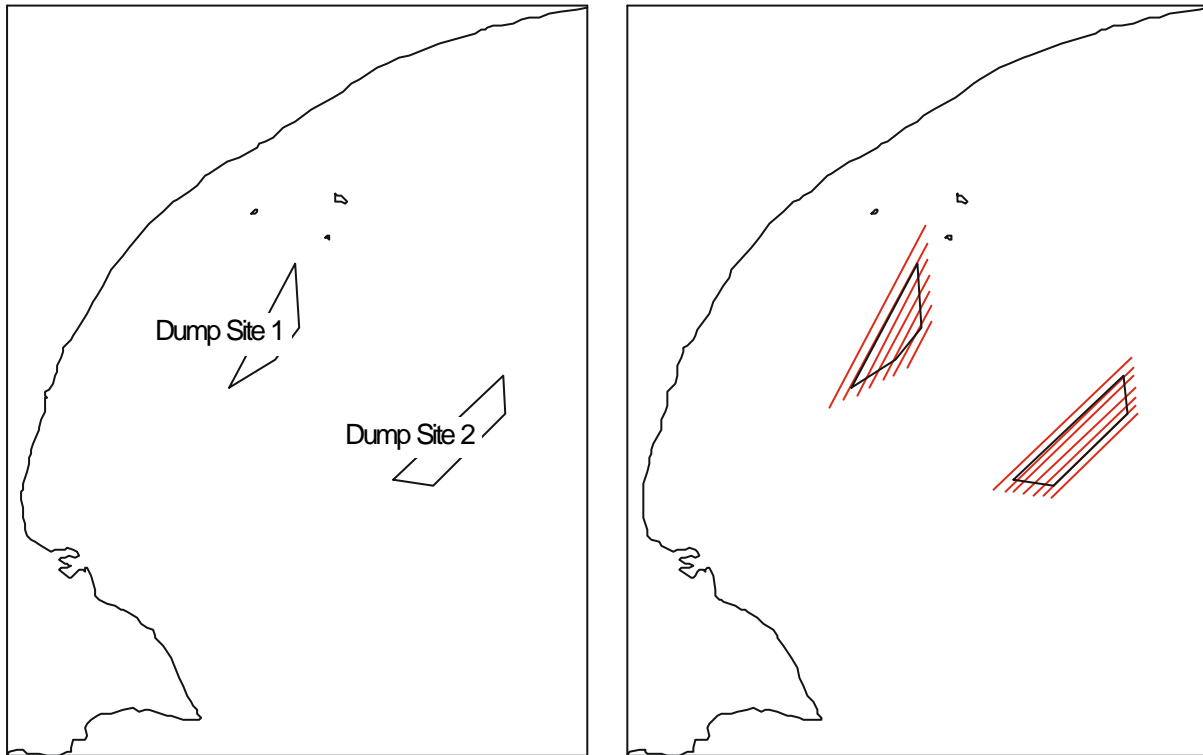


Figure A3.1: The layout of the proposed disposal sites (left) and the sampling design for the transects (right). The shape and co-ordinates of dump site 1 are those initially assessed, Figure 4.6 in the report shows the changes to the recommended dump site.

Mapping Benthic Topography

In order to map the bottom topography with a reasonable degree of resolution, 24 sample locations were allocated uniformly along each transect. At each of these locations, data were to be gathered regarding GPS position, depth and bottom type, with the latter two data series to have been inferred from the bottom trace of the onboard echo-sounder.

This procedure was not followed in the field, with data being collected at only 35 of a suggested 336 locations. However, the visual interpretations of bottom types suggested by the echo-traces

were confirmed by sediment grabs made with a Van Veen grab at each site. In addition, it was reported by field staff that the Van Veen grab could be effectively deployed and retrieved without additional equipment and that it sampled an adequate volume of sediment. Previous calculations indicate that this grab samples an area of roughly 0.056 m².

After confirming visual interpretation of bottom types from echo-traces by taking grab samples, the research vessel traversed the proposed dump sites following a haphazard pattern, but failed to identify any significant patches of reef.

1.2 SAMPLING STRATEGY - PHASE 2

The Randomised Stratified Sampling Design for Soft Sediments

Because no substantial areas of reef were identified in Phase 1, most of the sampling was conducted on muddy and sandy substrates using the Van Veen grab operated by hand from the surface. Based on the interpretations of the echo-sounder traces in Phase 1, each transect line at either site was assumed to be representative of the benthic habitat within a given depth/site stratum. Three grab-sample locations were allocated at random to each transect line (Figure A3.2) and at each of these sites, four grab samples were taken using the Van Veen grab. In order to assess the possibility of moving disposal site 1 away from Brenton Island by a further 1 nautical mile to the SW, six additional sites were designated to the southwest of the proposed site (these sites are denoted C1-C6 in the remainder of the text). Waypoint co-ordinates for the Disposal Sites, transects and the grab sample sites are presented in Appendix 5.

From each grab sample site, a single sediment sample (~ 250 g of sediment) was taken from one of the grabs and analysed using a sieve-column according to the methods described by Brown and McLachlan (1990). The remainder of the sediments from that sample as well the complete contents of each of the other grab samples were sieved through a 1 mm aperture nylon mesh in order to remove the finest sediments. Remaining macrofauna (animals unable to pass through 1 mm mesh) and sediment were placed in labeled plastic bags, which were frozen on return to the laboratory for later analysis.

Sampling Design for Reefs

Six dive sites were selected from the northern sector of Disposal Site 1, which is the closest section to St Croix and Brenton Islands (Appendix 5). Based on echo-traces, reef appeared to be absent or very sparse, and thus no dives were conducted at these sites. At each of these selected dive sites, a grab sample was taken instead to confirm the sediment type identified from the echo-trace. A few dives were conducted intermittently throughout the survey at random locations as a final failsafe to confirm bottom terrain.

1.3 ANALYSIS OF SOFT SEDIMENT SAMPLES

Macrofauna

In the laboratory, samples were thawed, before being extracted by means of elutriation, which involves placing small amounts (\pm 100 g) of sampled sediment into a bucket along with approximately 2 litres of water. These components are thoroughly mixed and the supernatant poured through a 1 mm mesh, from which retained organisms can easily be retrieved. This process is repeated until two successive elutriations result in no additional organisms being left behind on the mesh. The remaining sediment is subsequently sorted by hand to collect any heavier fauna that might not have been washed out. All organisms collected in this way were preserved in buffered 10% formalin.

Given that this assessment had to be conducted within an extremely short time period, it was considered not feasible to identify specimens to the species level, but instead as belonging to one of the following major taxonomic categories:

- Phylum Arthropoda (Subphylum Chelicerata – Class Pycnogonida)
(Subphylum Crustacea – Family Phyllocaridae; Order Cumacea, Tanaidacea, Isopoda, Amphipoda, Stomatopoda, Mysidacea; Class Ostracoda, Copepoda; Infraorder Anomura, Brachyura).
- Phylum Mollusca (Class Bivalvia, Gastropoda).
- Phylum Annelida (Class Polychaeta)
- Phylum Echinodermata (Class Crinoidea, Echinoidea, Ophiuroidea, Holothuroidea)
- Unidentified

1.4 INDICES OF ABUNDANCE AND DIVERSITY

In terms of these coarse taxonomic groupings, the most appropriate index of abundance per grab-sample site was considered to be the maximum number of organisms obtained in the four hauls from that site. This decision was reached because field personnel reported variable volumes of sediment being retrieved from the Van Veen grab and it was felt that it would be better to overestimate macrofaunal abundance rather than to underestimate it. The most appropriate index of diversity was assumed to be the taxonomic richness, defined for the purposes of this study as the maximum number of taxonomic groups encountered in any single sample from a given grab sample site.

1.5 STATISTICAL ANALYSIS

Although the sampling programme was strictly a stratified random design, the data were analysed as if they were drawn from a simple random design. This was done in order to simplify the structure and interpretation of analyses. It is unlikely that this could introduce any substantial bias into the results, as the effect of the stratification was to ensure that sampling provided data representative of the area under consideration. It is unlikely that any bias introduced would substantially affect the estimates of average abundance or diversity, although it might serve to increase the variability about that estimate, making confidence intervals slightly wider.

The mean indices of macrofaunal abundance and diversity were compared between the prospective disposal sites using conventional two-tailed t-tests, considering only one datum per grab sample site for each index. Multivariate analyses (*sensu* Clarke and Warwick 1994) were also employed to subjectively identify features of the data that may not have been detected by the univariate methods. A species-transect matrix was compiled from the abundance index for individuals of each species found at each grab sample site. Associations amongst samples were identified by means of hierarchical agglomerative clustering, using group-average linking on Bray-Curtis similarity measures obtained from fourth-root transformed abundance data from the species-sample matrix (PRIMER, version 4.0, Plymouth Marine Laboratory).

REFERENCES

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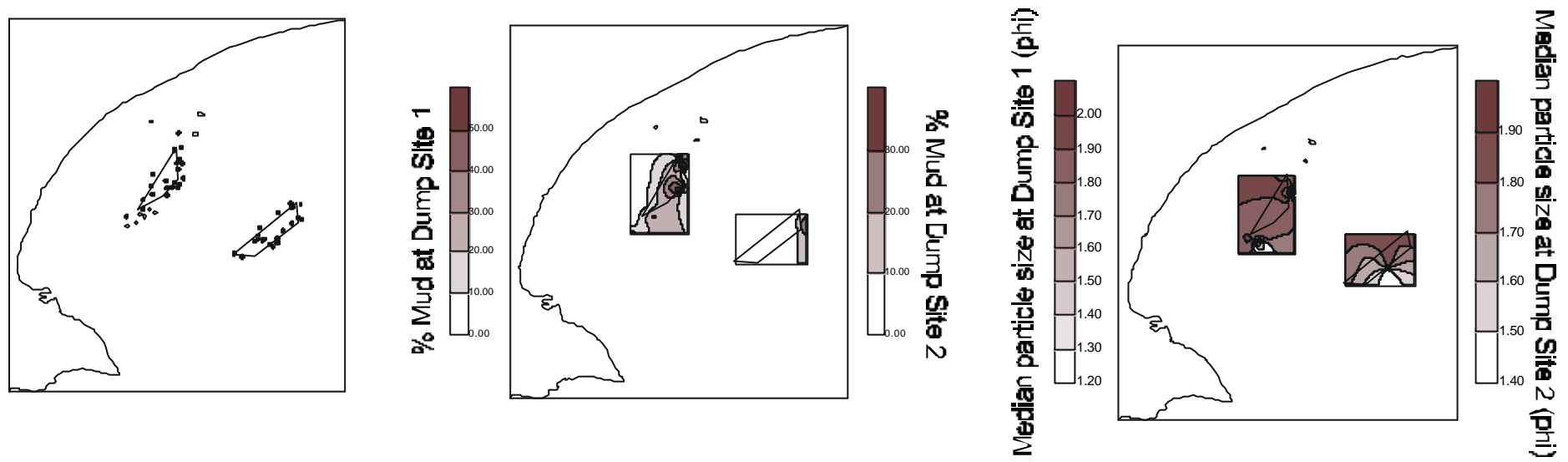


Figure A3.2: Grab sample sites and particle size for those sites analysed (circle size is proportional to mean particle diameter in phi units).

Appendix 4:

Co-ordinates for sample design (disposal sites, grab sites and dive sites). DS1 – Disposal site 1; DS2 – Disposal site 2; BL – Bottom left; BR – Bottom right; TL – Top left; TR – Top right. Transect lines at each site are labeled 1 – 7 from north to south and co-ordinates are provided for the southern (S) and northern (N) ends of each line.

Disposal sites

Label	Lat °S	Lat 'S	Long °E	Long 'E
DS 1 BL	33	52.967	25	42.967
DS 1BR	33	52.283	25	44.300
DS 1 TR	33	51.417	25	45.100
DS 1 TL	33	49.700	25	45.000
DS 2 BL	33	55.500	25	48.000
DS 2 BR	33	55.600	25	49.200
DS 2 TR	33	53.700	25	51.500
DS 2 TL	33	52.700	25	51.400
DS 1 1S	33	53.550	25	42.288
DS 1 1N	33	48.738	25	45.264
DS 1 2S	33	53.346	25	42.726
DS 1 2N	33	49.170	25	45.300
DS 1 3S	33	53.190	25	43.128
DS 1 3N	33	49.602	25	45.336
DS 1 4S	33	53.004	25	43.536
DS 1 4N	33	50.052	25	45.354
DS 1 5S	33	52.836	25	43.926
DS 1 5N	33	50.442	25	45.390
DS 1 6S	33	52.680	25	44.274
DS 1 6N	33	50.826	25	45.414
DS 1 7S	33	52.500	25	44.688
DS 1 7N	33	51.276	25	45.444
DS 2 1S	33	55.734	25	47.364
DS 2 1N	33	52.212	25	51.654
DS 2 2S	33	55.764	25	47.688
DS 2 2N	33	52.476	25	51.690
DS 2 3S	33	55.788	25	47.964
DS 2 3N	33	52.710	25	51.708
DS 2 4S	33	55.812	25	48.264
DS 2 4N	33	52.992	25	51.732
DS 2 5S	33	55.854	25	48.576
DS 2 5N	33	53.244	25	51.756
DS 2 6S	33	55.890	25	48.870
DS 2 6N	33	53.484	25	51.780
DS 2 7S	33	55.908	25	49.122
DS 2 7N	33	53.712	25	51.798

Appendix 4 continued

Grab Sample Sites for Disposal Site 1					Grab Sample Sites for Disposal Site 2				
Label	Lat °S	Lat 'S	Long °E	Long 'E	Label	Lat °S	Lat 'S	Long °E	Long 'E
DS 1/01	33	53.394	25	42.372	DS 2/01	33	54.000	25	49.458
DS 1/02	33	51.126	25	43.770	DS 2/02	33	53.208	25	50.436
DS 1/03	33	48.966	25	45.126	DS 2/03	33	52.692	25	51.084
DS 1/04	33	49.860	25	44.904	DS 2/04	33	52.914	25	51.162
DS 1/05	33	51.786	25	43.710	DS 2/05	33	54.420	25	49.350
DS 1/06	33	52.494	25	43.266	DS 2/06	33	55.440	25	48.084
DS 1/07	33	52.974	25	43.260	DS 2/07	33	54.780	25	49.176
DS 1/08	33	52.206	25	43.740	DS 2/08	33	54.672	25	49.326
DS 1/09	33	49.734	25	45.252	DS 2/09	33	52.746	25	51.648
DS 1/10	33	50.334	25	45.186	DS 2/10	33	54.660	25	49.680
DS 1/11	33	50.544	25	45.054	DS 2/11	33	54.732	25	49.614
DS 1/12	33	51.480	25	44.460	DS 2/12	33	55.620	25	48.516
DS 1/13	33	50.886	25	45.126	DS 2/13	33	54.126	25	50.676
DS 1/14	33	50.574	25	45.318	DS 2/14	33	53.748	25	51.138
DS 1/15	33	51.876	25	44.520	DS 2/15	33	53.454	25	51.498
DS 1/16	33	52.260	25	44.520	DS 2/16	33	53.508	25	51.732
DS 1/17	33	51.828	25	44.802	DS 2/17	33	54.606	25	50.370
DS 1/18	33	51.588	25	44.934	DS 2/18	33	54.960	25	49.950
DS 1/19	33	51.360	25	45.384	DS 2/19	33	55.086	25	50.124
DS 1/20	33	51.666	25	45.204	DS 2/20	33	54.900	25	50.352
DS 1/21	33	51.846	25	45.096	DS 2/21	33	54.840	25	50.424
Additional Grab Sample Sites					Prospective Dive Sites				
Label	Lat °S	Lat 'S	Long °E	Long 'E	Label	Lat °S	Lat 'S	Long °E	Long 'E
C1	33	53.900	25	42.400	DS1	33	49.17	25	45.3
C2	33	53.700	25	42.900	DS2	33	52.841	25	43.289
C3	33	53.250	25	43.100	DS3	33	49.314	25	44.934
C4	33	53.400	25	43.360	DS4	33	49.422	25	45.156
C5	33	53.010	25	43.620	DS5	33	49.746	25	45.282
C6	33	53.180	25	43.900	DS6	33	50.088	25	45.03
					DS7	33	49.95	25	44.832

Appendix 5: Raw data collected from the grab-sample sites

Site	Depth	Pycnogonida	Phyllocaridae	Cumacea	Tanaidacea	Isopoda	Amphipoda	Stomatopoda	Mysidacea	Anomura	Brachyura
C/1	29						2				
C/1	29					1	6				
C/1	29						22				
C/1	33			3	1	2	45				1
C/2	33			3			5				
C/2	33			3			2				
C/2	33										
C/2	33			1		1	3				
C/3	33			2		3	2				
C/3	33			3		5	7				
C/3	33			8		14	9		1		
C/4	35			6			13	1			
C/4	35						10	1			
C/4	35			4			6				2
C/4	34			4		1	20				
C/5	37						10				
C/5	37			6		3	1		1		1
C/6	38			7		1	15				1
C/6	38			3		1	16				1
DS 1/01	29					1	3				
DS 1/01	29					3	7				
DS 1/01	29						1				
DS 1/01	29						4				
DS 1/02	30					8	7				
DS 1/02	30					7					
DS 1/02	30					4					
DS 1/02	30			1	1						

Appendix 5 continued

Site	Depth	Pycnogonida	Phyllocaridae	Cumacea	Tanaidacea	Isopoda	Amphipoda	Stomatopoda	Mysidacea	Anomura	Brachyura
DS 1/03	25					1	1				
DS 1/03	25			3			3				
DS 1/03	25						4				
DS 1/04	31			1			6				
DS 1/04	31			1		1	1				
DS 1/04	31					1					
DS 1/05	33			1		1	2				
DS 1/05	33					5	1				
DS 1/05	33					5					
DS 1/06	33						6				
DS 1/06	33			3		8	5				1
DS 1/06	33				1	3	4				
DS 1/06	33						11				
DS 1/07	33					1	4				
DS 1/07	33					3					
DS 1/07	33			1		1	4				1
DS 1/07	33			2			1				
DS 1/08	34					8	1				
DS 1/08	34						1				
DS 1/08	34			1		2					
DS 1/09	31			2	1	8	19				
DS 1/09	31			14			1				
DS 1/09	31										
DS 1/09	31			5		1	3				
DS 1/10	35			2		3	3	1			1
DS 1/10	35			5			3				
DS 1/10	35			2			2				1
DS 1/11	35			4		1	1		1		1

Appendix 5 continued

Site	Depth	Pycnogonida	Phyllocaridae	Cumacea	Tanaidacea	Isopoda	Amphipoda	Stomatopoda	Mysidacea	Anomura	Brachyura
DS 1/11	35					1					
DS 1/11	35			1			1				1
DS 1/11	35		2	17							
DS 1/12	37						6				
DS 1/12	37										
DS 1/13	36										1
DS 1/13	36			2			4				1
DS 1/13	36			1		7	6				
DS 1/13	36					7	3		1		1
DS 1/14	35			2		3	55				2
DS 1/14	35			2		3	22		1		
DS 1/14	35					2	17				
DS 1/14	35			1	2		12				
DS 1/15	37			2		3					1
DS 1/15	37			1		1	1				
DS 1/17	38			4			1				
DS 1/17	38			6		2	2				
DS 1/17	38			11							
DS 1/18	38		1	8			2				
DS 1/18	38		1	5			3		1		
DS 1/18	38			5							
DS 1/19	39						6			1	2
DS 1/19	39			1							
DS 1/20	39			13		3	2				
DS 1/20	39			8			5				
DS 1/20	39						1				
DS 1/20	39			2			1		2		
DS 1/21	38			1		2	4				

Appendix 5 continued

Site	Depth	Pycnogonida	Phyllocaridae	Cumacea	Tanaidacea	Isopoda	Amphipoda	Stomatopoda	Mysidacea	Anomura	Brachyura
DS 1/21	38					3	20	1			1
DS 1/21	38					1	1				
DS 2/01	44			9	4	9	57				
DS 2/01	44			7	5	7	109				
DS 2/01	44		2	3	5	9	143	2			
DS 2/02	46		1	5			66	1			
DS 2/03	46			14	9	2	204				
DS 2/03	47			7	1	19	81				
DS 2/04	46			2	3		133		1	1	
DS 2/04	47			10	2	2	56				
DS 2/04	47			10	1		43	4			
DS 2/04	47			5	7	2	181	2			1
DS 2/04	47			7	5	2	60				
DS 2/05	46			9	12	4	103				
DS 2/05	43			2			41				
DS 2/05	43		1	12	9	1	96				
DS 2/05	43			1			21				
DS 2/05	43		2	1		1	54				1
DS 2/06	43			4		1	84				2
DS 2/06	43	1		14	5	4	205	1		1	1
DS 2/06	43	1	1		3	1	212	1			
DS 2/06	43		1	21	4	6	210				
DS 2/07	43		1	1	1		18				
DS 2/07	43			4			58				
DS 2/07	43		1			2	33				20
DS 2/07	43	1		18	3	2	101				
DS 2/08	43			61	20	20	306				
DS 2/08	43			1	2		17				2

Appendix 5 continued

Site	Depth	Pycnogonida	Phyllocaridae	Cumacea	Tanaidacea	Isopoda	Amphipoda	Stomatopoda	Mysidacea	Anomura	Brachyura
DS 2/08	43		1	8	2	4	46				
DS 2/08	43			7	2	3	111	1			
DS 2/09	47			10	4	17	172				
DS 2/09	47			8		1	20				1
DS 2/09	47			8			24				
DS 2/10	43			36	10	5	200				
DS 2/10	43		1	6	3	1	54				1
DS 2/10	43			2	3		23	1			
DS 2/10	43			1		1	31	1			
DS 2/11	43		1	16	2	1	158				1
DS 2/11	43		1	29	2	2	182				
DS 2/11	43			9	4	3	76	2			
DS 2/12	43		1	10	9	8	128	1			
DS 2/12	43		2	11	3	3	239				
DS 2/12	43			8		5	184				
DS 2/12	43			22	1	3	144	1			
DS 2/13	47			4	1	10	121				
DS 2/13	47					1	16	2			1
DS 2/13	47		2	12	8	3	256	2			
DS 2/13	47			2	1	3	59	1			1
DS 2/14	48			4	3	15	187				1
DS 2/14	48			2	1	3	135		1		
DS 2/14	48			11	6	2	227	2			
DS 2/14	48						10				
DS 2/15	49			8	5	13	130		1		
DS 2/15	49			12	3	2	193				
DS 2/15	49			9	3	2	123				
DS 2/16	48			7	4	1	95	1			

Appendix 5 continued

Site	Depth	Pycnogonida	Phyllocaridae	Cumacea	Tanaidacea	Isopoda	Amphipoda	Stomatopoda	Mysidacea	Anomura	Brachyura
DS 2/16	48			1	2		71	1			
DS 2/16	48			2	3		265				
DS 2/16	48		1	6	1		57				
DS 2/17	43			1			21				
DS 2/17	44		1	10	3	2	154				
DS 2/17	44		1	13		2	142		1		2
DS 2/17	44			6			26				
DS 2/18	44			18	5	19	76		1	1	
DS 2/18	44	2		19		31	115	1			
DS 2/18	44			19		20	177				
DS 2/18	44		3	10		2	35	1			
DS 2/19	44			20		28	149				
DS 2/19	44			2		3	16	3			1
DS 2/19	44				1		4				
DS 2/19	44		2	20		15	195	2			
DS 2/20	44		2	22	2	3	188				1
DS 2/20	44			4		1	67	4		1	
DS 2/20	44			17		1	93	1		1	2
DS 2/20	44		1	16	2	2	80				
DS 2/21	44			29	7	4	137			1	3
DS 2/21	44			3		2	104	1			
DS 2/21	44			7	1		82			2	
DS 2/21	44		1	3		2	31			2	
C/1	29					4				17	
C/1	29					3				18	
C/1	29			7		4					
C/1	33			4						1	
C/2	33			2		8				3	

Appendix 5 continued

Site	Depth	Pycnogonida	Phyllocaridae	Cumacea	Tanaidacea	Isopoda	Amphipoda	Stomatopoda	Mysidacea	Anomura	Brachyura
C/2	33			1		5				2	
C/2	33			2		1				2	
C/2	33			4		3				9	
C/3	33			8		15			1	5	
C/3	33			3		2				12	
C/3	33			15		13				4	
C/4	35			5		4				4	
C/4	35			4		7				7	
C/4	34			6		10				1	
C/5	37					10				1	
C/5	37			6		8				7	
C/6	38			2		12				2	
C/6	38			4		7					
DS 1/01	29				1	1				1	
DS 1/01	29			1		1				3	
DS 1/01	29						1				
DS 1/01	29			2	1	2				2	
DS 1/02	30			1	1					3	
DS 1/02	30			1	1						
DS 1/02	30			6		6					
DS 1/02	30			7	1	1			3		
DS 1/03	25	1		1					1		
DS 1/03	25					4				3	
DS 1/03	25					3				3	
DS 1/04	31					7					
DS 1/04	31					5			3		
DS 1/04	31					4		1		3	

Appendix 5 continued

Site	Depth	Pycnogonida	Phyllocaridae	Cumacea	Tanaidacea	Isopoda	Amphipoda	Stomatopoda	Mysidacea	Anomura	Brachyura
DS 1/05	33			3		2					
DS 1/05	33			3	1					6	
DS 1/05	33			1	8	2					
DS 1/06	33			10	1	6		3			
DS 1/06	33									5	
DS 1/06	33			1		1					
DS 1/06	33			1	1	2					
DS 1/07	33			5		7					
DS 1/07	33			3						4	
DS 1/07	33			7	3					7	
DS 1/07	33			4	2		1			1	
DS 1/08	34			1		2					
DS 1/08	34			9		4			1	2	
DS 1/08	34			8	2	1					
DS 1/09	31					3					
DS 1/09	31			4		1					
DS 1/09	31			1						1	
DS 1/09	31			1		2					
DS 1/10	35										
DS 1/10	35			21		14			1		
DS 1/10	35			7	1	4					
DS 1/11	35			10		4				1	
DS 1/11	35			23	1	10					
DS 1/11	35			3	1	4				2	
DS 1/11	35			20	1	5					
DS 1/12	37			8		2				3	
DS 1/12	37					1				3	
DS 1/13	36					1					

Appendix 5 continued

Site	Depth	Pycnogonida	Phyllocaridae	Cumacea	Tanaidacea	Isopoda	Amphipoda	Stomatopoda	Mysidacea	Anomura	Brachyura
DS 1/13	36			12		3			1		
DS 1/13	36			3					1		
DS 1/13	36					2					
DS 1/14	35					4					
DS 1/14	35					1					
DS 1/14	35					2					
DS 1/14	35	1		4	2	8					
DS 1/15	37			4	5	1					
DS 1/15	37			8	2	5					
DS 1/17	38			2	1	5					
DS 1/17	38			6		2					
DS 1/17	38			5	2	4				4	
DS 1/18	38		1	2						2	
DS 1/18	38				4	5	1			2	
DS 1/18	38			5	1	2				2	
DS 1/19	39					4					
DS 1/19	39			1		1					
DS 1/20	39			8		2					
DS 1/20	39					9					
DS 1/20	39					1					
DS 1/20	39					1				4	
DS 1/21	38	1		4			1				
DS 1/21	38			2		7		1			
DS 1/21	38					3				1	
DS 2/01	44			3		15					
DS 2/01	44			4		19					
DS 2/01	44			6	2	14				1	
DS 2/02	46			2	1	4			4		

Appendix 5 continued

Site	Depth	Pycnogonida	Phyllocaridae	Cumacea	Tanaidacea	Isopoda	Amphipoda	Stomatopoda	Mysidacea	Anomura	Brachyura
DS 2/03	46			25	1	41					
DS 2/03	47			6	1	14			1		
DS 2/04	46			20		8					
DS 2/04	47			2		17					1
DS 2/04	47			3		4			1	1	
DS 2/04	47			5		19					
DS 2/04	47			2		27	1				
DS 2/05	46			8	2	16			5		
DS 2/05	43				1	4					
DS 2/05	43			4	2	19		1	1		
DS 2/05	43										1
DS 2/05	43			4	1	5			2		
DS 2/06	43			2	3	6					
DS 2/06	43			5	1	20		1	1	1	
DS 2/06	43				2	10					
DS 2/06	43			2		21			1		
DS 2/07	43					2					
DS 2/07	43				4	1			1		
DS 2/07	43					4					
DS 2/07	43					17					
DS 2/08	43				20	122			1		
DS 2/08	43				1			1			
DS 2/08	43				2	9					
DS 2/08	43			3	2	7					
DS 2/09	47			8	1	36			1		
DS 2/09	47			1	1	3					
DS 2/09	47			2		4			2		
DS 2/10	43					15					1

Appendix 5 continued

Site	Depth	Pycnogonida	Phyllocaridae	Cumacea	Tanaidacea	Isopoda	Amphipoda	Stomatopoda	Mysidacea	Anomura	Brachyura
DS 2/10	43			1	2	2					
DS 2/10	43			2		2			1		
DS 2/10	43					2			2	4	1
DS 2/11	43				1	15			1		
DS 2/11	43			1	2	9			1		
DS 2/11	43			1	2	11			3		
DS 2/12	43			5		40			1		1
DS 2/12	43				5	21	1		1		
DS 2/12	43					2					
DS 2/12	43				3	10					
DS 2/13	47			9		7					1
DS 2/13	47			1							
DS 2/13	47			7		27					
DS 2/13	47			3	2	8		1		1	
DS 2/14	48			9	2	39				1	
DS 2/14	48			6	1	17					
DS 2/14	48			6		40					
DS 2/14	48			1		5					
DS 2/15	49			25		65		1	2		
DS 2/15	49			4		66					
DS 2/15	49			12	1	31					1
DS 2/16	48			4		21					
DS 2/16	48			3	1	6				1	2
DS 2/16	48			11	4	16					
DS 2/16	48			2	1	9			2		
DS 2/17	43			4			1				
DS 2/17	44			4	2	10					
DS 2/17	44			6		16			1		

Appendix 5 continued

Site	Depth	Pycnogonida	Phyllocaridae	Cumacea	Tanaidacea	Isopoda	Amphipoda	Stomatopoda	Mysidacea	Anomura	Brachyura
DS 2/17	44				1	2					
DS 2/18	44			9	1	26					
DS 2/18	44			4	1	18					
DS 2/18	44			4		8		3			
DS 2/18	44			4	2	2					
DS 2/19	44			9		14					
DS 2/19	44			2		1		1		1	
DS 2/19	44				1	3		1			
DS 2/19	44			4	3	19	1				2
DS 2/20	44			2	3	10			3		
DS 2/20	44			3	2	11			6		1
DS 2/20	44			6	4					1	
DS 2/20	44			3	3	6	1				
DS 2/21	44				4	19			3		
DS 2/21	44			4	3	7					

Appendix 6: Indices of abundance and diversity. Avg Total = Average of the total macrofaunal abundance per grab sample site; StDev Total = Corresponding Standard Deviation; CV = Coefficient of variation; $\pm 95\%$ Ci = 95% Confidence interval; Max Total = Maximum number of macrofaunal specimens in any grab at a grab sample site; Avg Tax = Average number of taxonomic groups per grab; Max Tax = Maximum number of taxonomic groups in any grab at that site.

Site	Lat °S	Lat 'S	Long °E	Long 'E	Avg Depth	n	AvgTotal	StDevTotal	CV	$\pm 95\%CI$	MaxTotal	AvgTax	MaxTax
C/1	33	53.900	25	42.400	30.00	4	35.75	31.22	87.34	49.68	73.00	4.25	6
C/2	33	53.700	25	42.900	33.00	4	12.75	4.99	39.15	7.94	18.00	4.75	6
C/3	33	53.250	25	43.100	33.00	3	42.00	19.97	47.56	49.62	65.00	6.33	7
C/4	33	53.400	25	43.360	34.75	4	32.00	12.96	40.50	20.62	46.00	5.25	7
C/5	33	53.010	25	43.620	37.00	2	27.00	2.83	10.48	25.41	29.00	5.00	6
C/6	33	53.180	25	43.900	38.00	2	39.00	1.41	3.63	12.71	40.00	7.00	8
DS 1/01	33	53.394	25	42.372	29.00	4	9.25	5.19	56.09	8.26	13.00	4.75	6
DS 1/02	33	51.126	25	43.770	30.00	4	14.50	4.12	28.44	6.56	19.00	4.25	5
DS 1/03	33	48.966	25	45.126	25.00	3	8.33	4.51	54.11	11.20	13.00	3.67	4
DS 1/04	33	49.860	25	44.904	31.00	3	11.00	6.00	54.55	14.90	17.00	3.67	5
DS 1/05	33	51.786	25	43.710	33.00	3	14.00	2.00	14.29	4.97	16.00	5.33	6
DS 1/06	33	52.494	25	43.266	33.00	4	19.75	6.99	35.41	11.13	29.00	5.00	6
DS 1/07	33	52.974	25	43.260	33.00	4	13.25	4.99	37.67	7.94	17.00	4.25	6
DS 1/08	33	52.206	25	43.740	34.00	3	16.33	3.21	19.68	7.99	20.00	5.00	6
DS 1/09	33	49.734	25	45.252	31.00	4	17.25	14.73	85.38	23.44	36.00	4.25	7
DS 1/10	33	50.334	25	45.186	35.00	3	23.33	17.62	75.50	43.76	43.00	5.00	7
DS 1/11	33	50.544	25	45.054	35.00	4	28.75	14.43	50.19	22.96	45.00	6.00	8
DS 1/12	33	51.480	25	44.460	37.00	2	10.00	12.73	127.28	114.36	19.00	3.00	5
DS 1/13	33	50.886	25	45.126	36.00	4	15.00	8.41	56.04	13.38	24.00	4.25	5
DS 1/14	33	50.574	25	45.318	35.00	4	37.25	18.84	50.58	29.98	65.00	5.75	8
DS 1/15	33	51.876	25	44.520	37.00	2	16.50	2.12	12.86	19.06	18.00	5.50	6
DS 1/16	33	52.260	25	44.520									
DS 1/17	33	51.828	25	44.802	38.00	3	18.00	4.00	22.22	9.94	22.00	5.00	6
DS 1/18	33	51.588	25	44.934	38.00	3	17.33	4.93	28.46	12.25	23.00	5.67	7
DS 1/19	33	51.360	25	45.384	39.00	2	9.00	5.66	62.85	50.82	13.00	4.00	4

Appendix 6 continued

Site	Lat °S	Lat 'S	Long °E	Long 'E	Avg Depth	n	AvgTotal	StDevTotal	CV	± 95%CI	MaxTotal	AvgTax	MaxTax
DS 1/20	33	51.666	25	45.204	39.00	4	14.75	14.08	95.46	22.40	31.00	3.75	7
DS 1/21	33	51.846	25	45.096	38.00	3	18.67	17.21	92.22	42.76	38.00	5.00	6
DS 2/01	33	54.000	25	49.458	44.00	3	145.33	42.39	29.17	105.32	184.00	8.00	9
DS 2/02	33	53.208	25	50.436	46.00	4	175.25	91.28	52.09	145.25	299.00	7.25	9
DS 2/03	33	52.692	25	51.084	47.00	1	134.00				134.00	9.00	9
DS 2/04	33	52.914	25	51.162	47.00	4	120.75	68.91	57.07	109.66	220.00	7.75	10
DS 2/05	33	54.420	25	49.350	43.00	4	72.25	54.80	75.85	87.20	149.00	6.00	9
DS 2/06	33	55.440	25	48.084	43.00	4	215.50	78.04	36.21	124.17	271.00	9.50	13
DS 2/07	33	54.780	25	49.176	43.00	4	68.75	52.73	76.70	83.91	143.00	5.50	7
DS 2/08	33	54.672	25	49.326	43.25	4	180.50	259.93	144.01	413.61	569.00	6.75	8
DS 2/09	33	52.746	25	51.648	47.00	3	107.33	121.84	113.51	302.66	248.00	6.33	7
DS 2/10	33	54.660	25	49.680	43.00	4	102.00	111.42	109.23	177.29	267.00	6.50	9
DS 2/11	33	54.732	25	49.614	43.00	3	180.00	65.48	36.38	162.67	236.00	10.00	12
DS 2/12	33	55.620	25	48.516	43.00	4	219.50	47.76	21.76	76.00	290.00	8.00	10
DS 2/13	33	54.126	25	50.676	47.00	4	142.00	128.10	90.21	203.83	316.00	6.75	9
DS 2/14	33	53.748	25	51.138	48.00	4	185.25	124.01	66.94	197.33	294.00	7.75	11
DS 2/15	33	53.454	25	51.498	49.00	3	237.67	48.34	20.34	120.07	280.00	7.67	10
DS 2/16	33	53.508	25	51.732	48.00	4	150.00	103.95	69.30	165.40	302.00	7.50	10
DS 2/17	33	54.606	25	50.370	43.75	4	107.50	88.46	82.28	140.75	188.00	5.75	9
DS 2/18	33	54.960	25	49.950	43.75	4	179.00	40.18	22.45	63.94	230.00	8.25	10
DS 2/19	33	55.086	25	50.124	44.00	4	130.50	132.34	101.41	210.58	265.00	7.00	12
DS 2/20	33	54.900	25	50.352	44.00	4	144.00	61.40	42.64	97.70	233.00	9.25	13
DS 2/21	33	54.840	25	50.424	44.00	4	119.75	68.33	57.06	108.73	205.00	7.75	10
DS 1 Average											26.05		6.00
C Average											45.17		6.67
DS 2 Average											253.48		9.81

Appendix 7: Available sediment size information analysed according to Brown and McLachlan (1990). All measurements are in phi-units, unless otherwise stated. MPS = median particle size; GMPD = graphic mean particle diameter; PQD = Phi quartile deviation; IGSD = inclusive graphic standard deviation; PQS = particle skewness; Sk1 = inclusive graphic skewness; KG = graphic kurtosis.

Sample	% Mud	MPS	GMPD	PQD	IGSD	PQS	Sk1	KG	Sorting	Skewness
C1	26.26	1.81	1.32	0.29	0.83	-0.12	-0.67	1.60	Moderately	Coarse skewed
C2	11.49	1.90	1.89	0.14	0.26	0.00	-0.07	1.41	Well	Near symmetry
C3	18.02	1.90	1.90	0.15	0.26	0.00	-0.04	1.33	Well	Near symmetry
C4	21.97	1.42	1.39	0.27	0.38	-0.02	-0.09	0.96	Well	Near symmetry
C5	31.85	1.84	1.80	0.23	0.40	-0.04	-0.24	1.35	Well	Coarse skewed
C6	26.59	1.81	1.78	0.26	0.42	-0.04	-0.19	1.23	Well	Coarse skewed
DS 1/01	2.88	1.85	1.81	0.15	0.25	-0.02	-0.27	1.13	Well	Coarse skewed
DS 1/02	13.24	1.89	1.87	0.13	0.23	0.00	-0.11	1.40	Well	Coarse skewed
DS 1/03	Not analysed									
DS 1/04	7.07	1.85	1.75	0.22	0.47	-0.06	-0.47	1.82	Well	Coarse skewed
DS 1/05	Not analysed									
DS 1/06	9.30	1.83	1.77	0.23	0.41	-0.06	-0.32	1.47	Well	Coarse skewed
DS 1/07	Not analysed									
DS 1/08	17.56	1.85	1.80	0.21	0.36	-0.04	-0.28	1.34	Well	Coarse skewed
DS 1/09	36.71	1.89	1.86	0.16	0.34	0.01	-0.22	1.67	Well	Coarse skewed
DS 1/10	58.99	1.98	1.84	0.35	0.66	-0.09	-0.52	1.50	Moderately	Coarse skewed
DS 1/11	34.71	1.77	1.66	0.31	0.66	-0.07	-0.40	1.69	Moderately	Coarse skewed
DS 1/12	40.62	1.83	1.78	0.23	0.38	-0.05	-0.28	1.29	Well	Coarse skewed
DS 1/13	14.92	1.90	1.85	0.20	0.51	-0.02	-0.38	2.16	Moderately	Coarse skewed
DS 1/14	5.76	1.23	1.22	0.34	0.51	-0.01	-0.08	1.05	Moderately	Near symmetry
DS 1/15	Not analysed									
DS 1/16	Not analysed									
DS 1/17	Not analysed									
DS 1/18	56.23	1.86	1.85	0.30	0.50	-0.03	-0.12	1.25	Moderately	Coarse skewed
DS 1/19	10.84	1.86	1.82	0.21	0.36	-0.04	-0.22	1.28	Well	Coarse skewed
DS 1/20	31.80	1.86	1.76	0.30	0.68	-0.07	-0.39	1.89	Moderately	Coarse skewed
DS 1/21	14.30	1.87	1.84	0.22	0.36	-0.03	-0.18	1.20	Well	Coarse skewed

Appendix 7 continued

Sample	% Mud	MPS	GMPD	PQD	IGSD	PQS	Sk1	KG	Sorting	Skewness
DS 2/01	Not analysed									
DS 2/02	3.49	1.88	1.85	0.14	0.26	0.01	-0.16	1.47	Well	Coarse skewed
DS 2/03	Not analysed									
DS 2/04	3.34	1.87	1.84	0.12	0.25	0.00	-0.31	1.76	Well	Coarse skewed
DS 2/05	1.68	1.64	1.59	0.25	0.39	-0.01	-0.25	1.02	Well	Coarse skewed
DS 2/06	2.98	1.80	1.76	0.21	0.32	-0.03	-0.23	1.14	Well	Coarse skewed
DS 2/07	1.98	1.66	1.61	0.25	0.39	-0.01	-0.23	1.06	Well	Coarse skewed
DS 2/08	2.17	1.67	1.61	0.25	0.38	-0.02	-0.29	1.03	Well	Coarse skewed
DS 2/09	Not analysed									
DS 2/10	1.25	1.64	1.61	0.24	0.37	0.00	-0.19	1.02	Well	Coarse skewed
DS 2/11	1.44	1.63	1.59	0.24	0.37	0.00	-0.22	1.04	Well	Coarse skewed
DS 2/12	1.20	1.66	1.63	0.26	0.42	0.01	-0.14	1.16	Well	Coarse skewed
DS 2/13	Not analysed									
DS 2/14	3.30	1.76	1.74	0.19	0.24	-0.01	-0.13	0.79	Well	Coarse skewed
DS 2/15	Not analysed									
DS 2/16	30.61	1.83	1.77	0.23	0.41	-0.06	-0.32	1.47	Well	Coarse skewed
DS 2/17	0.01	1.84	1.78	0.22	0.39	-0.05	-0.33	1.44	Well	Coarse skewed
DS 2/18	1.58	1.56	1.53	0.26	0.39	-0.02	-0.15	0.99	Well	Coarse skewed
DS 2/19	Not analysed									
DS 2/20	1.19	1.41	1.38	0.28	0.40	-0.03	-0.09	0.92	Well	Near symmetry
DS 2/21	1.22	1.51	1.49	0.25	0.38	-0.03	-0.10	1.01	Well	Coarse skewed

APPENDIX 8: EVALUATING AND PRESENTING THE IMPACT DATA

1. EVALUATION

To ensure a direct comparison between various specialist studies, six standard rating scales were defined and used to assess and quantify the identified impacts. This is necessary since impacts have a number of parameters that need to be assessed. The rating system used for assessing issues is based on three criteria, namely:

- 1) The relationship of the issue to temporal scales (Box A8.1);
- 2) The relationship of the issue to spatial scales (Box A8.2); and
- 3) The severity of the issue (Box A8.3).

These three criteria are combined to describe the overall importance rating, namely the significance (Box A8.4). In addition, the following parameters are used to describe the issues:

- 4) The risk or likelihood of the issue occurring (Box A8.5); and
- 5) The degree of confidence placed in the assessment of the issue (Box A8.6).

1.1 TEMPORAL SCALE

The temporal scale (Box A8.1) defines the significance of the impact at various time scales, as an indication of the duration of the impact.

Box A8.1: Temporal scale used in assessing issues.

<u>Short term</u> -	less than 5 years. Many construction phase impacts will be of a short duration.
<u>Medium term</u> -	between 5 and 20 years.
<u>Long term</u> -	between 20 and 40 years (a generation) and from a human perspective, essentially permanent.
<u>Permanent</u> -	over 40 years and resulting in a permanent and lasting change that will always be there.

1.2 SPATIAL SCALE

The *spatial scale* (Box A8.2) defines physical extent of the impact.

Box A8.2: Eight point spatial scale used in the EIA.

<i>Individual</i>	- This scale applies to person/s in and around the study area.
<i>Household</i>	- This scale applies to households in and around the study area.
<i>Localised</i>	- At localised scale and a few square kilometres in extent. The specific area to which it refers is defined in the chapter in which it appears.
<i>Dredge Area</i>	- The dredge and disposal sites and immediate surrounds.
<i>District</i>	- P.E. metropole and surrounds.
<i>Regional</i>	- East Cape Province.
<i>National</i>	- Republic of South Africa.
<i>International</i>	

1.3 SEVERITY/BENEFICIAL RATING SCALE

The *severity scale* (Box A8.3) was used by the various specialists in order to scientifically evaluate how severe negative impacts would be, or how beneficial positive impacts would be on a particular affected system (for ecological impacts) or a particular affected party. It is a methodology that attempts to remove any value judgements from the assessment, although it relies on the professional judgement of the specialist.

Box A8.3: Severity/beneficial scale used in the assessment of impacts/issues.

<p><i>Very severe</i> An irreversible and permanent change to the affected system(s) or party(ies) which cannot be mitigated. For example, the permanent change to topography resulting from a quarry.</p>	<p><i>Very beneficial</i> A permanent and very substantial benefit to the affected system(s) or party(ies), with no real alternative to achieving this benefit. For example, the creation of a large number of long term jobs.</p>
<p><i>Severe</i> Long term impacts on the affected system(s) or party(ies) that could be mitigated. However, this mitigation would be difficult, expensive or time consuming or some combination of these. For example, the clearing of forest vegetation.</p>	<p><i>Beneficial</i> A long term impact and substantial benefit to the affected system(s) or party(ies). Alternative ways of achieving this benefit would be difficult, expensive or time consuming, or some combination of these. For example, an increase in the local economy.</p>
<p><i>Moderately severe</i> Medium to long term impacts on the affected system(s) or party(ies), that could be mitigated. For example, constructing a narrow road through vegetation with a low conservation value.</p>	<p><i>Moderately beneficial</i> A medium to long term impact of real benefit to the affected system(s) or party(ies). Other ways of optimising the beneficial effects are equally difficult, expensive and time consuming (or some combination of these), as achieving them in this way. For example, a slight improvement in the (local) roads.</p>
<p><i>Slight</i> Medium or short term impacts on the affected system(s) or party(ies). Mitigation is very easy, cheap, less time consuming or not necessary. For example, a temporary fluctuation in the water table due to water abstraction.</p>	<p><i>Slightly beneficial</i> A short to medium term impact and negligible benefit to the affected system(s) or party(ies). Other ways of optimising the beneficial effects are easier, cheaper and quicker, or some combination of these. For example, a slight increase in the amount of goods available for purchasing.</p>
<p><i>No effect</i> The system(s) or party(ies) is not affected by the proposed development.</p>	<p><i>Don't know/Can't know</i> In certain cases it may not be possible to determine the severity of an impact.</p>

1.4 SIGNIFICANCE SCALE

The ENVIRONMENTAL SIGNIFICANCE scale is an attempt to evaluate the importance of a particular impact. This evaluation needs to be undertaken in the relevant context, as an impact can either be ecological or social, or both. The evaluation of the significance of an impact relies heavily on the values of the person making the judgement. For this reason, impacts of especially a social nature need to reflect the values of the affected society. A six-point significance scale has been applied (see Box A8.4).

In many cases scientists have to produce an assessment in the absence of all the relevant and necessary data. American legislation (CEQ regulations at 40 CFR 1502.22) has considered these limitations, and makes the following recommendations:

“When an agency is evaluating reasonably foreseeable significant adverse effects on the human environment in an Environmental Impact Statement (EIS) and there is incomplete or unavailable information, the agency shall always make clear that such information is lacking if the incomplete information is essential to a reasoned choice among alternatives. If the overall costs of obtaining it are not exorbitant, the agency shall include the information in the EIS”.

There are two acceptable procedures to follow to compensate for a shortage of data:

It is more important to identify likely environmental impacts than to precisely evaluate the more obvious impacts

All assessors (the different specialists) try to evaluate all the significant impacts, recognising that precise evaluation is not possible. It is better to have a *possible* or *unsure* level of certainty on important issues than to be *definite* about unimportant issues.

It is important to be conservative when reporting likely environmental impacts

Because of the fact that assessing impacts with a lack of data is more dependable on your own scientific judgement, the rating on the certainty scale cannot be too high. If the evidence for a potential type of impact is not definitive in either direction, the conservative conclusion is that the impact **cannot be ruled out with confidence**, not that the impact is not proven. It is for these reasons that a *degree of certainty* scale has been provided, as well as the categories DON'T KNOW and CAN'T KNOW.

Box A8.4: The significance rating scale

VERY HIGH

These impacts would be considered by society as constituting a major and usually permanent change to the (natural and/or social) environment, and usually result in **severe** or **very severe** effects, or **beneficial** or **very beneficial** effects.

Example: The loss of a species would be viewed by informed society as being of VERY HIGH significance.

Example: The establishment of a large amount of infrastructure in a rural area which previously had very few services, would be regarded by the affected parties as resulting in benefits with a VERY HIGH significance.

HIGH

These impacts will usually result in long term effects on the social and/or natural environment. Impacts rated as HIGH will need to be considered by society as constituting an important and usually long term change to the (natural and/or social) environment. Society would probably view these impacts in a serious light.

Example: The loss of a diverse vegetation type, which is fairly common elsewhere, would have a significance rating of HIGH over the long term, as the area could be rehabilitated.

Example: The change to soil conditions will impact the natural system, and the impact on affected parties (in this case people growing crops on the soil) would be HIGH.

MODERATE

These impacts will usually result in medium to long term effects on the social and/or natural environment. Impacts rated as MODERATE will need to be considered by society as constituting a fairly important and usually medium term change to the (natural and/or social) environment. These impacts are real but not substantial.

Example: The loss of a sparse, open vegetation type of low diversity may be regarded as MODERATELY significant.

Example: The provision of a clinic in a rural area would result in a benefit of MODERATE significance.

LOW

These impacts will usually result in medium to short term effects on the social and/or natural environment. Impacts rated as LOW will need to be considered by the public and/or the specialist as constituting a fairly unimportant and usually short term change to the (natural and/or social) environment. These impacts are not substantial and are likely to have little real effect.

Example: The temporary change in the water table of a wetland habitat, as these systems are adapted to fluctuating water levels.

Example: The increased earning potential of people employed as a result of a development would only result in benefits of LOW significance to people who live some distance away.

NO SIGNIFICANCE

There are no primary or secondary effects at all that are important to scientists or the public.

Example: A change to the geology of a particular formation may be regarded as severe from a geological perspective, but is of NO significance in the overall context.

DON'T KNOW

In certain cases it may not be possible to determine the significance of an impact. For example, the primary or secondary impacts on the social or natural environment given available information.

Example: The effect of a particular development on people's psychological perspective of the environment.

1.5 RISK OR LIKELIHOOD

The risk or likelihood (Box A8.5) of all impacts taking place as a result of project actions differs. There is no doubt that some impacts would occur if the port facility goes ahead, but certain other (usually secondary) impacts are not as likely, and may or may not result from the port facility. Although these impacts may be severe, the likelihood of them occurring may affect their overall significance and will be taken into account.

Box A8.5: The risk or likelihood scale used in assessing impact/issues.

Very unlikely to occur – the chance of these impacts occurring is extremely slim, e.g. a tidal wave destroying the harbour.

Unlikely to occur – the risk of these impacts occurring is slight, but impacts such as an oil spill may occur.

May occur – the risk of these impacts is more likely, although it is not definite, for example the chance that a road accident may occur as a result of harbour activities.

Will definitely occur – there is no chance that this impact will not occur, for example increased shipping in Ngqura Harbour.

1.6 DEGREE OF CONFIDENCE OR CERTAINTY

It is also necessary to state the degree of certainty or confidence (Box A8.6) with which one has predicted the significance of an impact. For this reason, a 'degree of certainty' scale has been provided to enable the reader to ascertain how certain we are of our assessment of significance:

Box A8.6: The degree of confidence or certainty scale used in the EIA.

Definite : More than 90% sure of a particular fact. To use this one will need to have substantial supportive data.

Probable : Over 70% sure of a particular fact, or of the likelihood of that impact occurring.

Possible : Only over 40% sure of a particular fact or of the likelihood of an impact occurring.

Unsure : Less than 40% sure of a particular fact or the likelihood of an impact occurring.

2. PRESENTATION OF IMPACTS

In the Environmental Impact and Mitigation chapters, the impacts must be related/grouped around Key Issues. The reason behind this is that many impacts may relate to a single issue and thus need to be grouped together to avoid repetition. This is not to say that a Key Issue may not have a single impact only.

Each Impact needs to be assessed using the following sub headings:

a) Cause and comment

This section outlines the background to the impact, the nature of the impact and most importantly any design criteria that have already been included into the project which reduces the impact of the project action.

b) Significance statement

The significance statement outlines the impact according to the different evaluation criteria. Please take note of the following examples:

c) Mitigation and management

This section outlines any regulations which automatically regulate the impact and any recommended mitigatory actions which will reduce the significance of the impact.

Please note that while each impact requires a **significance statement** and a **mitigation and management section**, the cause and comment descriptions may be grouped under one issue where applicable. In this situation the impacts will be similar in nature and thus do not warrant a separate cause and comment section for each impact. If the impacts relate to one issue but are very different in nature, then the cause and comment sections should be done per impact.

3. SUMMARY TABLES

Summary tables must be included at the end of each section.