



TRANSNET NATIONAL PORTS AUTHORITY

**SCOPING AND ENVIRONMENTAL IMPACT
REPORTING PROCESS FOR THE
DEVELOPMENT OF NEW BERTH 605 AND
ASSOCIATED INFRASTRUCTURE TO
SUPPORT THE CONTAINER HANDLING
FACILITY, PORT OF RICHARDS BAY,
KWAZULU-NATAL**

WAVE CLIMATE AND SHORELINE CHANGE STUDY

DOCUMENT NO: XRB.E.0030-T001-RPT-0107



TRANSNET NATIONAL PORTS AUTHORITY

**SCOPING AND ENVIRONMENTAL IMPACT
REPORTING PROCESS FOR THE DEVELOPMENT
OF NEW BERTH 605 AND ASSOCIATED
INFRASTRUCTURE TO SUPPORT THE
CONTAINER HANDLING FACILITY, PORT OF
RICHARDS BAY, KWAZULU-NATAL**

WAVE CLIMATE AND SHORELINE CHANGE STUDY

REPORT: CONFIDENTIAL

PROJECT NO. TNPA/2023/09/0019/43828/RFP

OUR REF. NO. 43102871

DATE: MARCH 2026

WSP

Building 1, Maxwell Office Park
Magwa Crescent West, Waterfall City
Midrand, 1685
South Africa

Phone: +27 11 254 4800

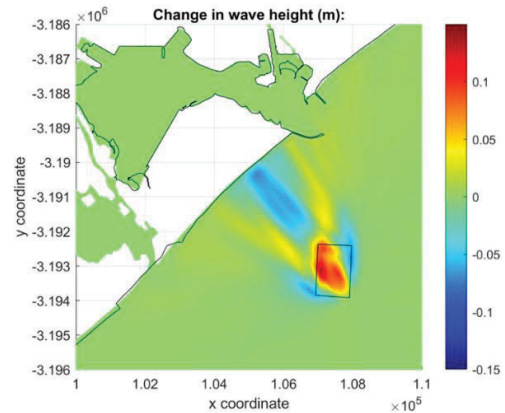
WSP.com

QUALITY CONTROL

Issue/revision	First issue	Revision 1	Revision 2	Revision 3
Remarks	Draft Final	Draft Final	Rev 02 to reflect final TNPA comments.	-
Date	7 May 2025	18 October 2025	9 March 2026	-
Prepared by	Geoff Smith, Roy van Ballegooyen, Samantha-Kerry Fourie, Nicki Abel, Danie Theron, and Gert Jacobs	Geoff Smith, Roy van Ballegooyen, Samantha-Kerry Fourie, Nicki Abel, Danie Theron, and Gert Jacobs	Geoff Smith, Roy van Ballegooyen, Samantha-Kerry Fourie, Nicki Abel, Danie Theron, and Gert Jacobs	-
Signature				-
Checked by	Yasmin Kistner Ruan Gilau	Roy van Ballegooyen, Ruan Gilau	Ruan Gilau	-
Signature				-
Authorised by	Wayne Petersen	Wayne Petersen	Wayne Petersen	-
Signature			 Petersen, Wayne (ZAWP04720)	-
Project number	43102871	43102871	43102871	-
Report number	XRB.E.0030-T001-RPT-0107 Rev 00	XRB.E.0030-T001-RPT-0107 Rev 01	XRB.E.0030-T001-RPT-0107 Rev 02	-
File reference	XRB.E.0030-T001-RPT-0107 – Wave Climate and Shoreline Change Study_Rev00.docx	XRB.E.0030-T001-RPT-0107 – Wave Climate and Shoreline Change Study_Rev01.docx	XRB.E.0030-T001-RPT-0107 – Wave Climate and Shoreline Change Study_Rev02.docx	-

EXECUTIVE SUMMARY

This specialist EIA study assesses the potential impacts of dredged material disposal at the existing Richards Bay offshore disposal site, focusing primarily on expected changes to the inshore wave climate, resulting alterations in sediment transport, and potential shoreline changes.



INTRODUCTION

The new Berth 605 is intended to be developed adjacent to the existing Berth 600 series, located in the Bayvue Precinct in the western region of the Port of Richards Bay (see figure below). The intention of the proposed new Berth 605 is to serve a proposed new container handling facility that is ultimately intended to increase container volumes handled at the port to stimulate economic development in the region.



Port of Richards Bay and the location of the proposed New Berth 605 and Container Handling Facility (CHF)

SCOPE OF WORK

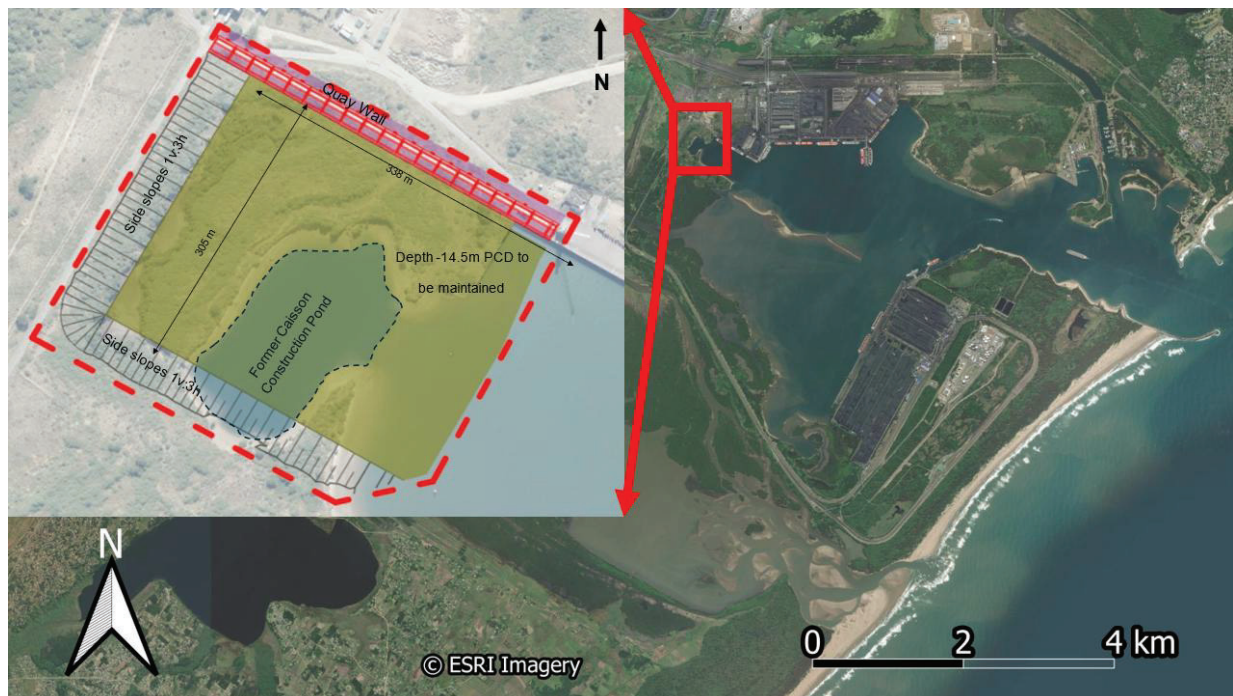
Based on the latest available information (project-specific geotechnical surveys and progressed engineering designs), the dredging required for the proposed Berth 605 development will result in disposal of approximately 4.23 million m³ of bulked material at the designated disposal site offshore. This is a slight reduction in the conservative 4.3 million m³ assumed in the wave modelling undertaken for this study. The altered bathymetry is likely to cause changes in nearshore wave conditions which in turn may affect:

- storm wave conditions impacting on the protective breakwaters; and
- longshore sand transport conditions, which may induce erosion and accretion of the shoreline.

This report assesses these potential environmental impacts.

DREDGING AND DREDGE MATERIAL DISPOSAL

A required depth of -14.5 m PCD needs to be maintained to accommodate the design vessel (see figure below). To achieve this depth, the basin area will be excavated by means of dredging, except for the topsoil (an assumed 300 mm of surface material) and associated vegetation that is to be removed and carted away separately. In addition to this basin dredging material, material will be excavated for road and rail construction as well as for the quay wall construction. The dredging will take place using a Cutter Suction Dredger (CSD) with material loaded into barges and transported to an offshore disposal site, here assumed to be the existing dredge spoil disposal site that is presently used for the disposal of spoil from ongoing maintenance dredging activities.



Basin area to be excavated plus outline of the existing pond where caissons were formerly cast, shown in the locational context of the Port of Richards Bay (Source WSP, 2024b).

DESCRIPTION OF THE PROPOSED DREDGING

Based on the initial geotechnical information and engineering designs available at the time of the commencement of this study, the total volume to be dredged by the cutter suction dredger (CSD) was estimated to be 2 895 000 m³. This consisted of:

- 2 393 000 m³ of *in-situ* material (including an allowance for overdredging) to be dredged from the berth areas and basin, accounting for approximately 83% of the total volume.
- 502 500 m³ of bulked material (using a bulking factor of 1.3) that has been placed in the former caisson construction pond, making up the remaining 17 % volume of material to be dredged by the CSD.

Due to the expected transformation of the rock material by the CSD and an assumed consolidation period of approximately one month, the volumes to be placed at the offshore disposal site are higher than the initial dredged volumes. In this initial assessment of material volumes that informed the wave and shoreline modelling undertaken for this study, a bulking factor of 1.55 was applied resulting in 4 308 290 m³ of bulked material to be disposed onto the offshore disposal site, comprising:

- 599 140 m³ of offshore disposal volume from excavated material excavated “in-the-dry” placed in the former caisson pond.
- 3 709 150 m³ of offshore disposal volume from material dredged in the berth areas and basin.

Available geotechnical data for this initial assessment included boreholes along the quay line and three additional boreholes to the west and south of the dredging area. No further project-specific data were available when the modelling necessary to inform this study was undertaken. Based on this limited information, the assumed material composition of *in-situ* volumes of material to be excavated and dredged were initially estimated to be as follows:

- Basin excavation: 23% Sand, 43% Silty clay, 21% Silty/Clayey sand, 13% Siltstone;
- Quay wall and road excavation: 29% Sand, 15% Silty clay, 17% Silty/Clayey sand, 39% Siltstone;

This resulted an estimated overall material composition of *in-situ* volume of material to be both excavated and dredged: of 23% Sand, 39% Silty clay, 21% Silty/Clayey sand, 17% Siltstone.

However, based on the updated geotechnical survey data and progressed engineering designs, a re-assessment of dredge volumes and types of dredge material has resulted in changes in overall estimated dredge volumes and material types as follows.

The total volume to be dredged by the cutter suction dredger (CSD) presently is estimated to be 2 907 810 m³. This consists of:

- 1 475 130 m³ of *in-situ* material (including an allowance for overdredging) to be dredged from the berth areas and basin, accounting for approximately 51% of the total volume.
- 1 432 680 m³ of bulked material (using a bulking factor of 1.3) that has been placed in or over the former caisson construction pond, making up the remaining 49 % volume of material to be dredged by the CSD.

Furthermore, based on an updated estimated (conservative) bulking factor of 1.64, it is estimated that 4 226 590 m³ of bulked material will be disposed of onto the offshore disposal site, comprising:

- 1 807 380 m³ of offshore disposal volume from excavated material excavated “in-the-dry” placed in or over the former caisson pond.
- 2 317 710 m³ of offshore disposal volume from the berth areas and basin.

Based on the updated geotechnical survey information and progressed engineering designs, the presently assumed material composition for all *in-situ* material to be excavated “in-the-dry” and dredged is 23% Sand, 39% Silty clay, 21% Silty/Clayey sand, 17% Siltstone.

Upon being dredged by a CSD, the 80% of the siltstone dredged is expected to be transformed into coarse material ($d_{50} = 6 \text{ mm}$) and the remaining 20% into fines ($< 63 \mu\text{m}$). This will change the material types disposed of on the offshore disposal site by transforming the rock into gravels and also increasing the overall fines content the dredged material released onto the offshore disposal site.

RETENTION OF DREDGE MATERIAL ON THE DISPOSAL SITE

Analysis of historical data suggests that most material disposed of at the offshore site is lost during the disposal process itself. Maintenance dredging material ($< 600\,000 \text{ m}^3/\text{year}$) appears to disperse relatively quickly, while larger volumes from capital dredging remain longer. This is likely due to the larger quantities and more rapid rate of accumulation and associated changes in depth on the disposal site (e.g., concentrated deposition in mounds) and the coarser nature of the material. This highlights the importance of spreading material as widely as possible across the disposal site to enhance dispersion; however, it should be noted that material initially is more rapidly removed from these mounds due to wave effects in the resultant shallower waters. While the fines eroded from the mounds are widely dispersed, this is not necessarily true for the sands and coarser materials on the mound that are likely to remain initially within the confines of the site and be more slowly dispersed from the disposal site.

Assuming that all dredged material placed on the disposal site remains on-site for the duration of the wave and shoreline change assessment (*i.e.* long-term), as was done for this study; is a highly conservative, given that historically no more than approximately 40% remains at the Richards Bay disposal site immediately after capital dredging and disposal activities and continues to erode from the site thereafter (albeit at a much lower rate). This assessment of the rate of removal of material from the disposal sites was made for dredge material comprising sand and silts. However, should a significant proportion of the material from capital dredging include rock (siltstone) as indicated by the initial assessment of the material to be dredged for Berth 605, then the volume remaining on the disposal site immediately after the cessation of capital dredging and disposal activities could be higher (perhaps as much as 60%, depending on the actual volumes of rock or rock-derived coarser material in the dredge material placed on the site).

However, compared to the initial assessment of material types used in the modelling studies, the re-assessment of updated, project-specific geotechnical survey data indicate an estimated 15% increase in the dry mass of less mobile non-cohesive sediments and a 40% decrease in more mobile fine sediments being released onto the disposal site. This suggests a slower dispersion of dredge material off the existing dredge spoil disposal site than that modelled. This greater longevity of dredge material on the disposal site (constituting a longer duration of effective reduction in the capacity of the dredge spoil disposal site), increases the risk of there being limitations on the rate of maintenance dredge spoil disposal onto the disposal site in the short- to medium-term.

Should one consider the cumulative impact associated with additional dredged material having been placed on the disposal site from another capital dredging project occurring within a similar time frame (say within 6 months to 18 months prior or after the occurrence of Berth 605 disposal activities), the present assessment (of potential wave and shoreline changes) will be less conservative but nevertheless remain valid for any development project within the Port of Richards Bay of a similar or lesser volume of capital dredging being undertaken for the Berth 605 project. All known imminent proposed projects meet this criterion, with the exception of the proposed Berth 210 project that involves the dredging of an estimated ~5 million m³ of *in-situ* material expected to comprise mainly more mobile material (fines and sand, with a limited or no rock component).

The updated dredge description based on additional geotechnical information and progressed engineering designs received after the completion of the modelling undertaken to inform this study, indicate an approximate 15% increase in the volume of non-cohesive (gravels and sand) material and an approximate 40% decrease in cohesive (fines) material placed on the dredge spoil disposal site. This suggests an increased longevity of the dredge spoil on the disposal site and that the time elapsed between major capital dredging activities possibly will need to be increased (~18 months to 2 years, depending on the nature of the dredge material from the other capital dredging operation) to ensure that there will be no significant risk of cumulative impacts due to persistent depth-related changes in wave climate and possible associated change in adjacent shorelines.

Given the conservative nature of the assumption in the modelling study to inform the assessment of wave and potential shoreline change in the present study can be considered to account for the cumulative impact of both the Berth 605 dredging and disposal activities at least one additional similar-sized major development occurring within roughly the same time frame as the Berth 605 development.

CHANGES IN EXTREME WAVE CONDITIONS

To assess changes in the wave climate, 87 representative wave conditions, covering wave height, period, direction and frequency of occurrence, were synthesized from the offshore wave time series. Extreme wave conditions were also selected to evaluate how bathymetric changes from dredge disposal might influence nearshore extremes in wave conditions. To ensure directional coverage, the highest wave conditions per 22.5° sector were chosen, including both long and short wave periods where relevant.

Using this representative extreme wave climate, two scenarios were simulated: the existing bathymetry and the post-disposal bathymetry. For the latter, a bulked dredge material disposal volume of ~4.3 million m³ was spread across the disposal site resulting in an even -13.5 m CD water depth across the site with a slightly shallower mound in the northern area of the disposal site where the dredge disposal has been concentrated in recent times and the existing water depth is already shallower than -13.5 m CD. This results in elevation of the seabed (*i.e.*, decrease in water depth) by up to 7 m in the deeper waters of the disposal site.

Wave data at 10 m depth opposite the breakwater showed that, under all extreme scenarios, wave height increases were no more than 5 cm. Even under more severe conditions, increases are unlikely to exceed 10 cm, suggesting minimal impact on breakwater stability.

SHORELINE CHANGE

Changes in wave climate resulting from dredge spoil disposal activities are expected to influence longshore sediment transport along the Richards Bay coastline, potentially leading to localised shoreline erosion or accretion. This study quantified the impact of altered wave climate on sediment transport and assessed the resulting shoreline response and potential coastal management needs.

The existing sediment transport regime is predominantly northward, increasing from the southern beaches to areas north of the port, with an estimated overall magnitude of approximately 800 000 m³/year. Using the UNIBEST CL+ model, wave-induced longshore transport was simulated at several locations between south of Mhlathuze Estuary and the north of the port entrance. The CoastLine (CL) module was then applied in *difference mode* to estimate shoreline evolution based solely on changes in sediment transport (caused by changes in the wave climate associated with dredge spoil disposal), excluding any existing trends.

Model results indicate variable changes on the longshore transport rate along the coast: negligible change at the far-south beach (south of the Mhlathuze Estuary mouth), a 2% reduction at the estuary mouth, a maximum 21% reduction in central and far-southern beaches, a maximum 17% increase near the south breakwater, and a 4% increase in northern areas. In the southernmost areas (south of the Mhlathuze Estuary), the predicted effects on the shoreline are generally minimal. Further north, along the central beach (between the estuary mouth and the south breakwater), more pronounced impacts are anticipated. Localised erosion may require manageable intervention, such as sand nourishment, particularly in the narrowest beach segments where the beach is currently relatively constrained. Near the south breakwater, slightly more severe erosion is predicted, up to 13 m over a 40-year period, but this is expected to be manageable given the existing wide beach in that area.

Lastly, an assessment of historical shoreline changes associated with offshore disposal indicates that, while such activities may have some influence on the central and far-southern beaches, the observed changes are inconsistent and appear minimal, likely overshadowed by other contributing factors. In contrast, the assessment of onshore disposal on the northern beaches highlights the effectiveness of direct beach nourishment in stabilizing vulnerable shorelines.

SUMMARY OF RESULTS

A brief summary of the results:

- **Extreme Wave Conditions:** Simulations show that dredge spoil disposal will cause only minor increases in wave height (≤ 10 cm), with minimal impact on breakwater stability. Most wave changes will affect the shoreline between the Mhlathuze Estuary and the southern breakwater.
- **Shoreline Change:** Altered wave conditions may slightly shift longshore sediment transport, leading to localized erosion or accretion. The most notable erosion (up to 13 m over 40 years) is expected near the south breakwater but is considered manageable. Historical data suggest offshore disposal has minimal long-term shoreline impact, while onshore disposal has been effective for beach stabilization on the northern beaches.

The above results are conservative in that the assumed longevity of the changes in water depth on the dredge spoil disposal site (40 years) is unlikely due to the dispersion of dredged material off the disposal site.

CONCLUSIONS AND RECOMMENDATIONS

Changes in Extreme Wave Conditions:

Analysis of extreme wave scenarios at 10 m depth along the breakwater indicates a maximum wave height increase of 5 cm, with a conservative upper bound of 10 cm. These changes are minimal and unlikely to affect breakwater stability.

Changes in Sediment Transport:

The assessment evaluated how dredge spoil disposal might alter northerly longshore sediment transport along the coastline from the far-southern beach to the northern beach. The impact of dredge spoil disposal on longshore sediment transport varies along the coastline, with most changes expected to be negligible. The region of the central beach (Mhlathuze Estuary mouth to the south breakwater) could experience detrimental erosion since the beach is currently narrow. However, this risk is mitigated to some extent by the rapid natural redistribution of dredged material, making the model results conservative for the Berth 605 project alone. Cumulative impacts from future projects are expected to be limited if sufficient time separates dredging events.

Recommendations:

Recommendations of the study are as follows:

- Conduct annual satellite-based shoreline monitoring, particularly along the southern beach.
- If beach width reduces to 20–30 m, consider targeted beach nourishment.
- Reassess cumulative impacts if multiple dredging projects are planned in close succession.

Contact name Geoff Smith

Contact details 072 573 8701 | geoffrey.smith@wsp.com

CONTENTS

EXECUTIVE SUMMARY	15
1 INTRODUCTION	1
1.1 BACKGROUND	1
1.2 SCOPE OF WORK	1
1.3 REPORT STRUCTURE	2
2 DREDGING AND DISPOSAL	3
2.1 DREDGING METHODOLOGY	3
2.1.1 QUANTITY OF MATERIAL TO BE DREDGED	4
2.1.2 COMPOSITION OF MATERIAL TO BE DREDGED	7
2.2 BENEFICIAL USE	8
2.3 DISPOSAL	8
3 ENVIRONMENTAL CONDITIONS	9
3.1 WINDS	9
3.2 WAVES	11
4 SEDIMENT RETENTION ON THE DISPOSAL SITE	14
4.1 FACTORS AFFECTING THE RATE OF DISPERSION OF SEDIMENTS FORM THE DREDGE DISPOSAL SITE	14
4.2 DREDGE DISPOSAL SITE	15
4.2.1 HISTORICAL VOLUMES DISPOSED OFFSHORE	15
4.2.2 BATHYMETRY SURVEYS	15
4.2.3 RETENTION OF DREDGE MATERIAL ON THE DISPOSAL SITE	17
5 WAVE MODEL SETUP AND CALIBRATION MODELLING	21
5.1 INTRODUCTION	21
5.1.1 DESCRIPTION OF THE WAVE MODEL	21

5.1.2	WAVE MODEL SETUP	21
5.1.3	WAVE MODEL CALIBRATION	24
6	CHANGES IN WAVE CONDITIONS DUE TO DREDGE DISPOSAL	28
6.1	INTRODUCTION	28
6.2	BATHYMETRY CHANGES DUE TO DREDGE DISPOSAL	28
6.3	DREDGE SPOIL DISPOSAL SCENARIO RESULTS	30
6.3.1	EXTREME WAVE CONDITIONS	30
6.3.2	FULL WAVE CLIMATE	31
7	CHANGES IN SEDIMENT TRANSPORT	34
7.1	EXISTING SEDIMENT TRANSPORT REGIME	34
7.2	APPROACH TO THE ASSESSMENT	35
7.3	RESULTS AND ANALYSIS	36
7.4	SUMMARY	40
8	CONCLUSIONS AND RECOMMENDATIONS	41
8.1	CHANGES IN EXTREME WAVE CONDITIONS	41
8.2	CHANGES IN SEDIMENT TRANSPORT	41
8.3	RECOMMENDATIONS	41
9	REFERENCES	42

TABLES

Table 2-1: Updated assessment of Dredging Volumes	6
Table 2-2: Re-evaluation of the composition of <i>in-situ</i> dredge material.	7
Table 3-1: Percentage (%) exceedance of significant wave height (H_{m0})	11
Table 3-2: The percentage joint occurrence distribution of wave height versus peak period based on all data	13
Table 4-1: Volume of dredging material (for assumed bulking factors of 1.20, 1.35 and 1.55) that has been disposed and subsequently accreted and/or eroded from the dredge disposal site for various time periods.	18
Table 6-1: Extreme wave conditions selected	30
Table 6-2: Predicted change in the most extreme wave condition	31
Table 7-1: Percentage change in sediment transport rate along the study area	37
Table 7-2: Resultant shoreline changes from difference model	39

FIGURES

Figure 1-1: Port of Richards Bay and the location of the proposed New Berth 605 and Container Handling Facility (CHF) (WSP from Google Earth, 2024)	1
Figure 2-1: Basin area to be excavated plus outline of the existing pond where caissons were formerly cast (Source WSP, 2024b).	4
Figure 3-1: Location of the wind stations in Port of Richards Bay	9
Figure 3-2: Wind roses at the Southern Breakwater, Port of Richards Bay, (Latitude: -28.81399°S, Longitude: 32.0978°E), for the period of 1994 to 2016.	10
Figure 3-3: Location of Waverider buoy (Latitude: -28.8265, Longitude: 32.1040)	11
Figure 3-4: Wave roses based on Waverider data collected outside Port of Richards Bay, (Latitude: -28.8265°S, Longitude: 32.1040 °E) for the period of 1979 to 2002.	12
Figure 4-1: Bathymetry (m CD) of the dredge disposal site (black inner outline) and the physical monitoring site (brown outer outline)	16
Figure 5-1: Large wave grid (black) and detailed curvilinear wave grid (blue)	22
Figure 5-2: Large wave grid bathymetry (CD)	23
Figure 5-3: Detailed wave grid bathymetry (CD) with existing dumpsite outlined in black	23
Figure 5-4: Detailed grid bathymetry (CD): zoomed in at dumpsite (indicated in black line - inner) and physical monitoring site (outlined in brown - outer)	24
Figure 5-5: Measured(black) and modelled (red) wave parameters at Waverider buoy during August 2005	25
Figure 5-6: Measured (black) and modelled (red) wave parameters at Waverider buoy during September 2005	25
Figure 5-7: Measured (black) and modelled (red) wave parameters at Waverider buoy during October 2005	26
Figure 5-8: Measured (black) and modelled (red) wave parameters at Waverider buoy during November 2005	26
Figure 5-9: Measured (black) and modelled (red) wave parameters at Waverider buoy during December 2005	27
Figure 5-10: Measured (black) and modelled (red) wave parameters at Waverider buoy during January 2006	27
Figure 6-1: Existing bathymetry (CD) at dumpsite before dredge spoil activities	29
Figure 6-2: Bathymetry (CD) at dumpsite after dredge spoil activities	29
Figure 6-3: Resultant change in wave height (m)	32

Figure 6-4: Resultant change in wave direction (° from TN 0)	32
Figure 6-5: Locations of interest for which output data from the wave model have been extracted to inform the sediment transport assessment	33
Figure 7-1: Richards Bay coastline types.	34
Figure 7-2: Cross-shore profile locations.	36
Figure 7-3: Erosion and Accretion zones resulting from dredge disposal activity	40

APPENDICES

APPENDIX A

HISTORICAL SHORELINE CHANGES

APPENDIX B

CHANGES IN EXTREME WAVE CONDITIONS

GLOSSARY

The glossary presented in Table 1 offers a reference for defines terms used throughout this document.

Table 1 - Glossary

Term	Definition
°	Degrees (used for direction)
µm	Micrometres
BF	Bulking Factor
CD	Chart Datum
CHF	Container Handling Facility
CL	CoastLine (shoreline evolution model)
CSD	Cutter Suction Dredger
CSIR	Council for Scientific and Industrial Research
d50	Median grain size diameter
DELFT3D	Delft Hydraulics 3D modelling suite
EIA	Environmental Impact Assessment
Hm ₀	Significant wave height
IPOSS	Integrated Port Operations Safety System
km	Kilometres
LLD	Land Levelling Datum
m	Metres
m/s	Metres per second

Term	Definition
m ³	Cubic metres
mm	Millimetres
PCD	Port Chart Datum
PRDW	Port and Coastal Engineering Consultants
Rev	Revision
RFI	Request for Information
RPT	Report
s	Seconds
SDS	Satellite-Derived Shorelines
SWAN	Simulating WAVes Nearshore (wave model)
TN	True North (used in wave direction)
TNPA	Transnet National Ports Authority
T _p	Peak wave period
UNIBEST CL+	UNIBEST CoastLine Plus (shoreline modelling software)
WSP	WSP Group (engineering consultancy)

1 INTRODUCTION

The background to this study, the scope of work and structure of the report are addressed below.

1.1 BACKGROUND

The new Berth 605 is intended to be developed adjacent to the existing Berth 600 series, located in the Bayvue Precinct in the western region of the Port of Richards Bay (Figure 1-1). The intention of the proposed new Berth 605 is to serve a proposed new container handling facility that is ultimately intended to increase container volumes handled at the port to stimulate economic development in the region.



Figure 1-1: Port of Richards Bay and the location of the proposed New Berth 605 and Container Handling Facility (CHF) (WSP from Google Earth, 2024)

1.2 SCOPE OF WORK

The dredging required for this project will result in disposal of ~4.3 million m³ of bulked material at the designated disposal site offshore (see Section 2.1.1 for more detail). The altered bathymetry is likely to cause changes in nearshore wave conditions which in turn may affect:

- Storm wave conditions impacting on the protective breakwaters; and
- Altered longshore sand transport conditions, which may induce erosion and accretion of the shoreline.

This report assesses these potential environmental impacts.

1.3 REPORT STRUCTURE

Section 2 of this report provides an outline of the dredging and disposal, including the quantities to be dredged, the composition of material to be dredged, potential for beneficial use of material and consequent disposal volumes. Section 3 provides an outline of the key environmental conditions. Section 4 provides an outline to the bathymetry which serve as model input. Section 5 deals with the setup and calibration of the wave model, while Section 6 deals with the modelling of changes to wave conditions as a result of the disposal mound. Section 7 employs these modelled results to assess the impact of extreme (storm) wave conditions on the breakwater as well as the effect of an altered wave climate on longshore sediment transport and shoreline evolution. Section 8 provides conclusions and recommendations of this study.

2 DREDGING AND DISPOSAL

The proposed dredging methodology, the quantity and composition of the material to be dredged, the dredging technology to be used and an outline of the planned dredging activities including beneficial use options and dredge spoil disposal are outlined below.

The initial assessment of dredge volumes and dredge material types was used in the modelling undertaken to inform this study. This was based on the geotechnical survey data and the engineering design as it existing at that time. Subsequently, updated, project-specific, geotechnical survey data and associated interpretation of such data have been received. The engineering design of the project and specifically the dredging activities has progressed since the modelling for this study was undertaken. The resultant changes in the specification of dredging volumes and dredge material types are described in great detail in the *Dredging and Dredge Material Disposal Modelling Study* (WSP, 2025). Only the most pertinent detail of such changes that are relevant to this study are summarised below, namely the changes in dredge material volumes to be placed on the offshore disposal site and changes in the composition of the dredge material.

2.1 DREDGING METHODOLOGY

An overview of the proposed dredging activities is contained in the initial Sedimentation and Dredging Concept report (WSP, 2024a) and the subsequent overall concept design report (WSP 2025), with greater detail of the dredging activities given in the *Dredging and Dredge Material Disposal Modelling Study* (WSP, 2025).

A proclaimed depth of -14.5m PCD needs to be maintained to accommodate the design vessel (WSP, 2024b). Added to this depth is an allowance for sedimentation (between maintenance dredging campaigns) and for bathymetry sounding accuracy, resulting in a required depth of -15.1 m PCD (WSP, 2024a). To achieve this depth, the basin area will be excavated by means of dredging, except for the topsoil (an assumed 300 mm of surface material and associated vegetation) that is to be removed and carted away separately (WSP, 2024c). In addition to this basin dredging material, material will be excavated for road (and rail) construction and for the quay wall construction (WSP, 2024a, 2025).

The excavation of road (and rail) material and a quay wall excavation will occur in the dry prior to the commencement of the main basin dredging activities. The material from these excavations will be placed in and/or over the existing pond where caissons were cast for a prior Berth 306 development project for the Port of Richards Bay (Goussard, 2009), henceforth referred to as the “former construction caisson pond”. Ultimately, this “former construction caisson pond” area will become part of the future basin opposite Berth 605 (Figure 2-1).

The dredging activity for the project thus will comprise the excavation of the basin as well as this additional material from the road (and rail) construction and quay wall excavation that has been placed in and/or over the former construction caisson pond. The dredging will take place using a Cutter Suction Dredger (CSD) with material loaded into barges and transported to an offshore disposal site, here assumed to be the existing dredge spoil disposal that is presently is used for the disposal of spoil from ongoing maintenance dredging activities (WSP, 2024b).



Figure 2-1: Basin area to be excavated plus outline of the existing pond where caissons were formerly cast (Source WSP, 2024b).

2.1.1 QUANTITY OF MATERIAL TO BE DREDGED

As noted above, the *in-situ* dredge volumes and composition of the *in-situ* material to be dredged has changed significantly since the initial assessment undertaken to inform this study. Based on update geotechnical survey data, its interpretation and progressed engineering design, the *in-situ* dredge volumes and composition of the *in-situ* material to be dredged was re-assessed and is as described below (Table 2-1).

The quantity of material excavated "in-the-dry" will comprise approximately 1 102 060 m³ of *in-situ* excavation material (comprising 1 037 160 m³ of *in-situ* material excavated for the quay wall construction/temporary access road excavations and 64 900 m³ of *in-situ* material from road and rail excavations that excludes 17 500 m³ of topsoil that will not be placed in the caisson pond to be subsequently dredged by the CSD). The 1 037 160 m³ of *in-situ* material excavated for the quay wall construction comprises a net volume of 522 815 m³ of *in-situ* material excavated on the seaward side of the proposed quay wall face and a volume of 514 340 m³ of *in-situ* material excavated on the landward side of the proposed quay wall face.

The material to be dredged from Berth 605 berths and basin only, will total approximately 1 413 240 m³ of *in-situ* material (comprising sediments and rock). If an allowance is made for a potential dredging accuracy of 0.4 m for a CSD, the volumes of material to be dredged from the Berth 605 berth and basin area then increases to 1 475 130 m³ of *in-situ* material. For the purposes of this study, we have conservatively assumed the larger of these two dredge volumes (1 475 130 m³ of *in-situ* material) that includes an allowance for potential over-dredging associated with a vertical dredging accuracy of 0.4 m (WSP, 2024b, c).

In summary, based on the above updated excavation and dredge material volumes, the CSD dredging operations thus will need to dredge 1 475 130 m³ of *in-situ* material from the proposed new basin area and a further 1 432 680 m³ of bulked material from the former caisson construction pond area. The total volume to be dredged by the CSD thus will be 2 907 810 m³.

For the purposes of this study, we have assumed the larger dredge volume that includes an allowance for potential over-dredging associated with a vertical dredging accuracy of 0.4 m (WSP, 2024a,c).

Given that the sediment loading rates in the dredge and dredge spoil disposal modelling study are based on the dry density of:

- the *in-situ* sediments being dredged by the CSD (lower for the sediments in the former caisson construction pond);
- the sediments in the hopper;
- the sediments once placed on the offshore dredge spoil disposal site (after a period of consolidation);

the volume of material placed on the dredge spoil disposal site initially was calculated used a bulking factor of between 1.40 to 1.50 on the total *in-situ* volume of material to be dredged (WSP, 2025). Applying a conservative bulking factor of 1.50 suggests that the bulked volume needing to be accommodated on the disposal site is approximately 3.87 million m³ that represents a decrease of just over 10% of that modelled both in this study and the companion Dredging and dredge Material Disposal Modelling Study (WSP, 2025).

However, the above bulking factor does not consider the lower dry density of the siltstone compared to other typical rock material. Taking the lower dry density of the siltstone into account, the predicted bulking factor increases to between 1.51 to 1.64 compared to the BF of between 1.4 and 1.50 expected for other typical rock material. This suggests that the bulked volume of material needing to be accommodated on the disposal site of approximately 4.23 million m³. This represents an approximate 1.9% decrease in the bulked volume of material needing to be accommodated on the disposal site compared to the volumes used in the modelling undertaken to inform both this study and the Wave Climate and Shoreline Change modelling study (WSP, 2025).

Table 2-1: Updated assessment of Dredging Volumes

Source of Material	<i>In-situ</i> volumes (m ³)	Volumes to be dredged by the CSD (m ³)	Volume of placed material on the offshore site for an assumed bulking factors as indicated (m ³)	
			Assumed bulking factor = 1.50 ^{*4}	Assumed bulking factor = 1.64 ^{*5}
Road Excavation	64 900	84 370 ^{*1}	97 350	106 440
Quay wall excavations	1 037 155	1 348 310 ^{*1}	1 555 740	1 700 940
Total volume of material excavated in the dry	1 102 060	1 432 680 ^{*1}	1 653 090	1 807 380
Berth and Basin Only	1 413 240	1 413 240^{*2}	2 119 860	2 317 710
Berth and Basin Only (including over-dredging)	1 475 130	1 475 130 ^{*2}	2 212 700	2 419 210
Total volumes being dredged by the CSD	2 577 190	2 907 810^{*3}	3 865 790	4 226 590

^{*1} These are the bulked volumes (assumed initial bulking factor of 1.3) to be re-dredged from the former caisson construction pond area after having been placed there from excavations undertaken in the dry.

^{*2} These are the *in-situ* volumes to be dredged from berths and adjacent basin.

^{*3} This is the volumes of material that will be dredged both from the caisson pond area (material from the “in-the-dry” excavations) and directly from the 600 basin and berths.

^{*4} An estimated bulking factor of 1.51 to 1.64 is indicated based on the updated material types and dry density of siltstone that was overestimated in the modelling study. These are the (bulk) material volumes assuming a least conservative bulking factor of 1.50 for the material placed on the dredge spoil disposal site based on the expected transformation of the rock material by the CSD and an assumed approximate one-month period of consolidation.

^{*5} Based on the updated material types and a (reduced estimate of) dry density for the siltstone (that was overestimated in the modelling study), the presently estimated bulking factor ranges between 1.51 to 1.64. The volume reported is based on a bulking factor of 1.64 that leads to the most conservative modelling outcomes in terms of potential impacts. This change means that the bulking factor (of 1.55) used in the initial modelling study was slightly underestimated. When considering the volumes of (bulk) material being deposited onto the disposal site and the associated consequences for volume of material accumulation on the disposal site, this minor underestimation of bulking factor is largely offset by the predicted reduction in *in-situ* dredge volumes compared to those used in the modelling study. The net result is that the modelled sediment thicknesses on the disposal site remain largely representative of those that will occur based on the updated geotechnical survey information and progressed engineering design, *i.e.*, the presently estimated (bulk) dredge volumes of 4.23 million m³ to be disposed of onto the disposal site are marginally less (-1.9%) than the ~4.3 million m³ (bulk) dredge spoil disposal volumes assumed in the modelling study

2.1.2 COMPOSITION OF MATERIAL TO BE DREDGED

Based on the update geotechnical survey information and progressed engineering designs, the composition of the *in-situ* material to be dredged is given in Table 2-2 below.

Table 2-2: Re-evaluation of the composition of *in-situ* dredge material.

Material type	Basin Excavation (including "in-the-dry" access road and quay wall excavations seawards of the quay wall) (<i>in-situ</i> volume) (m ³)	Basin Excavation (excluding "in-the-dry" access road and quay wall excavations seawards of the quay wall) (<i>in-situ</i> volume) (m ³)	Quay wall and access Road excavations seawards of the quay wall (<i>in-situ</i> volume) (m ³)	Quay wall and access Road excavations landwards of the quay wall (<i>in-situ</i> volume) (m ³)	Grain size (D ₅₀) of main material type	% of fines in the material type	Total volumes (m ³)
Sand	464 653	304 910	159 740	207 920 ^{*1}	350 µm	4%	672 570
Silty Clay	290 408	190 570	99 840	89 390	< 63 µm	100%	379 800
Silty/clayey sand	587 858	385 760	202 100	180 940	280 µm	25% ^{*2}	768 7800
Siltstone	655 023	593 890	61 130	101 000	6 mm ^{*3}	20% ^{*3}	756 020
Total	1 997 942	1 475 130	512 810	579 250	-	-	2 577 180

^{*1} This includes the road excavation material, that based on limited data, here is assumed to comprise sand only and not silty/clayey sands as initially assumed, but excludes the topsoil (17 500 m³) that will not be disposed of at the offshore dredge spoil disposal site.

^{*2} The initial assessment used in the modelling study suggested that only 20% of the silty/clayey sand comprised fines, however the updated geotechnical survey information suggest a higher fines content. Consequently, it has been conservatively assumed a the silty/clayey sands have a 25% fines content.

^{*3} The siltstone when dredged by the CSD is assumed to be transformed into 80% granular material (6mm) and 20% fines (<63µm) – see WSP (2024b; 2025).

Compared to the initial assessment of material types, the presently estimated mass of *in-situ* material to be excavated and/or dredged indicate a 17.3 % increase in siltstone, a 13.6% increase in non-cohesive sediments and an approximate 47.4 % decrease in fine sediments, but an overall decrease of 7.4% in the mass of sediments dredged. After dredging by the CSD (which transforms the siltstone into 80% gravels and 20% fines), the presently estimated mass of dredged material indicates a 14.9% increase in non-cohesive material (gravels and sands) and an approximate 39.3 % decrease in fine sediments. As noted above, there will be an overall 7.4% decrease in the mass of sediment dredged and disposed of at the offshore disposal site.

2.2 BENEFICIAL USE

The use of siltstone rock was considered for beneficial use. However, when dredged using a CSD, the material transforms to a condition which is not useful, *i.e.* a gravel (~6 mm grain size) with 20% fine material (WSP, 2025). This material is therefore not of use, for example, as for revetment rock in the port. Similarly, this coarse material is not ideal for placement on the beaches to the north of the port.

Sand can also be considered for nourishment discharge onto the beach. As may be noted from Table 2-2, about 672 570 m³ of sand (< 23% of the material to be dredged) exists with a low percentage of fines and a grain size that would be suitable for beach nourishment (silty/clayey sand is unsuitable for beach nourishment). However, most of this material is situated above existing water-level in the port and the proposed method of dredging is such that this suitable sand gets mixed with unsuitable material. Specifically, the cutter suction dredger will be working below water-level (where layers of material largely are not suitable) and will undercut the slope (sometimes with the aid of water jets) causing the suitable sand to collapse/avalanche into the basin where it will mix with the unsuitable material. The resulting material discharged into the hopper barges will then be sub-optimal for beach placement as it will contain a relatively high percentage of fines. This would result in significant plumes of fine sediment at the beach discharge, which is visually and ecologically undesirable.

A further consideration is the means of transport of material to the beach. The hopper barges discharge material by means of a split hull and are not geared for hooking up to the beach reclamation pipe and pumping material to the northern beach.

If this sand were to be used for beach nourishment, carting by truck and/or significant adaptations to equipment could be considered. However, noting that the quantity available is close to the annual sand requirement to the northern beach, it would be more economical to source the material from the sand trap and or the nearshore region of the southern beach.

2.3 DISPOSAL

Referring to Table 2-1 and considering that beneficial use is not practical, a bulked volume of approximately 4.23 million m³ is to be disposed of on the offshore dump site. The manner in which this volume of dredge material to be disposed of at the offshore disposal has been calculated is described in Section 2.1.1.

This is a slight reduction in the volume of 4.3 million m³ used in the modelling undertaken to inform this study, *i.e.*, the volume of material that will be employed to assess the localised shoaling in bathymetry (see Section 6.2).

3 ENVIRONMENTAL CONDITIONS

Given the role of local winds in the generation of local seas, a brief summary of wind conditions is provided below. The wind conditions are described in greater detail in the Dredging and Dredge Material Disposal modelling study (WSP, 2025).

This is followed by a description of offshore wave conditions that are covered in more detail in the Metocean Report for the Berth 605 project (WSP, 2024d), as well as the Dredging and Dredge Material Disposal modelling study (WSP, 2025).

3.1 WINDS

Wind records from the Integrated Port Operations Safety System (IPOSS) at Port Control (Latitude: -28.79704, Longitude: 32.09915) and particularly the more exposed southern breakwater site (shown in Figure 3-1, Latitude: 28.81399°S, Longitude: 32.0978°E) indicate a stronger wind regime than available wind data just north of the Port of Richards Bay (Arboretum). The median wind speed on the southern breakwater is approximately 30 to 40% greater than that recorded at more inland sites surrounding the Port of Richards Bay and is considered to be more representative of the coastal and open water wind climate. The wind roses for the southern breakwater site for the period 1994 to 2016 are presented in Figure 3-2.



Figure 3-1: Location of the wind stations in Port of Richards Bay

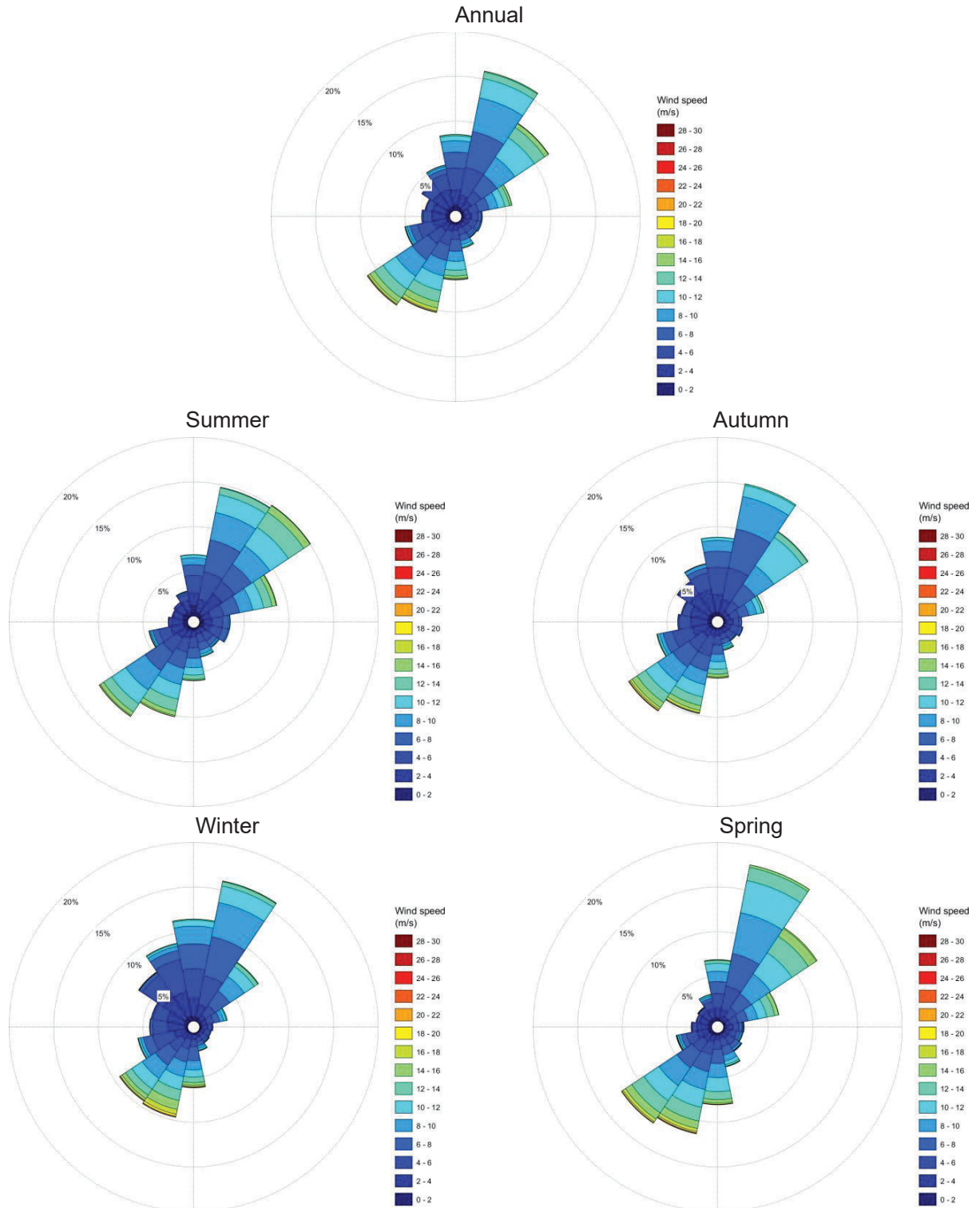


Figure 3-2: Wind roses at the Southern Breakwater, Port of Richards Bay, (Latitude: - 28.81399°S, Longitude: 32.0978°E), for the period of 1994 to 2016.

3.2 WAVES

The deep-sea waves are refracted as they move landwards into shallower waters with all but the shorter period waves (sea as opposed to swell) becoming more shore normal in direction. The resultant nearshore wave distribution has been measured at a site some 1.5 km south-east of the southern breakwater in an approximate water depth of -20m CD (see Figure 3-3).

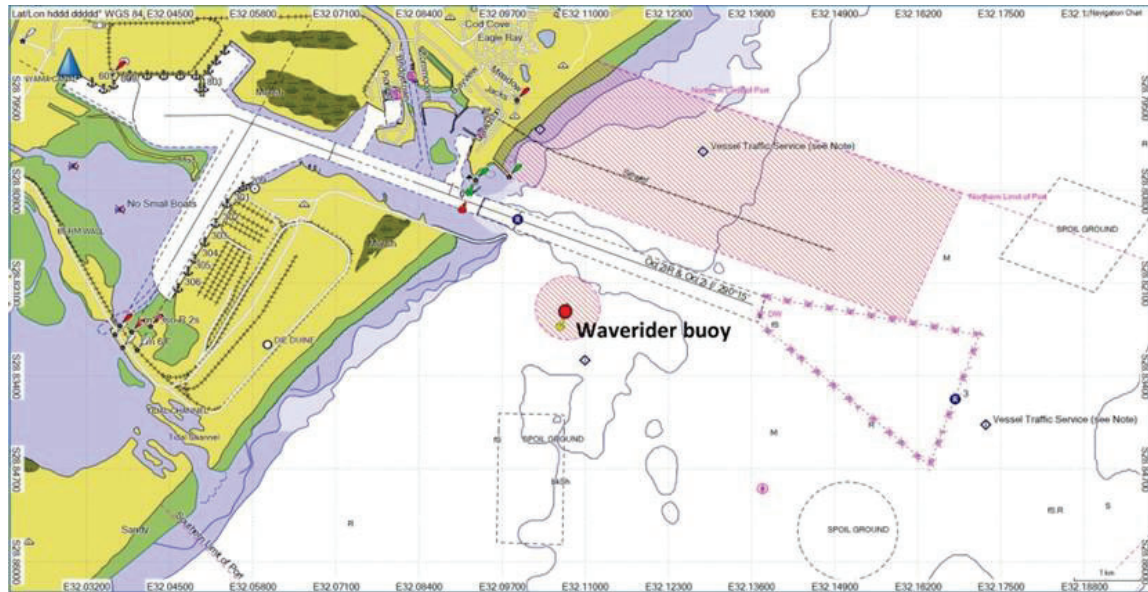


Figure 3-3: Location of Waverider buoy (Latitude: -28.8265, Longitude: 32.1040)

Furthermore, outside the port the waves are predominantly from south-southeast, but southeast and east-southeast wave components are not uncommon, particularly during the summer months. The directional distribution is clearly illustrated in the seasonal wave roses in Figure 3-4. As expected, the highest waves are observed during the winter months and to a lesser extent in spring.

Some general statistics, in terms of the percentage exceedance of wave height (H_{m0}), are given in Table 3-1. Approximately 13 years of data were available for deriving these values, which provide a reasonable overview of the general wave climate. As shown, the median wave height (50% exceedance value) is about 1.5 m, representing the average condition on an annual basis. The 1% wave height is 3.4 m, which could be exceeded on average, for 3.7 days per year. Thus, for 362 days of the year, the waves outside the port will be smaller than 3.4 m.

Table 3-1: Percentage (%) exceedance of significant wave height (H_{m0})

% Exceedance	H_{m0}
50	1.5 m
25	1.8 m
10	2.2 m
1	3.4 m
0.1	4.5 m



Figure 3-4: Wave roses based on Waverider data collected outside Port of Richards Bay, (Latitude: -28.8265°S, Longitude: 32.1040 °E) for the period of 1979 to 2002.

The joint occurrence distribution of wave height versus peak period is given in Table 3-2. The data covers the period 2003 to 2016. As shown, a significant wave height up to almost 8.5 m was recorded. The peak wave period ranges generally from about 6 s to 18 s, with dominant period between 10 s and 14 s.

Table 3-2: The percentage joint occurrence distribution of wave height versus peak period based on all data

H _{m0} (m)	Period (T _p) (s)																Total
	0-2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	20-22	22-24	24-26	26-28	28-30	30-32	
0.0 - 0.5			0.00*		0.00*	0.00*					0.00*						0.00
0.5 - 1.0		0.00*	0.11	0.50	0.82	2.49	1.44	0.54	0.07	0.01	0.00*						5.99
1.0 - 1.5		0.07	1.75	4.76	7.71	14.89	10.63	5.33	0.53	0.21	0.05	0.00*				0.00*	45.96
1.5 - 2.0		0.02	1.37	2.89	5.44	10.34	6.37	4.22	0.55	0.17	0.03	0.00*		0.00*			31.40
2.0 - 2.5	0.00*	0.01	0.20	1.06	1.64	3.76	2.14	1.69	0.25	0.09	0.01	0.00*					10.85
2.5 - 3.0			0.02	0.28	0.47	1.20	0.90	0.57	0.09	0.03	0.01	0.00*					3.56
3.0 - 3.5				0.04	0.11	0.43	0.43	0.32	0.04	0.02	0.00*						1.40
3.5 - 4.0				0.00*	0.03	0.19	0.16	0.14	0.01	0.01	0.00*						0.55
4.0 - 4.5					0.00*	0.04	0.07	0.05	0.01	0.00*							0.18
4.5 - 5.0						0.01	0.01	0.03	0.00*	0.00*							0.06
5.0 - 5.5						0.01	0.00*	0.01	0.00*	0.00*							0.03
5.5 - 6.0						0.01	0.00*	0.00*	0.00*	0.00*							0.01
6.0 - 6.5								0.00*	0.00*								0.00
6.5 - 7.0							0.00*	0.00*									0.00
7.0 - 7.5								0.00*	0.00*								0.00
7.5 - 8.0								0.00*	0.00*								0.00
8.0 - 8.5									0.00*								0.00
Total	0.00	0.11	3.46	9.53	16.24	33.37	22.16	12.90	1.56	0.55	0.10	0.01	0.00	0.00	0.00	0.00	100

* These values represent a < 0.01% but are included to indicate values that have a very low occurrence, e.g., the 8.5 m wave height recorded.

4 SEDIMENT RETENTION ON THE DISPOSAL SITE

Important in determining the capacity of the existing dredge spoil disposal is knowing how much of the material placed on the remains on the site over time, *i.e.* the evolution of dredge spoil disposal mounds on the disposal site. Similarly, the longevity of any mounding on the disposal site is also important when assessing the long-term changes in wave conditions and shorelines.

4.1 FACTORS AFFECTING THE RATE OF DISPERSION OF SEDIMENTS FORM THE DREDGE DISPOSAL SITE

A number of factors will determine the rate of dispersion of material off the disposal site. These are expected to include:

- **The rate of disposal and short-term accumulation of material on the disposal site:** Capital dredging results in a more rapid accumulation of material on the disposal site. While the rate of dispersal of such material initially is expected to be quite rapid (mostly occurring during the initial release of material onto the disposal site), the time taken for the further removal of the additional material placed on the site takes quite long, mainly due to the larger dredge material volumes involved. Conversely, maintenance dredging results in more intermittent and smaller dredge material disposal volumes onto the site that are likely to erode more slowly. However, given the smaller volumes involved, this additional material from maintenance dredging is relatively rapidly removed from the site. Thus, there is a greater longevity of accumulated material on the disposal site and associated depth changes for capital dredging activities compared to the shorter longevity accumulations of dredged material associated with maintenance dredging activities.
- **The nature of the material being disposed of on the disposal site:** Maintenance dredging activities typically will have a much larger degree of fines material being dredged and disposed of onto the disposal site. Not only is a significant fraction of these fines lost into the water column during the actual release of dredge material onto the disposal site (*i.e.* do not get to settle on the site), but also any fines settling to the seabed are expected to be more mobile and thus more easily removed from the disposal site, thus aiding the “recovery times” of the disposal site. For capital dredging it is not only the larger volumes that reduce the “recovery times” of the disposal site, but also the nature of the material. Capital dredging operation typically results in disposal of material with significantly lower fines content than that from maintenance dredging. Typically dredge material from capital dredging activities contain a greater fraction of courser material and possibly even rock. The generally lower mobility of these coarser size fractions is expected to result in a lower rate of dispersion of dredged material off the disposal site. However, the erosion of material from a disposal site of various material compositions remains a complex process (e.g. Mitchener and Torfs, 1996; Torfs *et al.*, 2000; van Ledden *et al.*, 2004; van Rijn, 2020; Chen *et al.*, 2021). Perhaps most significant is if a significant quantity of rock or coarse material derived from the dredging of rock, is placed on the disposal site. This can significantly slow the removal of material from the site with the coarser material and rock perhaps remaining on the site in the long-term.

- **The change in water depth (i.e., mounding) associated with the accumulated material on the disposal site:** In shallow water disposal sites, such as that used for the Port of Richards Bay, if there is significant mounding due to the placement of material on only a small area of the site, this could result in more rapid resuspension and removal of material from the site in the then essentially shallower waters at the top of the mounds.
- **The prevailing environmental conditions at the offshore disposal site:** Substantial sediments transport off the dredge spoil disposal site is only expected to occur for more robust storm conditions, with the large sediment movements occurring for more extreme conditions such as the storm event that occurred along the KwaZulu-Natal coastline in March 2007 (Mather and Stretch, 2012). This storm event coincided with the equinox, localised wave induced currents and topographically controlled currents forced by the reef alignment in the vicinity of the dumpsite (van den Bossche *et al.*, 2007).

4.2 DREDGE DISPOSAL SITE

Van den Bossche *et al.* (2007) evaluated the changes that occurred between the immediate post-dredging bathymetric survey in January 2006 and a further post-dredging survey undertaken in July 2007. The results reported seem to indicate no major loss of sediments from the dredge spoil site and surrounds over this period. Rather, there was erosion (-6 m) of one of the two dredge spoil disposal mounds generated during the Berth 306 capital dredging and the re-distribution of sediments into deeper water both onto and just beyond the limits of the disposal site.

The availability of additional bathymetry data has allowed a more nuanced assessment of the rate of dispersal of dredged sediments of the existing offshore disposal site to be undertaken in this study.

4.2.1 HISTORICAL VOLUMES DISPOSED OFFSHORE

Appendix A summarises the available information on the historical capital and maintenance dredging volumes and Table A-2 summarises the dredging and disposal volumes, including quantities associated with specific areas and activities, as reported in the referenced studies. Unfortunately, reliable detailed dredging volume data beyond 2003 is limited, and data on volumes pumped directly onto the beaches, particularly the southern beaches, is largely uncertain for the disposal activities prior to 1996. This lack of data poses a challenge to conducting a comprehensive analysis of potential correlations between offshore disposal activities and shoreline changes.

4.2.2 BATHYMETRY SURVEYS

Multibeam bathymetry surveys were conducted at the existing offshore physical monitoring site / dredge disposal site of Richards Bay:

- during July 2005 just prior to the commencement of the Berth 306 dredging activities (Ramsay and MacHutcheon, 2005),
- during January immediately post-dredging activities (Ramsay and MacHutcheon, 2005), and
- in June 2007 some 18-month post-dredging (van den Bossche, 2007).

In June 2022 and January 2025, single beam surveys were conducted by TNPA; however, these were confined to only the existing dumpsite area rather than a larger area surrounding disposal site as was undertaken in the 2005, 2006 and 2007 bathymetric surveys.

The bathymetry data from all the above surveys have been converted to a Lo31 Hartebeeshoek84 co-ordinate system. The vertical datum used for the bathymetry surveys is Chart Datum (CD) which is -1.015 (m) below Land Levelling Datum (LLD).

The existing bathymetry for the models is based on historical bathymetry data as reported in Van Ballegooyen and Jacobs (2020) where the bathymetry data for the existing dredge spoil disposal site (*i.e.*, the 2007 surveys included in the historical bathymetry data) has been replaced by the 2025 bathymetry survey data. Cutting the 2025 single beam survey into the 2007 multibeam survey required editing of the immediate area surrounding the disposal site due to the change in shape of the mound. This updated “existing” bathymetry of the dredge disposal site surrounds (as existed in 2025) is shown in Figure 4-1. The smaller area demarcated indicates the extent of the existing dredge spoil disposal site presently permitted for maintenance dredging disposal activities, while the larger area indicates the extent of the 2005 to 2007 multi-beam bathymetric surveys.

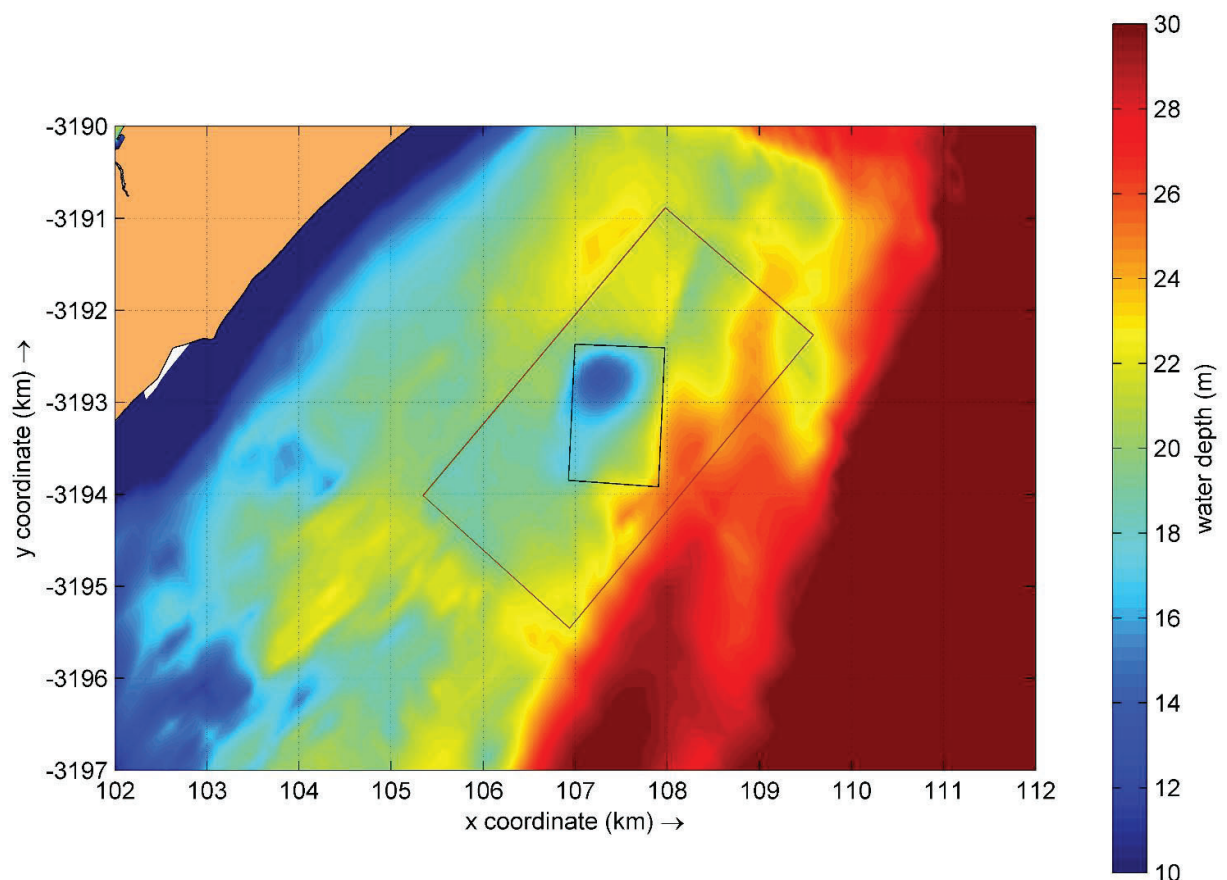


Figure 4-1: Bathymetry (m CD) of the dredge disposal site (black inner outline) and the physical monitoring site (brown outer outline)

4.2.3 RETENTION OF DREDGE MATERIAL ON THE DISPOSAL SITE

Using the above data, bathymetries were developed for the dredging spoil disposal site and its immediate surrounds for June 2005, January 2006, July 2007, June 2022 and January 2025.

These bathymetric survey data were then subtracted from one another to provide estimates of the net accumulation (or loss) of sediments from only the existing dredge spoil disposal site between these surveys. This was achieved using DELFT3D QUICKIN that calculates both the accumulation and loss of sediments from the designated disposal area. The net accumulation and loss of sediments over the full disposal site for the specified periods comprise the sum of these two values (*i.e.* accumulation and erosion volumes for the disposal site).

A summary of the available dredging disposal volumes is presented with the calculated accretion and erosion volumes in Table 4-1. The positive volumes indicate accretion of material on the site and the negative volumes erosion from the site.

The disposed volume on-site (m^3) is calculated using the bulking factors ranging from 1.25 to 1.55 on the reported *in-situ* dredge volumes. The material being dredged and disposed of for the Berth 605 capital dredging initially was assessed to have a bulking factor of 1.55 (see WSP, 2025). A re-analysis of updated geotechnical survey data and the resultant change in dredge material composition suggest a bulking factor ranging between 1.51 to 1.64 (see WSP (2025) for a more detailed discussion of the changes in dredge volumes and dredge material composition). Using the upper bulking factor value of 1.64 would seem to suggest that a higher volume of dredge material will need to be placed on the disposal site. However, as noted in in Section 2.3, the re-assessment of dredge volumes based on the updated, project specific geotechnical information and progressed engineering designs suggests a reduction in *in-situ* dredge material volumes to be place on the offshore disposal site. The net result of the reduced *in-situ* dredge material volumes, coupled with the higher bulking factors, is an approximate 1.9% decrease in the bulked volume of material needing to be accommodated on the disposal site (4.23 million m^3) compared to those used in the modelling (4.30 million m^3) undertaken to inform both the Dredging and Dredge Material Disposal Modelling Study (WSP, 2025) as well as this study.

However, where the dredging of substantive quantities of rock by a CSD is not involved, the effective bulking factor could be less, thus the reporting of results for lower bulking factors of 1.2 and 1.35. This is particularly true for more sandy dredged material.

For the Berth 306 project, only 31 % to 41 % of the dredged material remained on site shortly after the dredge spoil disposal ceased (see period 2005-2006 in Table 4-1). After a further 18 months, material was re-distributed, both on the disposal site and around the disposal site. This left only 26% to 33 % of the disposed dredge material from the Berth 306 capital dredging on the site (see period 2005 – 2007 in Table 4-1). Shorter term disposal of material from maintenance dredging seems largely to be removed from the site, provided the annual maintenance dredging volumes are not too large (see periods 2006 – 2007 and 2002-2025 in Table 4-1). However, long-term records between 2007 and 2022 suggest that as much as 15 % to 20 % of the long-term maintenance dredging spoil remained on the disposal site. The fact that the dredge spoil was disposed of mainly in a location to the north of the site and formed a substantial mound (less than -13 m CD) may be the reason for such a large quantity of maintenance dredging spoil remaining on the site during this period.

Table 4-1: Volume of dredging material (for assumed bulking factors of 1.20, 1.35 and 1.55) that has been disposed and subsequently accreted and/or eroded from the dredge disposal site for various time periods.

PERIOD	DISPOSED VOLUME UNBULKED (<i>in-situ</i> m ³)	DISPOSED VOLUME (Onsite) (m ³)	ACCRETED VOLUME (Onsite) (m ³)	ERODED VOLUME (Onsite) (m ³)	NET ACCRETION (Onsite) (m ³)	% MATERIAL LEFT ONSITE
2005 – 2006 (between Aug 2005 and Jan 2006)* ¹	3 840 361*	4 608 433 (BF=1.20) 5 184 487 (BF=1.35) 5 952 560 (BF=1.55)	1 878 810	5 286	1 873 523	41% (BF=1.20) 36% (BF=1.35) 31% (BF=1.55)
2006-2007 (between Jan 2006 and July 2007)	285 908	3 43 090 (BF=1.55) 385 976 (BF=1.55) 443 157 (BF=1.55)	356 290	588 084	-231 794	-68% (BF=1.20) -60% (BF=1.20) -52% (BF=1.20)
2006-2007 (between Jan 2006 and July 2007)	4 126 269	4 951 523 (BF=1.20) 5 570 463 (BF=1.35) 6 396 717 (BF = 1.55)	2 235 100	593	1 641 730	33% (BF=1.20) 29% (BF=1.35) 26% (BF=1.55)
2007-2021 (between Jul 2007 and Jun 2022)	13 59 3397	16 312 076 (BF=1.20) 18 351 086 (BF=1.35) 21 069 765 (BF=1.55)	3 236 630	153 359	3 221 370	20% (BF=1.20) 18% (BF=1.35) 15% (BF=1.55)
2022-2025 (between Jun 2022 and Jan 2025)	an estimated 1 800 000 for 2022-2025 (528 055 in 2022-2023)	2 160 000 (BF=1.20) 2 430 000 (BF=1.35) 2 790 000 (BF=1.55)	208 884 (between Jun 2022 and Jan 2025)	165 198	43 686	7% (BF=1.20) 6% (BF=1.35) 5% (BF=1.55)

^{*1} Volumes of *in-situ* dredge material for the Berth 306 project assumed to have been disposed of at the offshore disposal site are those reported in van Ballegooyen *et al.* (2015). However, the volume actually disposed of at the offshore disposal site remains uncertain. Analysis of the sediment cores collected during the feasibility studies suggest a fines (mud) content of 80%; however, analysis of 99 random samples taken from the *Lelystad* hopper during the dredging exercise, suggest that the dredge spoil contained a 56% mud and 44% sand content (Weerts, 2008). This discrepancy most probably arises from losses of fines at the dredging location and from hopper overflows. This fine material would not have made it to the offshore disposal site, resulting in the 3% to 41% initial retention on the disposal site reported in the table above constituting an underestimate of the percentage of material disposed of onto the disposal that is retained on the disposal site for the periods indicated. Volumes of dredge material disposal for the Berth 306 project reported in van Ballegooyen *et al.* (2015).

The rate at which dispersion of material occurs off the disposal site depends not only on the nature of the disposal (concentrated in mounds) but also on prevailing (particularly extreme) metocean conditions as well as the nature of the material being disposed of at the site. As noted by van Ballegooyen and Jacobs (2015), a particular concern is the amount of rock and coarse material disposed of at the disposal site as this material would be very slow to disperse if at all. Should a significant proportion of the material from capital dredging include rock, then the volume remaining on the disposal site immediately after the cessation of capital dredging and disposal activities could be higher than (31 % to 41 %) estimated for the Berth 605 capital dredging and disposal (perhaps as much as 60% or greater, depending on the actual volumes of rock or rock-derived coarser material in the dredge material placed on the site).

However, even fine material such as that dredged could remain on the disposal site for long periods. This was the case for the Berth 306 projects where the nature of the material and dredging operations (JetSed) seemed to generate a material that, although it contained 55% fines, was seemingly slower to disperse off the disposal site than expected (see WSP (2025) for a more detailed discussion of the dispersion of material from the offshore disposal site).

The above analysis of historical data indicates that material disposed of at the offshore disposal site is mostly lost during the actual disposal of the material onto the site. Maintenance dredging material (< 600 000 m³ per annum) seems to be fairly rapidly removed from the site (WSP, 2025). Large volumes of capital dredging material disposal on the disposal site seemingly are slower to disperse off the site, possibly due to the nature of the material (*i.e.* typically less fines than would be expected for material selected to offshore disposal rather than for maintenance of the northern shoreline), but more likely due to the concentrated nature of the accumulation of material in mounds on the disposal site. This highlights the value of attempting to disperse the material as widely across the disposal site as possible.

Noting that no more than approximately 40 % of sandy and silty material disposed of onto the existing Port of Richards Bay disposal site and possibly up to 60 % of dredge material (containing significant quantities of rock) is estimated to remain on the disposal site upon cessation of capital dredging activities. The assumption that all of the disposed dredge material remains on-site for an extended period of time constitutes a very conservative assumption when assessing changing wave conditions and associated shoreline change impacts that typically occur over long time periods.

However, the assumption in the that all the disposed dredge material remains on-site for an extended period becomes a much less conservative assumption if the potential cumulative impacts of the disposal of dredge material from other capital dredging activities in the port are considered. The fact that ~ 4.3 million m³ is being dredged for the Berth 605 project and nearly up to half or half of this material is very rapidly removed from the dredge spoil disposal site, the assessment of potential shoreline change impacts reported in this *Wave Climate and Shoreline Change* assessment, would remain sufficiently conservative even were another project of similar scale to occur within roughly the same period as the Berth 605 project.

The predicted dredge spoil disposal volumes for all the imminent proposed development projects within Richards Bay (PRDW, 2024) individually will produce lower capital dredge spoil disposal volumes than the Berth 605 project. The only exception possibly being the dredge spoil disposal volumes from development of Berth 210 where it is predicted that ~ 5 million m³ of *in-situ* dredge material will be dredged (PRDW, 2024). Thus, the assessment of changing wave conditions and possible shoreline changes undertaken in this study could be considered to implicitly include possible cumulative impacts of at least one additional proposed development of the nature of those presently envisaged for the Port of Richards Bay (*e.g.*, TNPA, 2021, 2022) as outlined in PRDW (2024).

5 WAVE MODEL SETUP AND CALIBRATION MODELLING

5.1 INTRODUCTION

The waves for this study are simulated using the Deltares DELFT3D-WAVE (SWAN – Simulating Waves Nearshore) module (Deltares, 2017). The wave modelling results are used to calculate the effect of changes in wave conditions (as induced by wave refraction over the disposal mound) on longshore sand transport and shoreline evolution.

The following processes need to be accounted for in the wave model to transform a deep-water incident wave condition into the nearshore and surf-zone environments:

- Refraction (*i.e.*, change in wave direction in shallow water);
- Depth-induced wave breaking;
- Depth-induced shoaling (*i.e.*, increase in wave height in shallow water); and,
- Bottom friction (*i.e.*, seabed effects that reduced wave height).

5.1.1 DESCRIPTION OF THE WAVE MODEL

The third-generation wave-generation and refraction model SWAN was used in this study (Booij *et al.*, 1999). SWAN is run within DELFT3D-WAVE environment (Deltares, 2017), which provides a convenient interface for pre- and post-processing and for including wave-current interactions.

The SWAN-model is based on the discrete spectral action balance equation and is fully spectral (in all directions and frequency), implying that short-crested random wave fields propagating simultaneously from widely different sources can be accommodated (*e.g.*, a swell with superimposed wind sea). SWAN computes the evolution of random, short-crested waves in coastal regions with deep, intermediate and shallow water and ambient currents. The SWAN model accounts for refractive propagation due to currents and depth and can represent the processes of wave generation by wind, dissipation by white-capping, bottom friction and depth-limited wave breaking and non-linear wave-wave interactions (quadruplets and triads) explicitly with state-of-the-art formulations. Wave blocking by currents is also explicitly represented in the model. However, diffraction (*i.e.*, the lateral transfer of energy along the wave crest) is not explicitly modelled in SWAN.

5.1.2 WAVE MODEL SETUP

The computational grid, bathymetry and wave conditions used in the wave model are described below.

5.1.2.1 Computational Grids

For the wave modelling, two computational grids were used, a large outer grid and an inner nested, high-resolution curvilinear grid that has also been used for the hydrodynamic modelling undertaken in the Dredging and Dredge Material Disposal modelling study (WSP, 2025).

The larger outer computational grid (Figure 5-1) extends well beyond the limits of the inner nested grid to ensure that the lateral boundaries of the larger outer grid is located far from the region of interest (*i.e.* boundaries of the inner, high-resolution grid) to prevent inaccuracies in boundary conditions of the outer grid affecting the simulations in the area of interest, *i.e.* the inner high-resolution grid area. The extent of the inner high-resolution grid is selected to ensure that the wave conditions at the boundary of the inner, high-resolution grid are applied in water depths where refraction has not yet occurred. This also ensures that the wave conditions of the inner, high-resolution grid are available to the full extent of the hydrodynamic model used for the Dredging and Dredge Material Disposal Study (WSP, 2025).

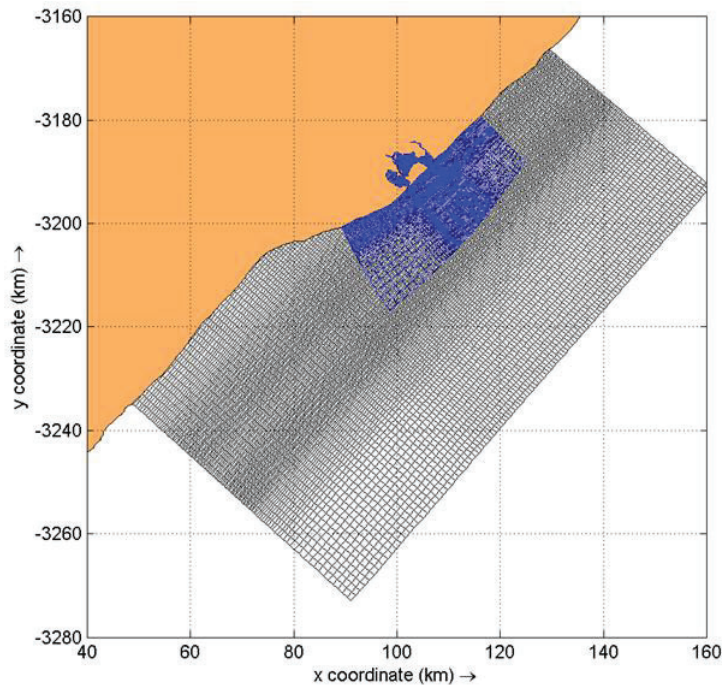


Figure 5-1: Large wave grid (black) and detailed curvilinear wave grid (blue)

5.1.2.2 Bathymetry

The bathymetry used in the large grid is presented in Figure 5-2, with the detailed curvilinear grid bathymetry presented in Figure 5-3. The area around the dumpsite within the physical monitoring site was updated with the 2007 survey as well as the dredge disposal site updated with the 2025 survey and is presented in Figure 5-4.

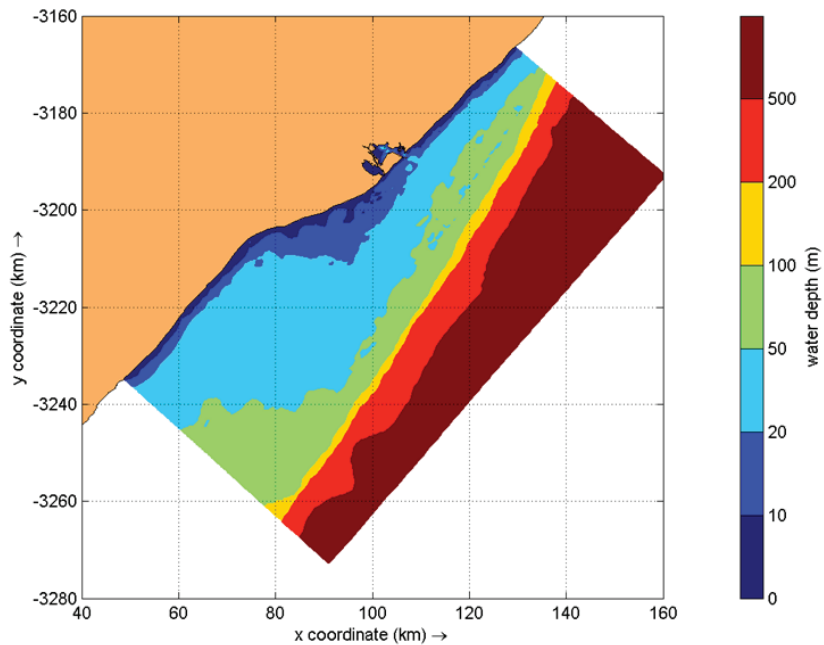


Figure 5-2: Large wave grid bathymetry (CD)

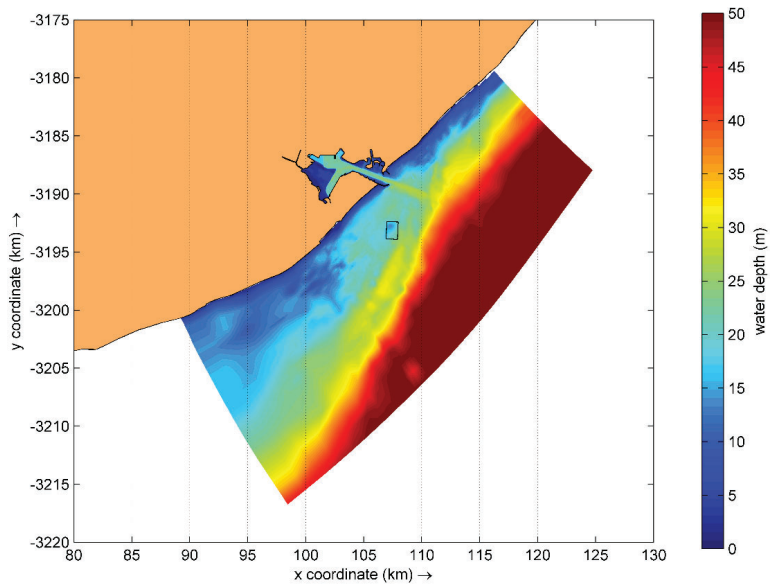


Figure 5-3: Detailed wave grid bathymetry (CD) with existing dumpsite outlined in black

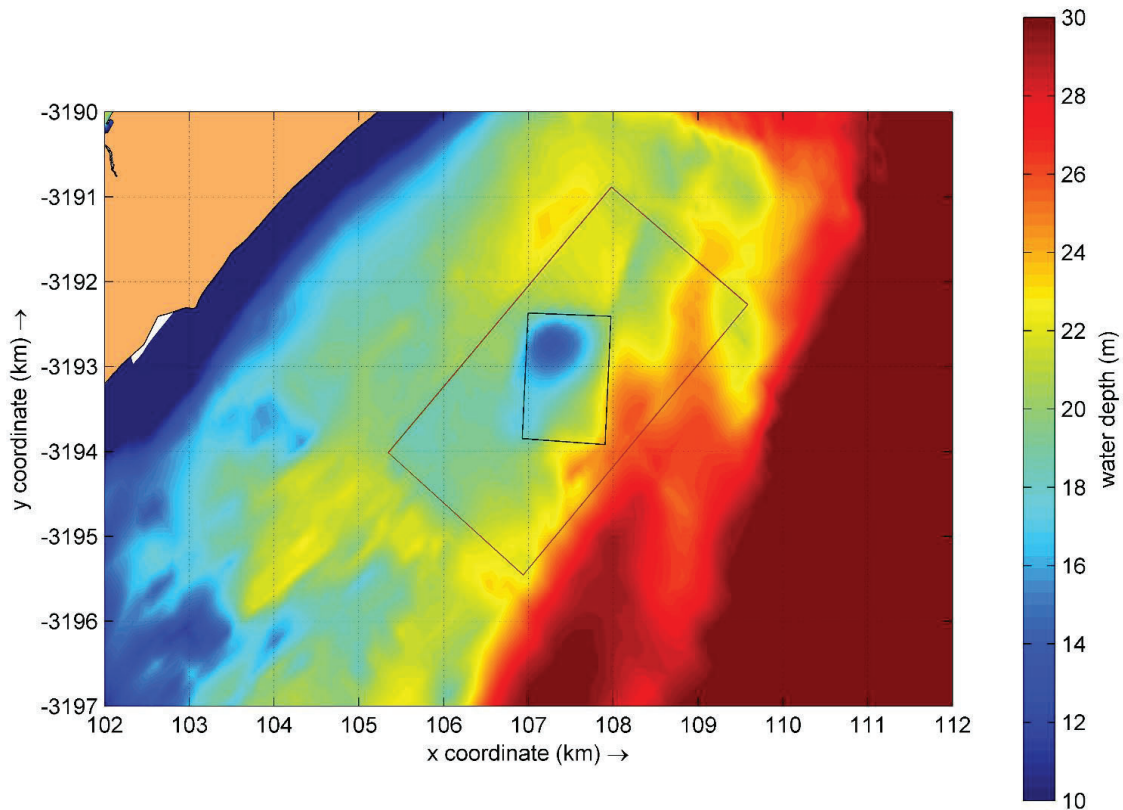


Figure 5-4: Detailed grid bathymetry (CD): zoomed in at dumpsite (indicated in black line - inner) and physical monitoring site (outlined in brown - outer)

5.1.2.3 Offshore Conditions

To calibrate the model, the data used are those measured for the Transnet IPOSS system at a location some 1.5 km south-east of the southern breakwater of the Port of Richards Bay (see Figure 3-3 for the location of the wave buoy). The approach used is from a number of the previous studies where a database of model results is developed by running all possible offshore wave conditions that could lead to the wave characteristics measured at the IPOSS wave buoy calibration time series measurement point. A look-up table was then developed that allowed the synthesis of an appropriate wave time series to apply at the model boundary that would result in the modelled data at the IPOSS wave buoy time series measurement point matching the measured data at this location. This is appropriate since the aim is to provide the correct wave forcing for the hydrodynamic model and for longshore transport calculation, not to develop design wave conditions.

5.1.3 WAVE MODEL CALIBRATION

Time series of the modelled wave characteristics and measured data at the Transnet IPOSS wave buoy measurement location are plotted in Figure 5-5 to Figure 5-10 below. The resultant data indicate a close correspondence between the modelled and measured wave data; however, a few small discrepancies do occur. These discrepancies are associated mostly with occasions when the winds swing rapidly from north-easterly to south-westerly (*i.e.* the south-westerly buster).

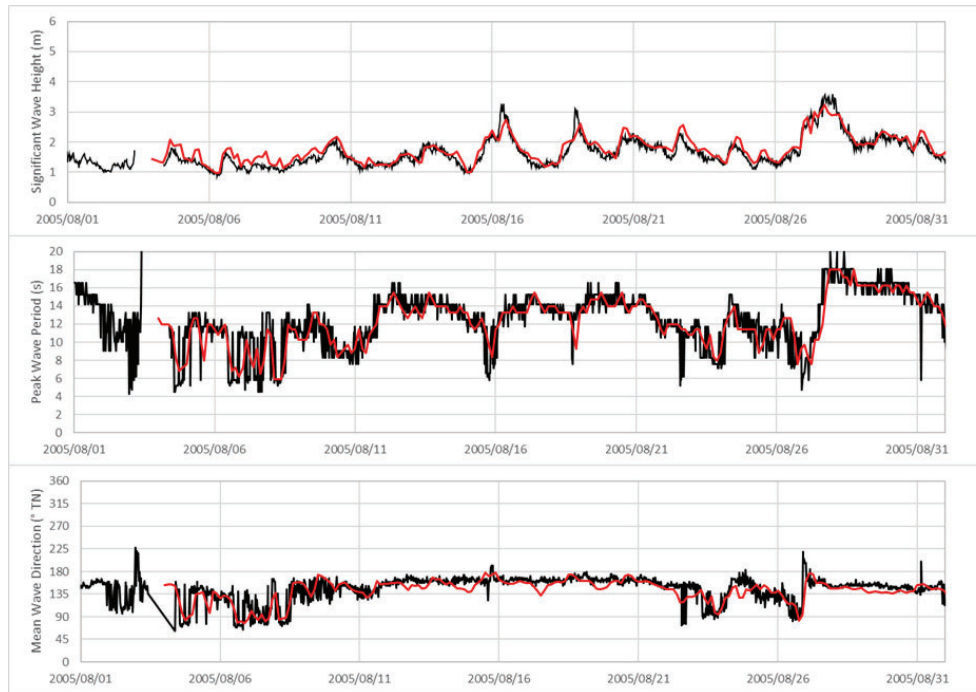


Figure 5-5: Measured(black) and modelled (red) wave parameters at Waverider buoy during August 2005

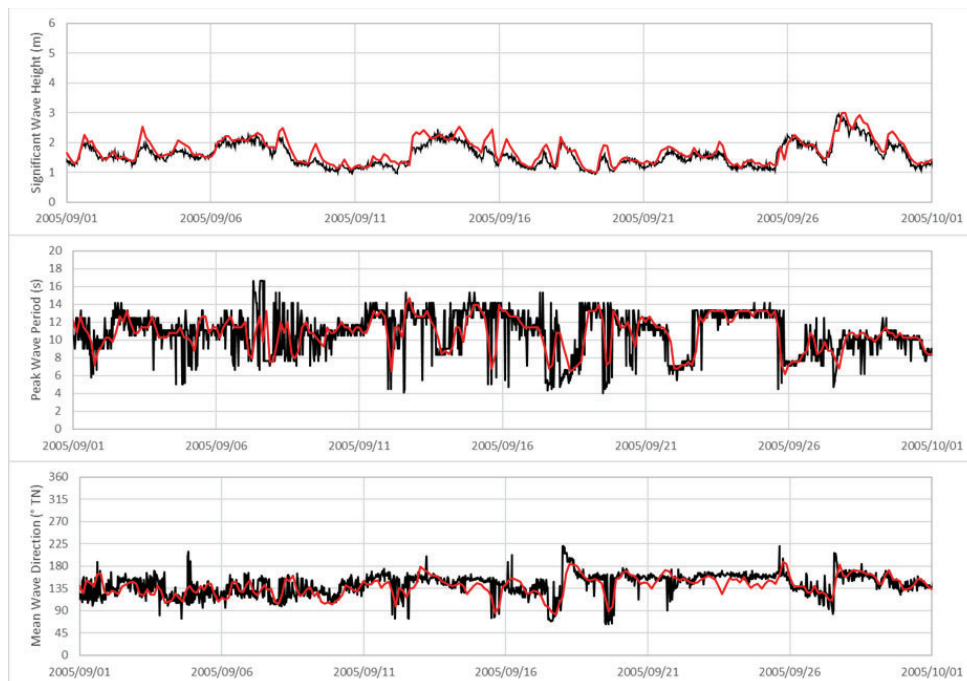


Figure 5-6: Measured (black) and modelled (red) wave parameters at Waverider buoy during September 2005

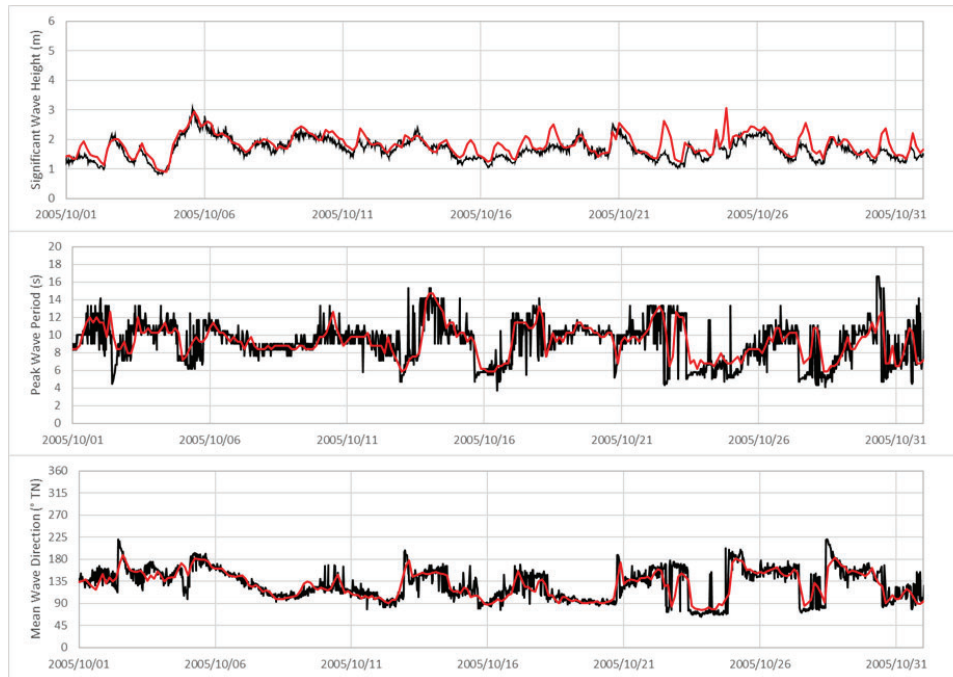


Figure 5-7: Measured (black) and modelled (red) wave parameters at Waverider buoy during October 2005



Figure 5-8: Measured (black) and modelled (red) wave parameters at Waverider buoy during November 2005

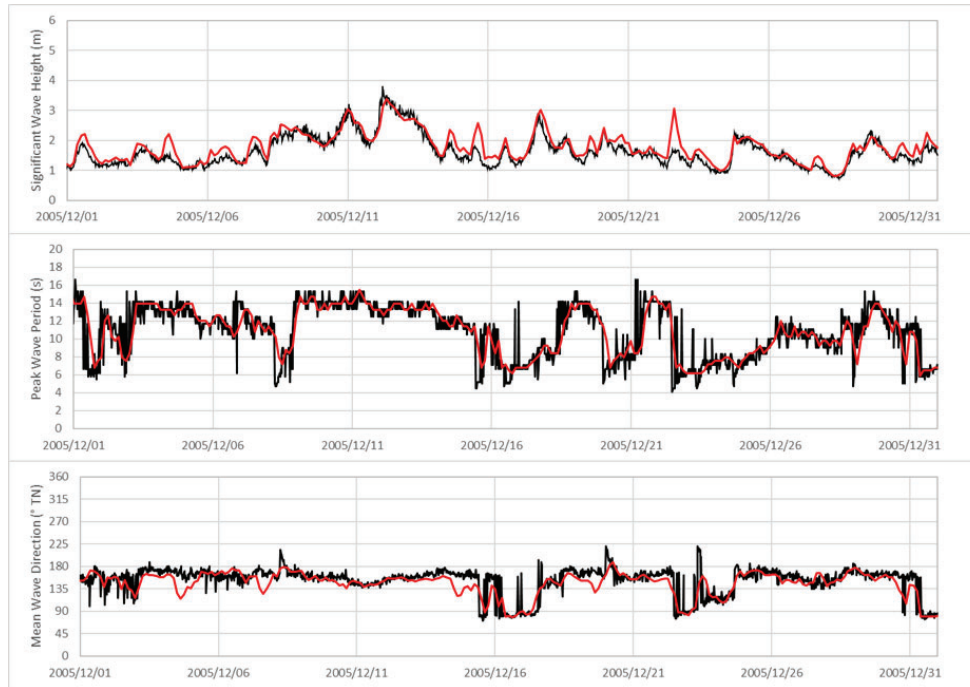


Figure 5-9: Measured (black) and modelled (red) wave parameters at Waverider buoy during December 2005



Figure 5-10: Measured (black) and modelled (red) wave parameters at Waverider buoy during January 2006

6 CHANGES IN WAVE CONDITIONS DUE TO DREDGE DISPOSAL

6.1 INTRODUCTION

Changes in bathymetry due to dredge spoil disposal could impact the nearshore wave climate, which in turn, may impact longshore transport conditions. To assess the changes in the wave climate, a representative set of 87 conditions of wave height, period and direction and duration of occurrence was synthesised from the offshore wave time series. A set of extreme wave conditions were also selected from the existing wave data to investigate how the changes in bathymetry will impact or aggravate the nearshore extreme wave conditions. Of specific potential concern is a possible increase in wave heights impacting the breakwaters, if design conditions are exceeded. While changing wave conditions, if large enough, could also be of concern for ship navigation, it is expected that such would have a negligible influence on navigation. This is confirmed by the results of the modelling.

Employing this representative wave climate and the extreme wave climate, an existing scenario was simulated (no change to the bathymetry) as well as the scenario with the bathymetry associated with the dredge disposal on the existing dumpsite. This allowed an assessment of the relative changes in wave conditions due to the dredge disposal activities.

6.2 BATHYMETRY CHANGES DUE TO DREDGE DISPOSAL

For the purpose of this assessment, the bulked dredge disposal volume of just over 4.3 million m³, discussed in Section 2.3, was evenly distributed across the dredge disposal site (whilst leaving an approximate 50 m boundary around the extremities of the dredge spoil disposal site). Assuming a well-distributed dumping approach across the whole site, the bathymetry was elevated to -13.5 m CD with a mound retained where the dredge disposal generally occurs. The existing bathymetry is presented in Figure 6-1, while the bathymetry after adding the dredge volume to the dumpsite is presented in Figure 6-2.

The elevation increases from the existing bathymetry to the bathymetry resulting after dredge spoil disposal ranges from 7 m at the deepest (southeast) corner of the dredge disposal site to 1 m around the existing dredge mound.

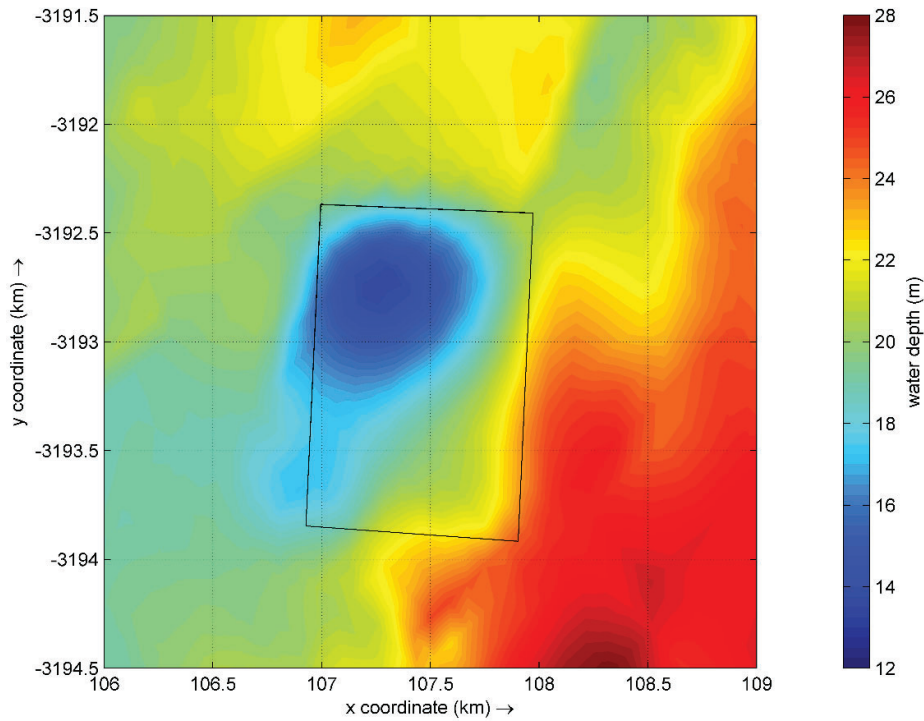


Figure 6-1: Existing bathymetry (CD) at dumpsite before dredge spoil activities

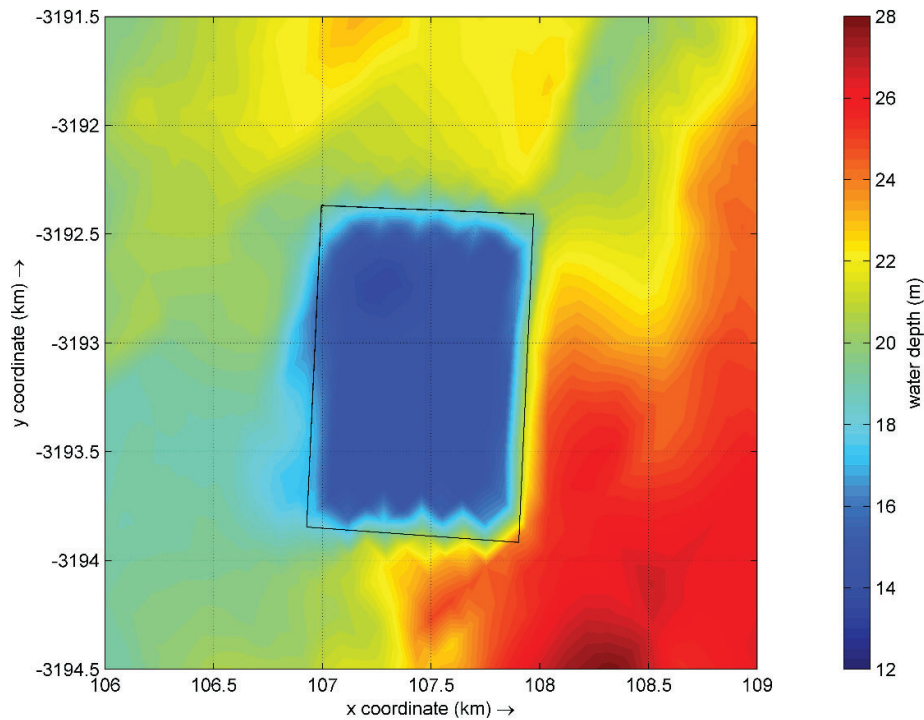


Figure 6-2: Bathymetry (CD) at dumpsite after dredge spoil activities

6.3 DREDGE SPOIL DISPOSAL SCENARIO RESULTS

6.3.1 EXTREME WAVE CONDITIONS

The extreme conditions selected for the model simulations comprise a representative range of extreme offshore wave conditions. To ensure that the range of wave directions are adequately represented, the highest conditions per 22.5-degree sector were selected from the available data. The selection of wave conditions per direction sector included high wave conditions with both long and short wave periods, where applicable. The inclusion of longer period waves is important as the increase in wave height of such waves is much greater in the nearshore region due to wave shoaling. The extreme wave conditions selected for the wave modelling are those reported in Table 6-1.

Table 6-1: Extreme wave conditions selected

Condition	H _{m0} (m)	T _p (s)	Dir (TN)
A	3.3	6.2	55
B	2.951	5.2	68.7
C	2.929	12.5	107.1
D	2.751	9	108.0
E	3.045	13.3	133.5
F	2.617	6.6	120.7
G	3.601	14.2	156.6
H	5.5	12.5	160.9
I	6	12.5	199.3
J	5.092	9.3	193.5
K	6.333	14.2	202.7
L	5.3	9	210.0

Appendix B illustrates changes to each of the selected extreme wave conditions (in Table 6-1) as a result of the changes in bathymetry on the dredge disposal site. While marginal changes in wave direction (of a few degrees at most) could impact sand transport, it is deemed that such changes will not affect breakwater integrity or navigation. It is noted, for several of these cases, that no impact will occur on the breakwater.

Interpretation of wave data directly opposite the breakwater (in 10 m depth) show that the maximum increased wave height for all of these extreme scenarios is no more than 5 cm: the result depicting the most significant change in wave climate due to the dumping activity is presented in Table 6-2.

Table 6-2: Predicted change in the most extreme wave condition

Extreme wave condition	H _{m0} Existing (m)	H _{m0} Resulting (m)	Change (m)
K	3.53	3.58	+0.05

This prediction relies on an offshore wave dataset covering a single year. Even if more severe extreme conditions than those selected were to occur, the wave height increase on the breakwater will unlikely exceed 10 cm and thus will be unlikely to have a significant impact on increased breakwater damage.

6.3.2 FULL WAVE CLIMATE

To observe the resultant changes due to dredge spoil disposal at the existing dumpsite for the full wave climate (here represented by 87 discrete and unique combinations of significant wave height, peak wave direction and peak wave period), the difference between each condition for the existing and the dredge spoil scenario was determined and the changes reported in terms of changes in wave both wave heights and wave direction.

This change in wave height or wave direction was multiplied by the long-term annual frequency of occurrence of that particular wave condition and then summed over time. From this, a difference plot was created indicating the areas where a significant frequency-weighted change will occur in wave height (Figure 6-3) and wave direction (Figure 6-4). Note that a positive change in wave direction implied a clockwise rotation of the wave direction.

It should be noted that this exercise primarily serves to define the footprint of impact. Conclusions regarding the magnitude and direction of longshore sediment transport cannot be made directly from the wave height and direction information in these images, since sediment transport employs wave heights and directions (together with wave period and other data) in a complex manner, resolvable only by means of direction calculations of longshore transport (Section 7). Nevertheless, it is clear that wave height and wave direction changes will primarily impact the beach between the Mhlathuze Estuary and the southern breakwater.

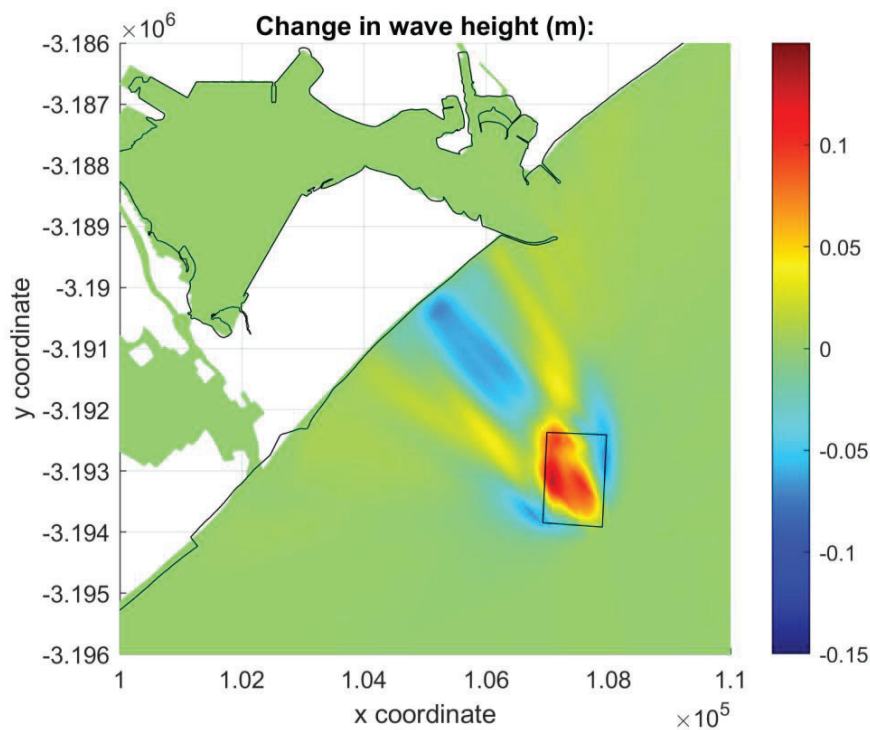


Figure 6-3: Resultant change in wave height (m)

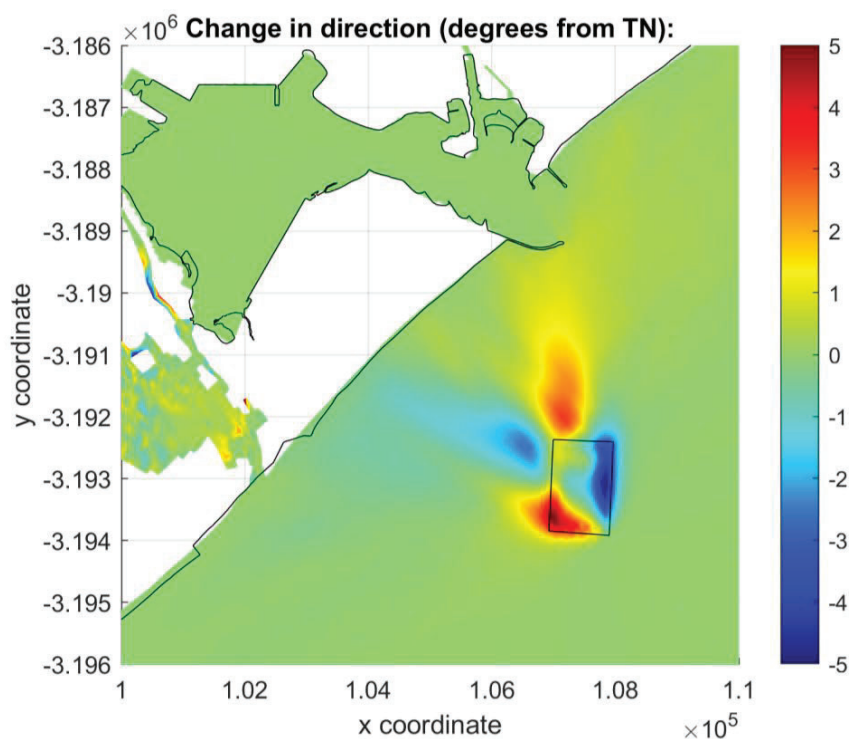


Figure 6-4: Resultant change in wave direction (° from TN 0)

For the assessment of the changes in the longshore sediment transport, output locations were placed along the 10 m contour of the bathymetry of the existing shoreline (Figure 6-5). The changes in longshore transport and in shoreline evolution are dealt with in the following Section 7.

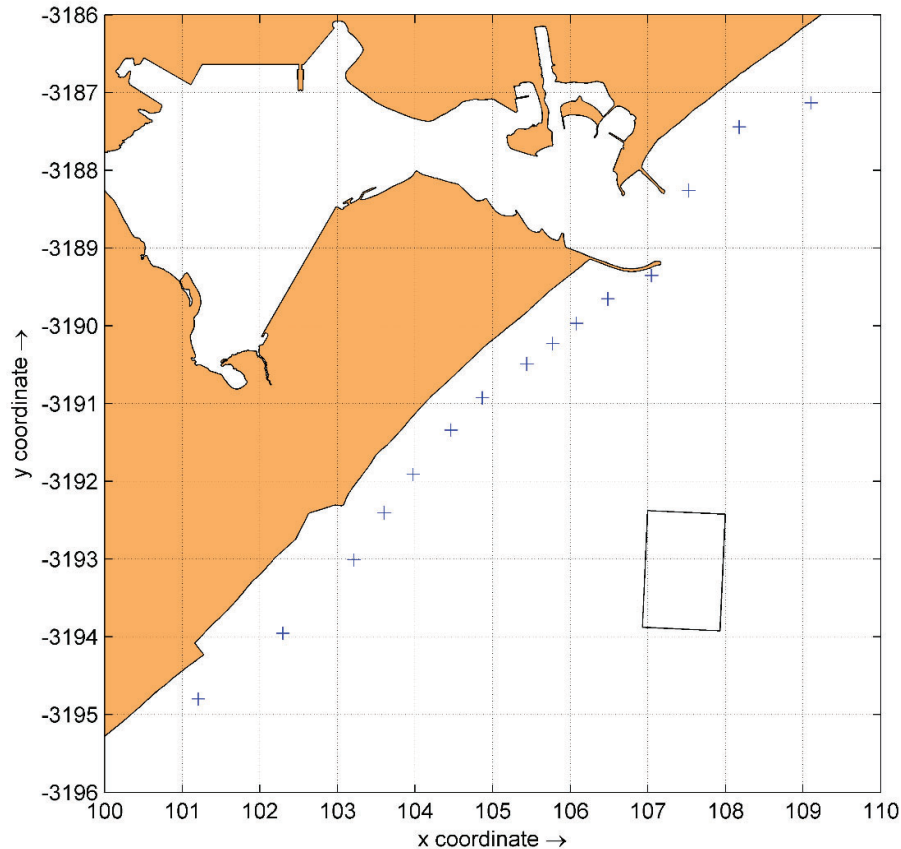


Figure 6-5: Locations of interest for which output data from the wave model have been extracted to inform the sediment transport assessment

7 CHANGES IN SEDIMENT TRANSPORT

Section 6 highlights the changes in wave climate inshore of the dredge spoil disposal site resulting from changes in water depth on the dredge spoil disposal site due to dredge spoil disposal activities. These changes will impact the existing longshore sediment transport along parts of the Richards Bay coastline, which will result in shoreline accretion and/or erosion relative to the existing condition. In this section the effect of a changed wave climate on longshore transport is quantified together with an assessment of consequent shore accretion / erosion and coastal management / mitigation requirements.

7.1 EXISTING SEDIMENT TRANSPORT REGIME

The Richards Bay coastline is predominantly smooth with gentle curves, comprising a mix of sandy beaches - both dissipative and reflective - and rocky high-shore regions, as identified by Harris *et al.* (2011). Most of the coastline in this area is sandy, particularly in the southern sections, while the northern beaches feature rocky areas along the upper shore (refer to Figure 7-1).

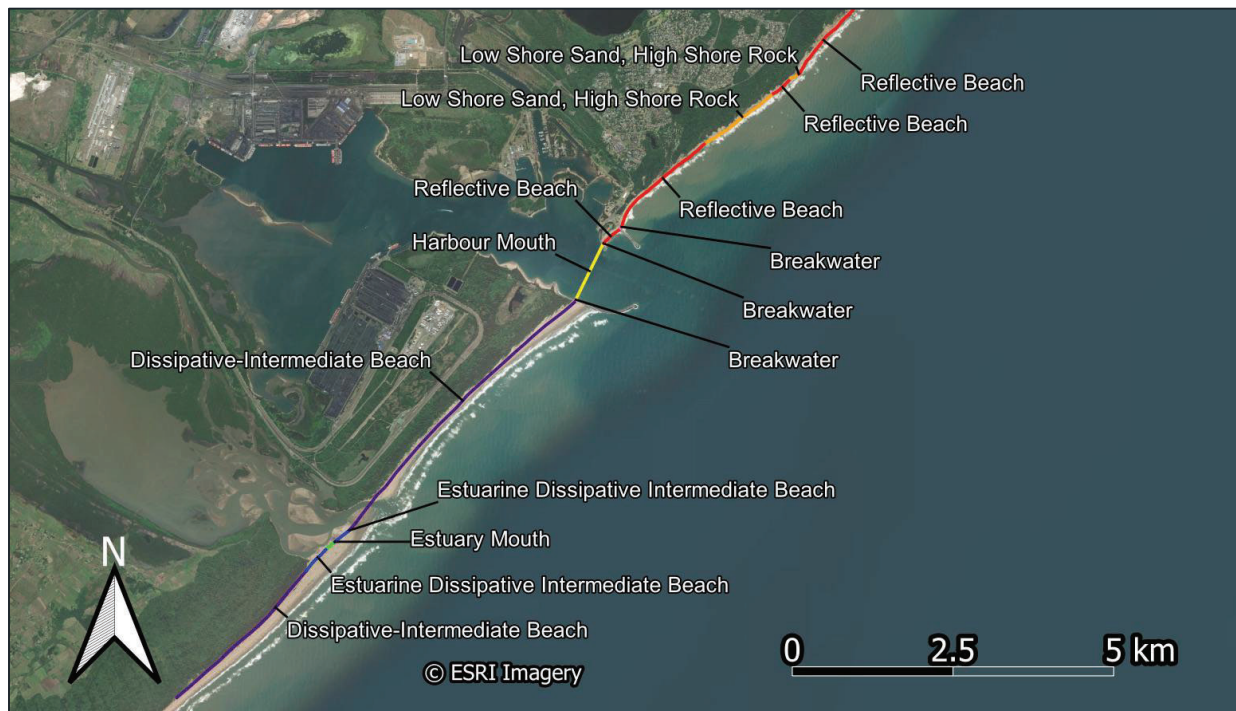


Figure 7-1: Richards Bay coastline types.

A detailed historical overview of shoreline changes and the sediment transport regime is provided in Appendix A. The reported values of the net longshore sediment transport rate along the Richards Bay coast are approximately 800 000 m³/year (CSIR, 1978; Swart, 1981 and Laubscher *et al.*, 1991; CSIR, 2008; Van Rijn, 2014). However, transport rates can vary significantly along different sections of the coast (Coppoolse *et al.*, 1994; CSIR, 2008): around 579 000 m³/year at the far-southern beach, 250 000 m³/year at the central beach, 800 000 to 1 000 000 m³/year at the northern beach, and up to 1 200 000 m³/year at the far-northern beaches (see Figure 7-2 that follows). According to Coppoolse and Schoonees (1991), these rates indicated the volume of material that would need to be dredged from the southern side of the port for bypassing to the beaches located to the north. In agreement with these magnitudes, the net north going sediment transport along the east coast of South Africa between Durban and Richards Bay is estimated to be about 500 000 to 800 000 m³/year based on measured results (Schoonees, 2000 in van Rijn, 2014). Additionally, it is demonstrated that the direction of net longshore transport can shift from north to south, or vice versa, with even a slight change in wave direction or wave climate (Coppoolse and Schoonees, 1991; van Rijn, 2014; CSIR, 2015). Therefore, the gross longshore transport is much larger than the above reported net longshore transport magnitudes (CSIR, 2015). These longshore sediment transport rates are supported by data on the volumes of sand disposed of on the northern beaches as per CSIR (2015).

The shoreline dynamics at Richards Bay are complex, influenced by both natural factors, like Mhlathuze Estuary inputs and longshore sediment transport, and significant human interventions associated with the port, including sand bypassing, dredging and offshore dredge spoil disposal. For a comprehensive analysis of this area's shoreline evolution and sediment transport regime, refer to Appendix A.

While the present sediment transport assessment focuses on evaluating the relative changes caused by dredge spoil disposal activities, understanding the existing transport rates is crucial. This knowledge helps quantify the impact of these relative changes in sediment transport due to changes in bathymetry due to material disposal at the offshore dump site.

7.2 APPROACH TO THE ASSESSMENT

The assessment is focussed on the dredge spoil disposal changes offshore bathymetry leading to altered wave conditions (Section 6) and subsequent variations in the longshore sediment transport regime. The focus is on the stretch of coastline from the Mhlathuze Estuary mouth region up to the southern breakwater of the port entrance (Figure 7-2); however, minor changes further to the north are also considered.

The UNIBEST CL+ model, specifically its Longshore Transport (LT) module, was employed to calculate wave-induced longshore sediment transport. The model incorporates all relevant nearshore coastal processes (*e.g.* wave refraction, wave shoaling, wave breaking, generation of a longshore current and the suspension and transport of sand by this current) to calculate longshore sand transport. This was achieved at several locations along the Richards Bay coastline, from the Mhlathuze Estuary mouth to north of the Richards Bay Port entrance (Figure 7-2). These locations were selected, based on the modelled footprint of wave height and angle change as discussed in Section 6 above.

Additionally, the CoastLine (CL) module by UNIBEST is used in *difference mode* to simulate the shoreline evolution driven by the changes or differences in longshore sediment transport gradients obtained from the LT-module. This process visually demonstrates the impact of differential sediment transport on the coastline, offering a valuable summary of the predicted evolution.

The *difference-mode* modelling focusses on changes in longshore transport predicted to occur (as a result of changed wave conditions) as well as the extent of these changes. This information allows for a broad assessment of where erosion and accretion are predicted to occur; however, only due to the altered conditions driven by the dredge spoil disposal activities (*i.e.*, exclusive of any existing erosion/accretion trends). Accordingly, areas are identified where coastal management interventions may be required.



Figure 7-2: Cross-shore profile locations.

7.3 RESULTS AND ANALYSIS

Table 7-1 below represents the percentage change in longshore transport as calculated at each of the identified cross-sections (Figure 7-2). The percentage change is reported relative to the existing longshore transports, *i.e.* without any mounding of material on the disposal site. A negative percentage thus indicates a decrease in longshore transport due to the presence of a dredge spoil disposal "mound" on the disposal site.

Table 7-1: Percentage change in sediment transport rate along the study area

Location		% Change
Far-southern Beach	1	-0.26
	2	-0.48
	3	-2.20
Southern Beach	4	-2.35
	5	-3.92
	6	-0.94
	7	1.12
	8	-21.46
	9	-17.12
	10	-7.14
	11	10.93
	12	16.92
Northern Beach	13	0.67
	14	4.19
	15	2.15

Key observations relating to these changes follow, noting that alongshore variations in the change of sediment transport rate (due to the disposal mound) will translate to either shoreline erosion or shoreline accretion, are discussed below.

Far-southern beach:

- A very small decrease in northerly longshore sediment transport is predicted. Given the nature of the coastline between locations 1 to 3, some accretion could be expected. Note the influence of the estuary mouth in this region can dramatically impact the shoreline behaviour.

Central Beach:

- Near the Mhlathuze Estuary (Location 4 & 5), while a decrease in transport suggests potential sediment accretion, the powerful natural processes associated with the estuary dominate, rendering any impact from these minor changes negligible.
- At the narrowest beach section (Locations 6 & 7), a localized transport imbalance is expected to aggravate erosion. Given the beach's limited width (~40 m), this creates shoreline vulnerability that requires monitoring and potentially targeted management actions, such as sand nourishment.
- Further north (Locations 8 – 10), a significant reduction in sediment transport rates is predicted throughout this zone, further limiting the amount of sediment transport in a northerly direction.
- Closer to the breakwater (Location 11 & 12); however, a localized increase in northerly sediment transport is anticipated. This specific increase is expected to exacerbate erosion on the beach in this region.

Considering the overall picture, despite the localized increase near the breakwater, the net volume of sediment transported northward towards the breakwater appears reduced relative to the existing conditions. While this contributes to an erosional trend for the southern beach (relative to the existing condition) the change is relatively small and thus unlikely to impact on the sand bypass activities.

Northern Beach:

- A slight increase in northerly sediment transport is anticipated for locations north of the breakwater. This change will likely induce erosion on the northern beach. To prevent this erosion and offset the increased transport rate, the quantity of sediment bypassed around the structure may need to be increased accordingly. However, since the change in transport is a small percentage of the total annual volume (estimated at 800,000 m³), the required additional sand supply to the northern beaches is expected to be in the order of a few tens of thousands m³/year.

Difference model:

The *difference model* was employed to simulate the specific shoreline morphological changes resulting from offshore dumping activities, as discussed in Chapter 6. The model simulates the effect of changing wave conditions (due to offshore dumping only) on the shoreline over a specified time period.

This model was applied to the central and far-southern beaches to illustrate the shoreline changes over a 40-year period (note that the model was not applied to the northern beach since the transport changes are small in this region). The resulting shoreline changes for the southern and far-southern beaches are shown in Table 7-2.

Table 7-2: Resultant shoreline changes from difference model

Location		Change [m]	Comment
Far-southern Beach	1	7.2	Accretion
	2	5.6	Accretion
	3	0.4	Stable
Southern Beach	4	-1.1	Erosion
	5	-5.2	Erosion
	6	-8.5	Erosion
	7	-9.1	Erosion
	8	-8.1	Erosion
	9	-10.9	Erosion
	10	-12.6	Erosion
	11	-13.0	Erosion
	12	-8.2	Erosion

Results from the difference model reveal a distinct spatial pattern of net shoreline change relative to baseline conditions. North of the Mhlathuze Estuary mouth (southern beach), net erosion dominates, reaching a maximum predicted ~13 m adjacent to the breakwater and tapering approximately linearly down to ~1 m near the estuary. South of the estuary (far-southern beach), net accretion occurs, intensifying gradually from ~0.4 m near the estuary to ~7 m at the southern model extent.

Historical context:

As mentioned in Appendix A, offshore disposal of dredged material may have some influence on the central and far-southern beaches (Locations 1 to 11). The observed historical shoreline changes in these areas due to offshore disposal are inconsistent and appear to be minimal compared to mechanisms causing shoreline change and likely overshadowed by these other contributing mechanisms, *i.e.*, the magnitude of the predicted changes due to offshore dredge spoil disposal is likely negligible compared to the natural variability in shoreline change driven by waves, wind, estuary runoff and nearshore currents. As a result, any erosion related to offshore disposal is likely to be obscured by more dominant coastal processes, especially when the order of this erosion processes is an approximate maximum of 13 m over 40 years (Table 7-2) – a relatively minor change when noting that some of these beaches had shoreline changes of up to 80 m over 2 to 3 years.

It is furthermore noted that sediment disposed of at the offshore mound will be subject to transport by wave and currents – as highlighted in Section 4.2.3 most of the material has historically been transported off the disposal site. Particularly over a long period (e.g., the 40 years considered in the shoreline modelling) the effects of the mound on wave and transport conditions will significantly diminish.

7.4 SUMMARY

Overall, the results indicate that the changes in wave climate due to the dredge disposal activities have varying impacts on the sediment transport at different locations along the coastline, relative to the existing sand transport and shoreline regime. A summary of the above assessment follows and is represented by the result of the difference model that was run.



Figure 7-3: Erosion and Accretion zones resulting from dredge disposal activity

In the southernmost areas (Locations 1-5), the predicted effects on sediment transport are generally minimal. Further northward of the estuary mouth (Locations 6-9), more pronounced effects are anticipated. Erosion requiring manageable intervention (sand nourishment) could be required in the narrowest beach segment (between Locations 6-7) due to localized transport changes, since the beach is (presently) relatively narrow here. In the areas near the south breakwater (Locations 10-12), model predictions indicate slightly more severe erosion; however, the existing beach is very wide and can likely accommodate the predicted erosion of about 13 m.

8 CONCLUSIONS AND RECOMMENDATIONS

The conclusions and recommendations of the study are presented below.

8.1 CHANGES IN EXTREME WAVE CONDITIONS

Wave data from a selection of extreme wave conditions was extracted along the breakwater (in 10 m depth). The results indicate a wave height increase of no more than 5 cm. Even if the extremes were underestimated (as the wave data employed was for a limited period of a year) the increase is unlikely to be any more than 10 cm.

8.2 CHANGES IN SEDIMENT TRANSPORT

The assessment evaluated how dredge spoil disposal might alter northerly longshore sediment transport along the coastline from Location 1 (Far-southern Beach) to Location 15 (Northern Beach). The results indicate that the impacts vary significantly along this stretch, strongly influenced by existing natural conditions. Most changes due to the dumped mound will likely be undetectable in the context of other influences. Only in the area of locations 6 and 7 could the predicted erosion cause detrimental effects, as the beach is presently narrow in this region.

The potential impact is further mitigated by the historical observation that material is removed from the disposal site relatively rapidly. This would cause a reduction in the impact on longshore sediment transport and on beach stability (erosion and accretion). Simply stated, the above results are conservative in that the assumed longevity of the changes in water depth on the dredge spoil disposal site (40 years) is unlikely due to the dispersion of dredged material off the disposal site.

Consequently, the model results are deemed very conservative if only the capital dredging and dredge spoil disposal activities associated with only the Berth 605 development are considered, less so should the cumulative impacts of other proposed developments within the Port of Richards Bay be considered. Such cumulative impacts would decrease with an increasing duration between the dredge spoil disposal activities of project likely to lead to such cumulative impacts. Given the likely elapsed time between such capital dredging projects and the rates of removal of material of the disposal site, the results reported above are likely to remain sufficiently conservative should such cumulative impacts be considered likely to occur.

8.3 RECOMMENDATIONS

Recommendations of the study are as follows:

- Conduct annual satellite-based shoreline monitoring, particularly along the southern beach.
- If beach width reduces to 20–30 m, consider targeted beach nourishment.
- Reassess cumulative impacts if multiple dredging projects are planned in close succession.

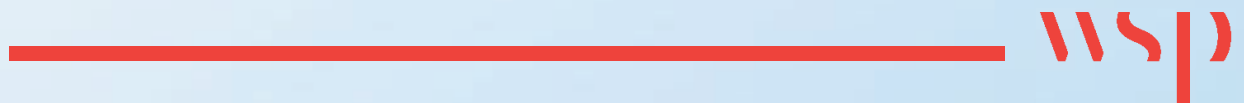
9 REFERENCES

- Booij, N., Ris, R. and Holthuijsen, L.H (1999). A third-generation wave model for coastal regions, Part 1, Model description and validation. *Article in Journal of Geophysical Research Atmospheres*, 788, 7649-7666.
- Chen, D. J. Zheng, C. Zhang, D. Guan, Y. Li and Y. Wan (2021) Critical shear stress for erosion of sand-mud mixtures and pure mud, *Front. Mar. Sci.* 8:713039. doi: 10.3389/fmars.2021.713039
- Coppoolse, R.C. and Schoonees, J.S. (1991). Maintenance Dredging at Richards Bay: Sensitivity Analysis of Predictive Models and the Location of an Offshore Dump Site. *Proceedings: CEDA Dredging Day*, Amsterdam, Netherlands, 1991.
- Coppoolse, R.C., Schoonees, J.S., and Botes, W.A.M. (1994). Physical Impacts of the Disposal of Dredger Spoil at Richards Bay, South Africa. 28th PIANC, Seville, May 1994.
- CSIR (1978). Effect of Richards Bay Harbour Development of North Beaches. CSIR Report C/SEA 7801/1 and 2, National Research Institute for Oceanology, Stellenbosch.
- CSIR (2008). Beach Erosion Study Northern Beaches Umhlathuze Municipality. Report No. CSIR/NRE/ECO/ER/2008/0109/C.
- CSIR (2015). Reconfiguration of the Richards Bay Sand-Trap and Related Dredging Issues. Draft Report. CSIR, PO Box 320, 7599, Stellenbosch.
- Deltares (2017). Delft3D Wave User Manual (Version 3.05).
- Goussard, L. (2009) New Berth 306 expansion capacity of Richards Bay Coal Terminal, Civil Engineering, May 2009, pp8-12.
- Harris, L., Nel, R. and Schoeman, D. (2011). Mapping beach morphodynamics remotely: A novel application tested on South African sandy shores. *Estuarine, Coastal and Shelf Science*. 92. 78-89. 10.1016/j.ecss.2010.12.013.
- Laubscher, W.I., Coppoolse, R.C., Schoonees, J.S. and Swart, D.H. (1991). A calibrated longshore transport model for Richards Bay. *Coastal Sediments '91*, Volume 1L 197-211, Seattle, Washington.
- Mather and Stretch (2012). A Perspective on Sea Level Rise and Coastal Storm Surge from Southern and Eastern Africa: A Case Study Near Durban, South Africa, *Water* 2012, 4, 237-259; doi:10.3390/w4010237
- Mitchener, H., and Torfs, H. (1996). Erosion of mud/sand mixtures. *Coast. Eng.* 29, 1–25. doi: 10.1016/s0378-3839(96)00002-6
- Schoonees, J.S. (2000). Annual variation in the net longshore sediment transport rate. *Coast. Eng.* 40, 141–160.
- PRDW (2024) Provision of Environmental services for environmental specialist studies for the KZN logistics hub programme: Port of Richards Bay TNPA/2022/04/0350/RFP; Part 2 Engineering inputs to the Dredge Disposal Strategy, PRDW Report TNPA-2022-04-0350-RFP-RPT.Rev04, 28pp, January 2024-

- Schoonees, J.S. (2000). Annual variation in the net longshore sediment transport rate. *Coast. Eng.* 40, 141–160.
- Swart, D.H. (1981). Effect of Richards Bay Harbour Development on the adjacent coastline. 25th PIANC, Edinburgh, 5: 899 – 917.
- TNPA (2021). PoRB Masterplan 2021-2035 Richards Bay, TNPA.
- TNPA (2022). Port Development Framework Plans 2022 Update, TNPA Report, 127pp + 35pp Appendices.
- Torfs, H., Jiang, J., and Mehta, A. (2000). Assessment of the erodibility of fine/coarse sediment mixtures. *Proc. Mar. Sci.* 3, 109–123. doi: 10.1016/s1568-2692(00)80116-3.
- Van Ballegooyen, R.C. and G. Jacobs (2020). Nseleni Independent Floating Power Plant (NFIPP) and associated infrastructure, Port of Richards Bay, KwaZulu-Natal: Dredging and Dredge Spoil Disposal Modelling Study. WSP Report 431 001 376-R01, 112 pp.
- Van den Bossche, P., MacHutchon, M.R. and P.J. Ramsay (2007). July 2007 Multibeam Bathymetry Survey of the offshore physical monitoring site associated with the development of Berth 306 – Richards Bay, Marine Geosolutions Report no. 2007-011, 27pp.
- Van Rijn, L.C. (2014). A simple general expression for longshore transport of sand, gravel and shingle. *Coastal Eng.* 90 (2014) 23-29.
- Van Ledden, M., Van Kesteren, W. G. M., and Winterwerp, J. C. (2004). A conceptual framework for the erosion behaviour of sand-mud mixtures. *Cont. Shelf Res.* 24, 1–11. doi: 10.1016/j.csr.2003.09.002
- Van Rijn, L. C. (2020). Erodibility of mud-sand bed mixtures. *J. Hydraul. Eng.* 146:04019050. doi: 10.1061/(ASCE)HY.1943-7900.0001677
- WSP (2024a) Dredging and Sedimentation Concept Report. *WSP Report No. 605-WSP-SW-XX-RP-ALL-112*, November 2024
- WSP (2024b) Engineering Basis of Design and Draft Terminal Operating Philosophy report, *WSP Report No. XRB.E.0030-T001-DB-0001*. October 2024.
- WSP (2024c) Provision of detailed engineering design, construction planning and project execution for new berth 605 at the Port of Richards Bay: Concept Design Report, *WSP Report No. XRB.E.0030-T001-RPT-0014*, 112pp + 16pp App.
- WSP (2024d) Metocean Report, *WSP Report No. XRB.E.0030-T001-RPT-0005, Rev02*, December 2024.
- WSP (2025) Berth 605, Port of Richards Bay EIA Specialist Studies: Dredging and Dredge Material Disposal Modelling Study, *WSP Report No. XRB.E.0030-T001-RPT-0106-V01*, 169 pp + 5pp Appendices,

Appendix A

HISTORICAL SHORELINE CHANGES



A-1 INTRODUCTION

Offshore disposal of dredged material at the Port of Richards Bay has been ongoing for many years, with records dating back to 1977. Since then, offshore disposal has occurred almost annually, with varying volumes of dredged material being deposited offshore (CSIR, 2004a,b; 2005a,b). Dredging activities have primarily involved material from the sand trap located just south of the South Breakwater head, as well as from the port channels and basins. Over the years, various studies have modelled turbidity plumes and assessed other considerations related to the disposal of dredged material in different areas, including reconfigurations of the sand traps (e.g., CSIR, 2015).

However, the historical impacts on nearby shorelines have largely been overlooked, partly due to limited data availability and the inherent complexity of establishing defensible links between offshore disposal characteristics, wave transformation, and resulting shoreline changes. Historical monitoring of the shorelines both south and north of the Port of Richards Bay has been inadequate for such purposes, or the relevant data is not readily accessible.

With recent advancements in satellite-derived shoreline (SDS) technologies, it is now possible to assess historical shoreline changes using satellite imagery. These technologies offer a means to address gaps in historical shoreline monitoring—even in cases where no monitoring previously occurred. This brief review aims to provide a preliminary assessment of historical shoreline changes potentially linked to offshore dredged material disposal by leveraging these modern technologies and available data.

A-2 SHORELINE DYNAMICS AT RICHARDS BAY: AN OVERVIEW

The shoreline dynamics of Richards Bay are shaped by a complex interaction of natural coastal processes and anthropogenic interventions. Since the construction of the Port of Richards Bay in the 1970s and the associated breakwater structures, the sediment transport regime, shoreline morphology, and sediment deposition patterns have undergone significant alterations. Since this study focuses on historical shoreline changes, it is important to understand, among others, the primary sources of sediment in the region, how they have changed over time, and the influencing factors. These include, among others, longshore sediment transport, dredged sediment pumped onto beaches, input from the Mhlathuze River and estuary, the offshore disposal mound, the breakwater that disrupts natural sediment flow, and sand bypassing operations.

A-2.1 LONGSHORE SEDIMENT TRANSPORT AND SHORELINES

One of the primary drivers of shoreline change at Richards Bay is the complexities associated with longshore sediment transport, which is governed by mainly the direction and energy of the incident waves. The reported values of the net longshore sediment transport rate along the Richards Bay coast are approximately 800 000 m³/year (CSIR, 1978; Swart, 1981 and Laubscher *et al.*, 1991; CSIR, 2008; Van Rijn, 2014). However, transport rates can vary significantly along different sections of the coast (Coppoolse *et al.*, 1994; CSIR, 2008): around 579 000 m³/year at the far-southern beach, 250 000 m³/year at the central beach, 800 000 to 1 000 000 m³/year at the northern beach, and up to 1 200 000 m³/year at the far-northern beaches. According to Coppoolse and Schoonees (1991), these rates indicated the volume of material that would need to be dredged from the southern side of the port for bypassing to the beaches located to the north. In agreement with these magnitudes the net north going sediment transport along the east coast of South Africa between Durban and Richards Bay is estimated to be about 500 000 to 800 000 m³/year based on measured results (Schoonees, 2000 in van Rijn, 2014). Additionally, it is demonstrated that the direction of net longshore transport can shift from north to south, or vice versa, with even a slight change in wave direction or wave climate (Coppoolse and Schoonees, 1991; van Rijn, 2014; CSIR, 2015). Therefore, the gross longshore transport is much larger than the above reported net longshore transport magnitudes (CSIR, 2015). The sensitivity analysis of Coppoolse and Schoonees (1991) showed that, as expected, with an increase or decrease in the modelled input wave height the net transport responds accordingly with the larger quantities of transport occurring at the highest wave height increases. They also showed that by increasing the peak wave period, the tendency is for southbound net longshore transport while decreasing the peak period leads to northbound net longshore transport. Confirming the significance of the wave height and angle to longshore sediment transport, CSIR (2015) found that most significant sediment transport at Richards Bay took place during a few events where wave angles were particularly conducive to high transport rates (approx. 200°). These wave conditions are, as expected, associated with storm events (Zimmermann *et al.*, 2012 in CSIR, 2015), in this case mid-latitude cyclones (typical cold front systems during winter) resulting in significant northward longshore sediment transports.

Furthering the complexity, Coppoolse *et al.* (1994) reported that, historically, dredged material had been disposed of on both the southern and northern beaches of the Port of Richards Bay. The most recent disposal at the time of their study, amounting to 2 million m³, was carried out on the far-southern beach, south of the Mhlathuze Estuary mouth. Coppoolse *et al.* (1994) investigated the effects of pumping dredger spoil onto the beach. Four potential beach discharge locations were considered for dredger spoil: P1–P3 on the central beach and P4 on the far-southern beach (Figure A-1). P1–P3 are closer to Quay 609 where the capital dredging was to take place, offering logistical advantages, while P4 was selected to maximize distance from the estuary and port without being impractical. The spoil consisted of 18% sand (1.33×10^6 m³) and 82% silt/clay (6.07×10^6 m³), with an upper sand content estimate of 30% (2.2×10^6 m³). A total of 7.4×10^6 m³ was planned to be pumped over 6–8 months (7 months were assumed for the modelling study). Sand and some silts were expected to settle near the discharge point, while most silt was expected to disperse into the surf zone and offshore. The maximum accumulation at the estuary mouth and the sand trap position south of the breakwater was also determined and defined as the maximum value during either the build-up or retreat phase. It was reported that in most cases the retreat phase was the dominant factor due to northward migration of the sediment slug.

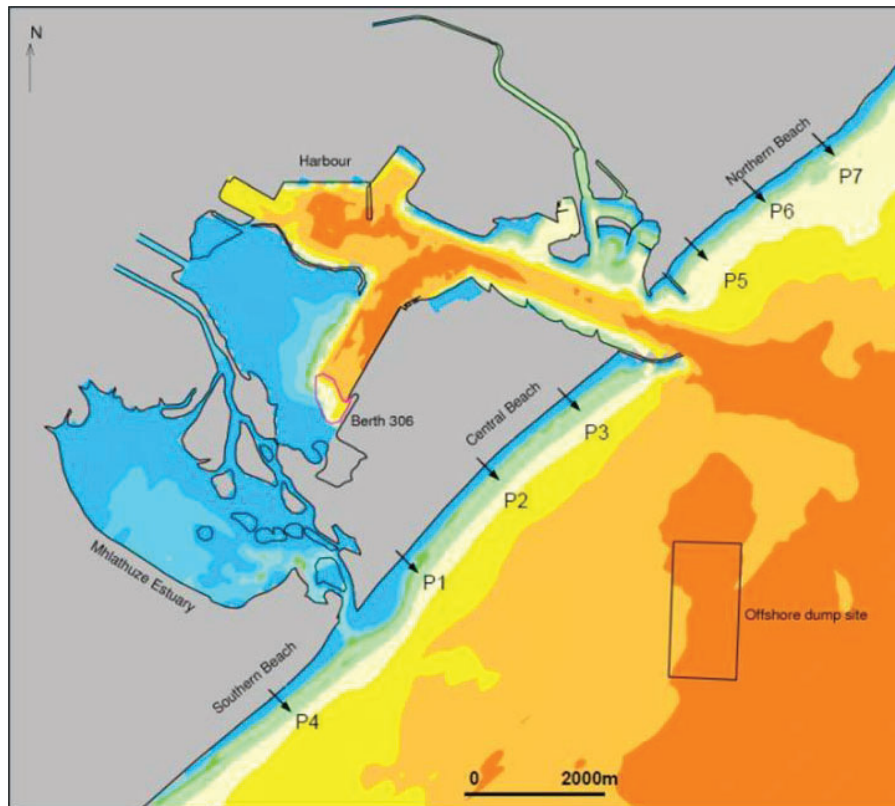


Figure A-1: Locations of disposal sites (P1 to P7) as shown in Figure [source: CSIR, 2004c in BKS, 2013].

Their investigation indicated that initial shoreline changes of up to 210 m could occur at the initial feeding position, 0 to 50 m at the estuary mouth and 35 to 75 m at the sand trap. Furthermore, it is anticipated that under the first extreme wave condition, the estuary mouth could potentially close if dredged material were to be pumped onto the beach at Position P1 or P4. Therefore, extreme shoreline change is expected to occur during these disposals. Unfortunately, limited or no data availability on whether these disposals occurred, as well as their exact quantities and locations, complicates efforts to isolate historical shoreline impacts linked to offshore dump site activities. The build-up of sediment at the estuary mouth and at the sand trap near the southern breakwater was also assessed in their study. Cyrus *et al.* (2008) report that in 1996 a total volume of 3 705 800 m³, and in 1997 a total volume of 1 609 800 m³ and in 1998 a total volume of 682 900 m³ was disposed of on the Central beach area near P3, *i.e.*, a total of 5 998 429 m³ of dredge spoil. It is understood that this disposal is related to the disposal campaign that was assessed by earlier literature, *e.g.*, Coppoolse *et al.* (1994).

Luger *et al.* (2002) conducted limited one-line numerical modelling to assess shoreline changes resulting from the sand fraction in dredge spoil discharged onto the beach, as part of their study on optimising the dredging of Berth 306 for the South Dunes Coal Terminal. Four discharge scenarios (Options 1, 2, 3, and 5) were evaluated. Option 1 involved placing all material 2.4 km south of the Mhlathuze estuary mouth; Option 2 discharged the material 3.4 km north of the estuary mouth; Option 3 placed it 1.55 km north of the northern breakwater; and Option 5 entailed depositing 33% of the material on Central Beach and the remainder at the offshore dumpsite. For Option 2, a maximum shoreline accretion of approximately 240 m was predicted at the discharge location, with noticeable accretion (greater than 20 m) extending about 1 800 m alongshore on either side. Similar accretion patterns, ranging from 200 to 240 m horizontally and 1 600 to 1 800 m alongshore, were predicted for Options 1 and 3 (CSIR, 1999). In contrast, Option 5, involving less sand being deposited on the beach, was predicted to cause only about 60 m of shoreline accretion, affecting a much shorter alongshore distance of approximately 300 m. As with the dredged material placement associated with the Quay 609 extension described by Coppoolse *et al.* (1994), the same uncertainties potentially could exist as to the final location of the placement of the dredge spoil envisaged from the Berth 306 project (Luger *et al.*, 2002). However, it is confirmed in van Ballegooyen *et al.* (2015) that for the Berth 306 development that a total of 3 840 361 m³ of *in-situ* dredge material was dredged and disposed of at the offshore dredge spoil disposal site in 882 barge trips (average of 4 354 m³ of *in-situ* dredged sediment per 10 330 m³ hopper load) over a period of 22 weeks. Maintenance dredging records for this period seemingly do not exist (see Table A-2 and associated footnotes). Thus, it is not clear how much material was disposed of at the existing offshore disposal site during the same period.

While limited data exists on the volumes dumped directly on the beach from 1996 to 1998 (Cyrus *et al.*, 2008), it is uncertain whether this was the only disposal that took place during this period (*e.g.*, Coppoolse *et al.* (1994) also refers to dredge disposal directly onto the beach happening prior to their study). This lack of reliable data complicates efforts to assess and isolate the historical impacts of offshore disposal activities on shoreline evolution.

CSIR (2015) evaluated several scenarios related to the sand trap adjacent to the south breakwater, including variations in trap configuration, fill levels, and their impacts on the surrounding nearshore environment. The study found that if the sand trap is not dredged regularly, accumulated sediment becomes available for redistribution by natural coastal processes, leading to potential accretion along the Central Beach up until the further south beaches and within the harbour entrance channel. These findings highlight that sediment dynamics in the vicinity of the sand trap (e.g., Central Beach) are strongly influenced by both the sand trap's operational status and maintenance practices.

A-2.2 NEARSHORE CHARACTERISTIC CHANGES

Coppoolse and Schoonees (1991) postulated that an abrupt change in nearshore depth caused by the dump site, could significantly affect the local wave climate. Effects could include changes in longshore sediment transport potential and wave focussing. They assessed two scenarios involving reduced depths at the proposed dumpsite area: the first scenario involved a 1.5 m decrease in depth (3 million m³ of storage), and the second, a 3 m depth decrease (6 million m³ of storage). The nearshore wave characteristics (wave height, wave direction and longshore energy flux) at the -5 m MSL contour was investigated. It was found that the 1.5 m depth reduction had minimal impact on wave height and direction at both the beaches and breakwaters. Similarly, the 3 m scenario showed little effect at the beaches, though wave heights at the breakwater increased by approximately 10%. Their study concluded that the dump site will have a negligible effect on the nearshore wave characteristics at the beaches. However, this study did not extensively assess changes in longshore transport (other than energy flux) and accordingly changes in shoreline evolution. This is considered to be a significant limitation.

The potentially increased wave heights at the breakwater are not the only factor influencing sediment dynamics in its vicinity. CSIR (2015) notes that reduced flow velocities within the sand trap promote sediment deposition, as sand drops out of suspension when currents slow. Additionally, recirculation patterns have been observed along the southern side of the breakwater, a phenomenon also reported in earlier studies (Luger *et al.*, 2002; van Ballegooyen *et al.*, 2015, as cited in CSIR, 2015). Records of breakwater repairs (Phelp, 1999) suggest that erosion is occurring in this area, potentially allowing increased wave energy to reach the structure and cause damage to the armour units. This erosion may also contribute to undermining of the breakwater toe. Consequently, the operational condition and maintenance of the sand trap play a critical role in shaping local sediment levels and morphology, irrespective of the potentially relatively minor influence from the offshore sediment disposal mound.

According to CSIR (2008) the northern beaches appear not to have been subject to any significant long-term erosion or accretion in 1937 to 1973 (pre-construction of the Port of Richards Bay). However, with the post-construction of the port, the accretion shoreline response to beach nourishment of the northern beaches close to the northern breakwater are evident in 1977, 1983 and circa 1985-1987. CSIR (2008) reported that aerial imagery has revealed that the alignment of Central Beach has gradually shifted over time, changing from approximately 43° to 46°. Therefore, following the development of the Port of Richards Bay in the 1970s and the subsequent construction of the breakwater, the coastline has undergone significant changes (Schoonees *et al.*, 2006). Since longshore sediment transport is strongly influenced by the angle at which waves approach the coast, this change in beach orientation has resulted in a significant reduction in the net (northward) longshore sediment transport. Similarly, Coppoolse *et al.* (1994) found that the general change in the coastline orientation, especially during build-up from disposal of sediment on the central beach in their study, causes a decrease in the net (northward) longshore transport rate. The reduced sediment flow along Central Beach helps explain the occasional difficulty in sourcing sufficient sand for bypassing operations from the sand trap located next to the south breakwater and the need for increased sand bypassing activities (CSIR, 2008; CSIR, 2015). Between 1990 and 2006, the average annual volume of sand dredged from the sand trap was about 528 000 m³/year (WSP, 2007 in CSIR, 2008).

A comprehensive study by the CSIR (2002), cited in BKS (2013), found that bathymetric changes of 1.7 m across an area of 3.5 km² in water depths of 20–40 m could lead to approximately 10 m of shoreline erosion. To avoid significant wave focusing and associated erosion, it was recommended that changes to bathymetry at depths around 20 m should be limited to 0.5 m, a recommendation shown by the present study to likely to be too conservative. The present study shows that the extent of erosion is not too severe, for changes in bathymetry greater than 0.5 m in waters shallower than 20 m). Regarding disposal options for the Port of Richards Bay Expansion Programme (RBPEP) under assessment by BKS, placing dredged material onto an offshore disposal site (in water depths of ~ 20m via pipeline near the Central Beach was deemed unsuitable for long-term use due to the high volume and sand content (37%) of the material, which would likely cause wave focusing and consequent beach erosion. Similarly, BKS (2013) reported that offshore disposal at the current offshore dump site resulting in an accumulation of sand could lead to wave focussing and shoreline erosion within 5 to 10 years from their study when considering the rate of maintenance dredging disposal at that time.

A-2.3 DUMP SITE SEDIMENT TRANSPORT

Coppoolse and Schoonees (1991) investigated the quantity and general net direction of sediment movement at a proposed offshore dumpsite using wave and current data. This dumpsite was 1200 m by 1700 m and located approximately 2 km south of the south breakwater. The sediment transport rates were calculated for years with the best wave data coverage (1982 to 1988). Figure A-2 summarise the transport rates per directional sector. It is seen that a total of 7.5 m³ per metre per year will be transported in a northwest direction (toward the Central Beach area), amounting to approximately 13 000 m³ per year for the dump site. CSIR (2001) reported that the sediment (60.9% is mud, 2.1% very fine sand, 21.4% fine sand, 12.4% medium sand, 2.0% coarse sand, 0.5% very coarse sand and 0.6% coarser material) deposited at the offshore dumpsite (referred to as Option 5 in their study on the dredging of Berth 306 for the South Dunes Coal Terminal) becomes resuspended during periods of high wave and wind activity and is advected from the site in the form of turbidity plumes. These plumes generally remain offshore and rarely reach the shoreline. Furthermore, it was predicted that only about 3% of the fine sediment would remain at the dump site by the end of the dredging operation. Subsequent assessments based on measurements (van Den Bos and modelling studies (e.g., van Ballegooyen *et al*, 2015) indicated this to be incorrect as much more material is indicated to remain in the dredge spoil disposal site (see Section 4 of the main report).

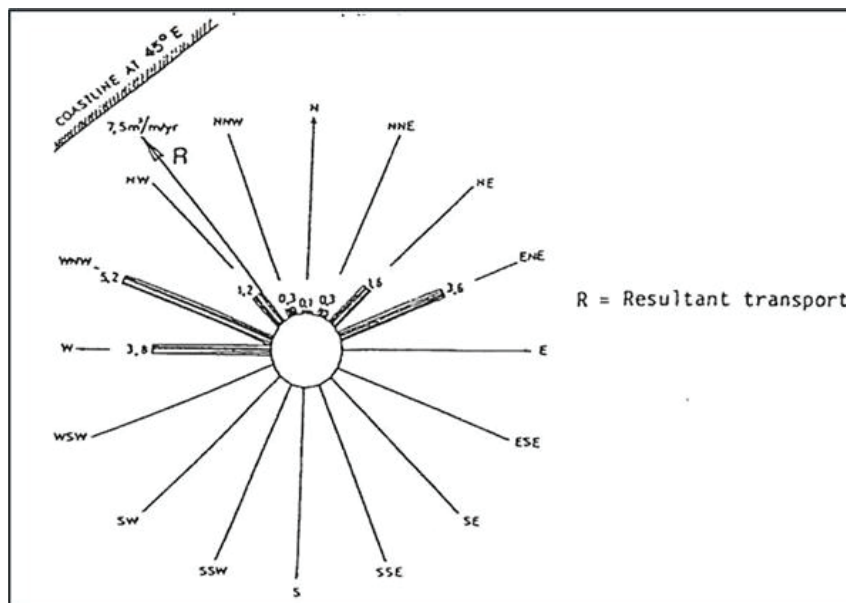


Figure A-2: Net sediment transport at dump site (Coppoolse and Schoonees, 1991).

Van den Bossche *et al.* (2007) documented notable changes at the offshore dumpsite between 2006 and 2007. Bathymetric data revealed three distinct, interconnected dredge spoil mounds—northern, central, and southern. The most significant change was the erosion of approximately 500 000 m³ from the northern mound, accompanied by a nearby sediment accumulation of around 430 000 m³ to the southeast, covering roughly 678 000 m². Van den Bossche *et al.* (2007) noted that sediment transport, inferred from subaqueous dune orientations, was predominantly directed in a north easterly direction and into deeper waters. van den Bossche *et al.* (2007) states that this aligns with observations from previous surveys conducted in 2005 and 2006 (Ramsay & MacHutchon, 2005; 2006); however, an overall complex transport pattern was reported. It was also reported that the minimum depth across the mounds deepened from -11 m in 2006 to -14.3 m in 2007, indicating significant erosion. A bathymetric comparison showed a maximum erosion of 6.3 m, a maximum accumulation of 2.1 m, and a mean change of +0.16 m across the 4 km by 2 km area, suggesting a slight net accumulation of sediment since January 2006. Figure A-3 indicates that a large portion of the eroded sediment was transported 200–750 m southeast, near the reef area. While this suggests most sediment was redeposited nearby, an estimated 75 000 m³ remains unaccounted for - van den Bossche *et al.* (2007) postulates that it was likely dispersed by winnowing, wave or current transport, or can be accounted for through further settling.

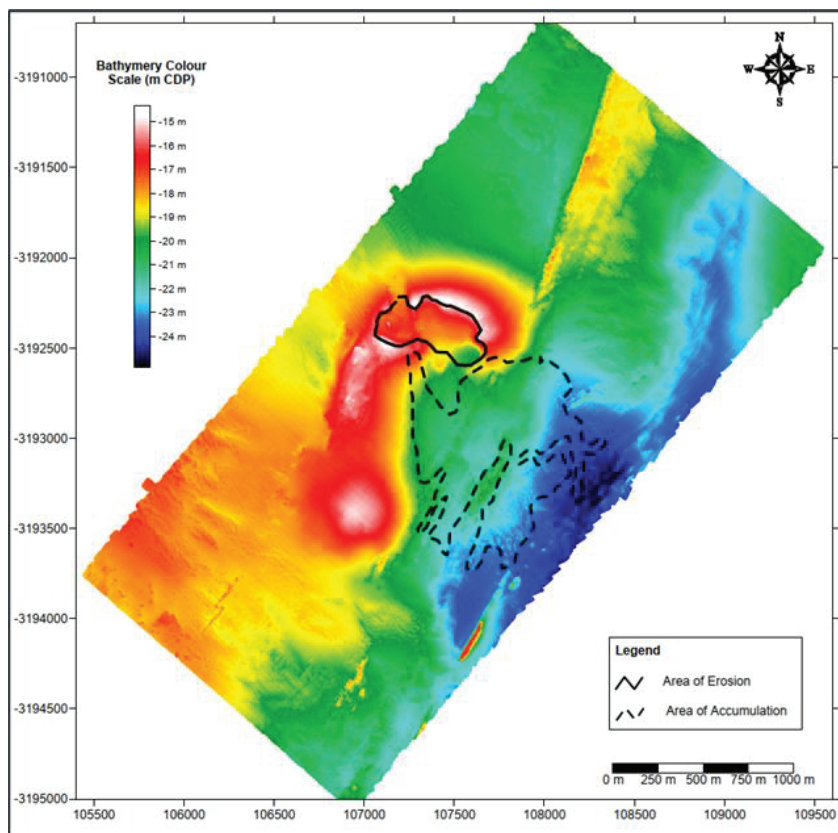


Figure A-3: Multibeam bathymetry map showing the location of maximum sediment erosion and accumulation (CSIR, 2007).

The erosion and re-deposition of dredge spoil observed in the survey are likely due to a combination of factors. The primary driver appears to be high-energy storm swells—particularly the significant storm event along the KwaZulu-Natal coast in March 2007 (the high-water line retreated by up to 30 m as reported in Smith *et al.*, 2010). Smith *et al.* (2010) notes that although the primary driver of these dramatic changes at the offshore mound was most likely due to the March 2007 storm event, the survey may include effects from subsequent swell events. Other contributing factors may include localized wave-induced and topographically influenced currents near the reef. Furthermore, this amount of erosion is equivalent to the Richards Bay annual longshore drift volume (Schoonees, 2000 in Smith *et al.*, 2010).

A-2.4 MHLATHUZE ESTUARY SEDIMENT LOADS

The proximity of the Mhlathuze Estuary to the Port of Richards Bay most likely gives it an important role in the area's coastal dynamics. Coppoolse *et al.* (1994) reported that the annual runoff from the Mhlathuze River between 1977 and 1991 ranged widely, from approximately 30 million to 680 million m³/year, highlighting substantial year-to-year variability. Despite this, along with previous dredged material disposals both north and south of the estuary mouth and fluctuating longshore transport rates, the estuary has remained open since its formation. The Mhlathuze River's average annual sediment load is approximately 237 100 m³/year (CSIR, 1993 in Coppoolse *et al.*, 1994). However, this load varies significantly and can be many times higher, especially after dry periods.

Historical runoff from the Mhlathuze River was assessed using data from gauge station W1H032 (Mhlathuze River @ Umhlathuze Valley). According to the DWS data portal (2025), the catchment area is 2 678 km², and the gauge station is located at latitude 28°48'4.57"S and longitude 31°57'19.37"E. Its location relative to the Port of Richards Bay is shown in Figure A-4. The station is positioned far downstream within the catchment, suggesting that it captures the majority of the catchment's flow, with minimal additional contributions expected beyond the station.



Figure A-4: Location of gauge station W1H032 - Mhlathuze River.

However, the quality of the runoff data is fairly poor, as illustrated by the raw monthly flow volumes shown in Figure A-5 (DWS, 2025), which were recorded at gauge station W1H032 on the Mhlathuze River. The dataset, spanning the available historical period, contains inconsistencies, gaps, and possible anomalies that limit its reliability for detailed quantitative analysis. While it offers a general indication of seasonal and interannual runoff trends, caution should be exercised in interpreting the values. Moreover, runoff volumes do not necessarily correlate with sediment yield, as multiple independent factors influence each process. Table presents the processed annual runoff volumes for the Mhlathuze River, based on data from gauge station W1H032 (Mhlathuze River @ Umhlathuze Valley). The runoff volumes vary significantly, from near-zero to several hundred million cubic metres, highlighting the substantial interannual variability also noted by Coppoolse *et al.* (1994). Later in this study, these runoff volumes will be compared to shoreline trends near the estuary mouth to evaluate whether any meaningful correlations can be identified without overextending the interpretation, given the uncertainty in data quality.

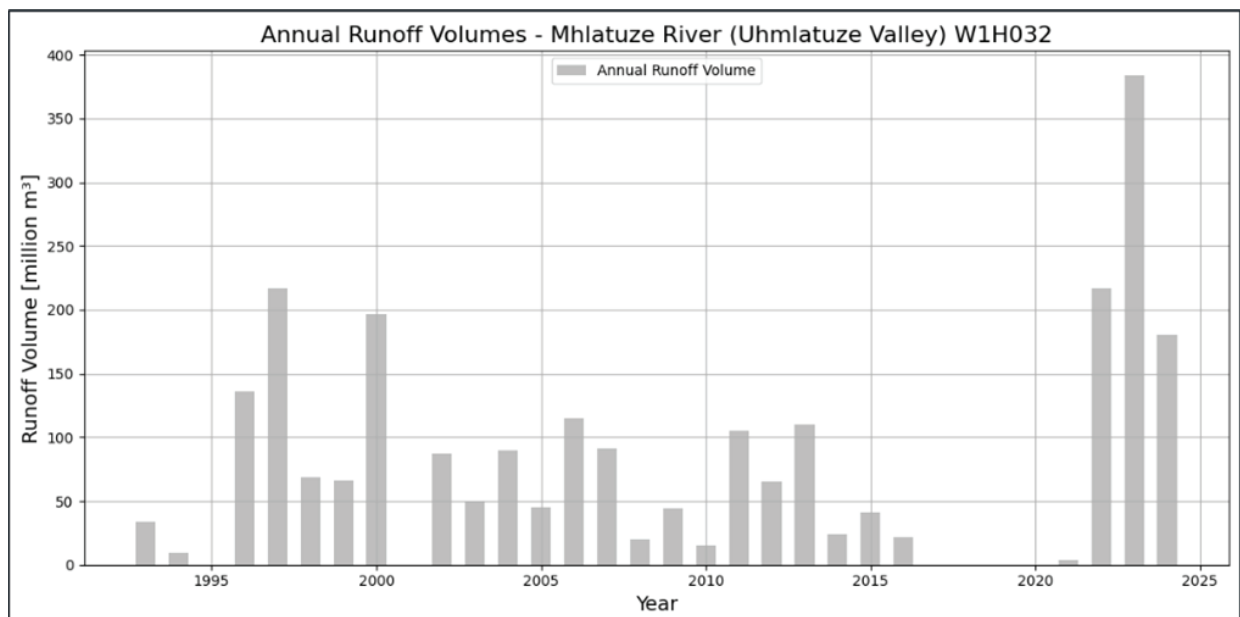


Figure A-5: Annual runoff volumes for Mhlathuze River. (See Table A-1 for data gaps and therefore possible inaccuracies in these plotted data)

Table A-1: Monthly flow volumes Mhlathuze River (DWS, 2025).

Data are continuously updated and reviewed.
Format of the data is as follows : (I4,X,I4,13(X,A6,A1,A1) where:
I4 = CCYY
X = /
I4 = CCYY
13(X,A6,A1,A1) = 12 Monthly volumes in million cubic metres from Oct to Sep.
Value 13 is the yearly total.
X = Space
A6 = 999999
A1 = &/+E/*m/M or space(& = Good monthly reading)
(+ = Above rating)
(E = Estimated Data)
(* = Calculated estimate)
(m = Greater than)
(M = Less than)
A1 = # or space (# = record incomplete or does not exist)

MONTHLY VOLUMES W1H032
Variable 100.00 Surface Water Level
I4,X,I4,13(X,A6,A1,A1)
AAAAAAAAAAAA

1992/1993							1.06	0.439	0.078	0.068	0.016	0.058	1.38	#
1993/1994	27.2+	0.876	2.93	1.03	2.08	1.09	0.741	0.095	0.013	0.003	0.090	0.001	36.1+	
1994/1995	0.688	3.50	0.066	0.050	0.031 #	#	#	#	3.93 #	1.13	0.005 #	0.048	#	
1995/1996	2.02	0.001	29.9+	46.8m	19.1m#	16.2m	11.7	8.15	2.57	17.0	5.99	0.597	160m#	
1996/1997	1.67	1.75	4.77	18.7	29.5+	16.3	16.9	4.33	5.30	8.82	4.75	12.3	125+	
1997/1998	28.8+	31.4m	39.7+	14.5	16.0	16.3	8.64	0.542	0.019	0.001	0.001	0.015	156m	
1998/1999	1.96	0.772	9.63	8.98	11.4 #	3.74	0.755	1.99	0.989	0.542	1.38 #	3.83	46.0 #	
1999/2000	12.4M	5.32	14.6+	47.4+	30.8	16.6	31.7	36.2	11.0	6.17	3.25	3.94	219M	
2000/2001	3.54	6.45 #	#	#	#	#	#	#	#	0.600 #	0.460	10.0	#	
2001/2002	11.3	33.5	56.4+	28.6	25.2	4.20 #	0.216 #	0.426	0.380	0.071 #	2.17 #	11.6	174+#	
2002/2003	3.84	7.76 #	2.94 #	1.30	16.5+	1.54	17.7+	3.10	2.17	3.72	0.061 #	1.19	61.9+#	
2003/2004	0.171	0.861	0.596	16.6+	34.6	15.4	2.40	0.091	0.612	10.1+	3.81+	2.12	87.4+	
2004/2005	0.490	1.37	2.00	2.43	9.54	15.3	5.36	1.40	1.83	3.65	0.655	0.127	44.2	
2005/2006	0.861	1.59	2.19	1.12	33.5+	15.7+	6.54	8.74	8.28	1.94	4.85	2.24	87.6+	
2006/2007	5.35	9.66	16.9	8.27	0.465	0.343	1.83	0.450	15.1+	7.65	2.29	0.643	69.0+	
2007/2008	16.1	30.9+	7.58	0.233 #	1.35 #	3.19	2.36	1.53	2.23	1.33	0.420	2.16	69.4+#	
2008/2009	0.901	0.919	3.74	2.84	4.82	17.1+	2.60	2.24	1.01	0.274	4.85	0.646	42.0+	
2009/2010	0.709	2.36	4.75	3.48	0.750	1.46	3.03	0.433	0.125	0.254	0.997	0.042 #	18.4 #	
2010/2011	#	4.78 #	0.226	23.3+	7.78	7.18	12.4	4.44 #	11.4+#	9.72	6.14	1.55	#	+
2011/2012	9.36	11.9+#	#	#	2.54 #	7.59	2.08	1.11	1.39	0.967	0.893	20.3+	#	+
2012/2013	10.7	10.0	8.19	16.0	22.3+	14.2+	9.48	3.84	2.87	7.06	3.97	3.13	112+	
2013/2014	6.14	8.71 #	12.7 #	2.59	1.67	1.03	0.895	1.68	3.77	2.46	1.48	45.8 #		
2014/2015	1.53	2.24	2.31	2.30	2.08	5.96	4.01	20.0	0.001	0.001	0.001	0.614	41.0	
2015/2016	1.20	1.32	3.34	2.40	0.001	0.001	0.864	14.9	0.001	0.001	0.001	0.001	24.1	
2016/2017	0.015	1.32	2.40	3.44	4.11	6.17	6.34	6.65	6.04 #	#	5.57 #	5.54	#	
2017/2018	5.69	1.46 #	#	5.42 #	3.51	2.01 #	#	#	3.94 #	#	#	#	#	
2018/2019	#	#	#	#	#	#	#	#	#	#	#	#	#	
2019/2020	0.000 #	0.909	7.78 #	1.01 #	#	#	#	#	#	#	#	#	#	
2020/2021	0.156 #	0.066	0.041	0.245	1.23	#	#	#	#	0.000 #	0.001	0.936	#	
2021/2022	0.734	0.042	0.519	3.89 #	17.0	4.00	64.4+	36.6	21.0	8.62	6.62	9.74	173+#	
2022/2023	5.15	15.4	24.5	35.2	103+	48.0	16.6	28.5	13.1	8.85	3.75	3.07	305+	
2023/2024	41.7+#	45.3	36.9	88.1+	14.2	7.87 #	9.71	7.59	7.75	2.91	3.04	6.75	272+#	
2024/2025	14.4	11.7	6.83	#	#	#	#	#	#	#	#	#	#	

ZZZZZZZZZZ

A-2.5 DISPOSED DREDGE VOLUMES

The CSIR has been a key contributor to several past studies on dredging operations and disposal activities at Richards Bay (e.g., CSIR 2001, 2004a, 2007, 2015). Figure A-6 illustrates the historical dredging volumes that were disposed of, as reported in CSIR (2004a, 2015) and TNPA (2025). Table A-2 summarises the available dredging and disposal volumes, including quantities associated with specific areas and activities, as reported in the referenced studies above. Unfortunately, reliable detailed dredging volume data beyond 2003 is limited, and data on volumes pumped directly onto the beaches, particularly the southern beaches, is largely unavailable. This lack of data poses a challenge to conducting a comprehensive analysis of potential correlations between offshore disposal activities and shoreline changes. Nevertheless, the following sections will present a comparison of historical shoreline positions with the available dredge disposal data. The data from these references were integrated, and where minor discrepancies were observed, the data from the more reliable source was adopted. For example, while TNPA (2025) and CSIR (2015) reported slightly different disposal volumes for 2011, the CSIR (2015) data was used due to its perceived reliability.

Note: The TNPA (2025) dataset provides dredging volumes for 'Actual Sand' and 'Actual Silt'. It is assumed that all the sand (from 'Actual Sand') was disposed of on the northern beaches, while the silt ('Actual Silt') was deposited on the offshore disposal mound. The received data was categorised by financial year (e.g., March 2011 to March 2012), and in the table that follows, each financial year is labelled according to the calendar year in which the majority of its months fall; for example, the period from March 2011 to March 2012 is recorded as the 2011 volume. Additionally, the CSIR (2015) report shows that the sand portion of dredged material was reclaimed to Alkantstrand. These values align with the TNPA (2025) dataset, supporting the reasonableness of the above assumption regarding TNPA (2025)'s 'Actual Sand' and 'Actual Silt' distinction.

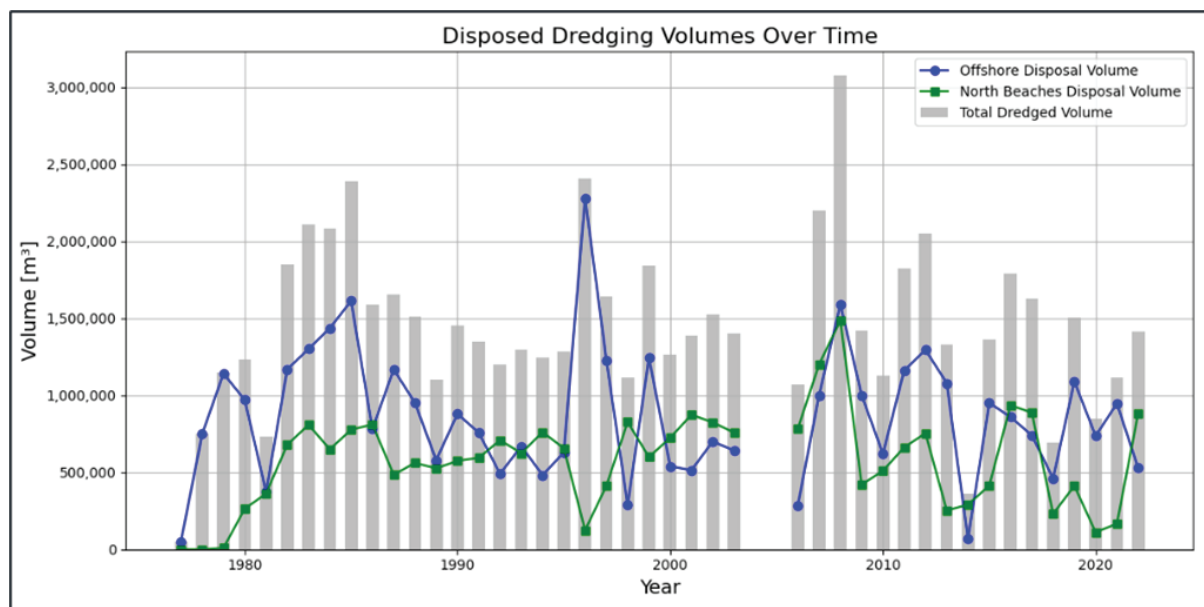


Figure A-6: Dredge disposal volumes (CSIR, 2005; CSIR, 2015; TNPA 2025).

Table A-2: Maintenance dredging volumes (CSIR, 2005; CSIR, 2015; TNPA 2025).

YEAR	DREDGED VOLUMES [m³]			SUM	DISPOSED OF [m³]	
	SANDTRAP	CHANNELS	BASINS		NORTHERN BEACH	OFFSHORE
1977	8 500	5 500	37 200	51 200	0	51 200
1978	413 600	298 300	37 200	749 100	0	749 100
1979	841 030	271 400	37 200	1 149 630	9 000	1 140 630
1980	604 300	591 550	37 200	1 233 050	264 000	969 050
1981	583 017	114 300	37 200	734 517	361 277	373 240
1982	1 117 944	692387	37 200	1 847 531	679 374	1 168 157
1983	722 609	1 348 763	37 200	2 108 572	808 134	1 300 438
1984	630 257	1 417 197	37 200	2 084 654	649 621	1 435 033
1985	985 199	1 365 646	37 200	2 388 045	776 198	1 611 847
1986	320 089	1 233 945	37 200	1 591 234	810 569	780 665
1987	5 557	1 609 283	37 200	1 652 040	484 543	1 167 497
1988	346 009	1 128 816	37 200	1 512 025	560 767	951 258
1989	372 206	697 204	34 814	110 4224	525 541	578 683
1990	531 956	887 361	34 447	1 453 764	574 435	879 329
1991	618 470	720 324	11 789	1 350 583	593 763	756 820
1992	696 688	490 591	11 222	1 198 501	708 209	490 292
1993	648 523	593 351	51 651	1293525	624 319	669 206
1994	698 201	499 764	44 596	1 242 561	760 777	481 784
1995	698 248	568 043	18 283	1 284 574	656 277	628 297
* ³ 1996	167 800	2 210 803	25 750	2 404 353	124 477	2 279 876
* ³ 1997	338 113	1 294 934	6 985	1 640 032	412 718	1 227 314
* ³ 1998	371 308	717 277	26 130	1 114 715	826 034	288 681
1999	425 347	1 370 740	45 234	1 841 321	598 715	1 242 606
2000	524 958	638 285	100 443	1 263 686	724 109	539 577
2001	678 410	670 804	37 665	1 386 879	873 380	513 499
2002	796 099	683 644	44 480	1 524 223	824 014	700 209

YEAR	DREDGED VOLUMES [m ³]			SUM	DISPOSED OF [m ³]	
	SANDTRAP	CHANNELS	BASINS		NORTHERN BEACH	OFFSHORE
2003	652 805	681 368	64 505	1 398 678	757 703	640 975
*4 2004	-	-	-	no data	no data	no data
*4,5 2005	-	-	-	no data	no data	no data
*1 2006	-	-	-	1069047	783 139	285 908
*1 2007	-	-	-	2 200 000	1 200 000	1 000 000
*1 2008	-	-	-	3 075 000	1 485 000	1 590 000
*1 2009	-	-	-	1 420 000	420 000	1 000 000
*1 2010	-	-	-	1 130 000	510 000	620 000
*1 2011	-	-	-	1 822 017	662 017*2	1 160 000
*1, 2012	-	-	-	2 047 911	7533 98*2	1 294 513
*1, 2013	-	-	-	1 331 776	252 834*2	1 078 942
*1 2014	-	-	-	360 203	290 593*2	69 610
*1 2015	-	-	-	1 364 445	414 046	950 399
*1 2016	-	-	-	1 792 974	934 509	858 465
*1 2017	-	-	-	1 627 399	887 267	740 132
*1 2018	-	-	-	689 569	229 893	459 676
*1 2019	-	-	-	1 501 619	412 445	1 089 174
*1 2020	-	-	-	847 351	111 263	736 088
*1 2021	-	-	-	1 113 154	166 756	946 398
*1 2022	-	-	-	1 410 955	882 900	528 055

*1 TNPA (2025) dataset contains volumes for 'Actual Sand' and 'Actual Silt'. In the absence of information to the contrary, it is assumed that all the 'actual sand' was disposed on the northern beaches (Alkanstrand) and the 'actual silt' was disposed on the offshore dredge spoil disposal site. Furthermore, the received data was categorised by financial year (e.g., March 2011 to March 2012). In the above table, each financial year is labelled according to the calendar year in which the majority of its months fall; for example, the period from March 2011 to March 2012 is recorded as the 2011 volume.

*2 CSIR (2015) dredging volumes shows the sand portion was reclaimed to Alkanstrand (*i.e.*, the northern beaches). These values concur with the TNPA (2025) dataset justifying the above assumption as reasonable.

*3 Between 1996 and 1998 approximately 5 998 429 m³ of dredge spoil was disposed of onto the Central beach area at P3 located to the south of the port entrance (see Figure A-1). Cyrus *et al.* (2008) report that in 1996 a total volume of 3 705 800 m³, and in 1997 a total volume of 1 609 800 m³ and in 1998 a total volume of 682 900 m³ was released onto the beach near location P3. It is understood that this disposal is related to the dredging of the 600 series quay basin at that time, as assessed in earlier literature, e.g., Coppoolse *et al.* (1994). It is understood (but somewhat uncertain) that the values reported in the table do not include these capital dredging volumes.

- *4 No data was provided for this period. It is unknown if such data exists or not. Similarly, the dredge volumes for the various areas (sandtrap, channel and basins) for the period from 2004 onwards may be available but not requested for this study.
- *5 It is confirmed in van Ballegooyen *et al.* (2015) that for the Berth 306 development that a total of 3 840 361 m³ of *in-situ* dredge material was dredged and disposed of at the offshore dredge spoil disposal site in 882 barge trips (average of 4 354 m³ of *in-situ* dredged sediment per 10 330 m³ hopper load) over a period of 22 weeks. Goussard (2009) reports a value of 3.8 million m³ for the dredge spoil disposal volumes and that 0.53 m³ of material was dredged from a borrow pit. de Waal *et al.* (2007) report a higher volume for the material dredged from the borrow pit, possibly a planned rather than an actual volume dredged. These capital dredging volumes are understood to not be included in the Table above.

A-3 SATELLITE SHORELINE COMPARISON

As mentioned, with recent advancements in satellite-derived shoreline (SDS) technologies, it is now possible to assess historical shoreline changes using satellite imagery. CoastSat is one of the most widely used and accurate SDS technologies applied internationally. Theron (2024a) used CoastSat to extract historical shorelines for the entire South African coast. The portion of his data pertaining to the Richards Bay area was used to assess historical shoreline changes. For further details on the methodology and application of CoastSat in the South African context refer to Theron (2024a), the data associated with his study (which was also used here) can be found at Theron (2024b). Figure A-7 illustrates the areas of interest assessed for the historical shoreline changes. Table A-3 summarises the length and transects (100 m alongshore spacing) of each of these selected areas. Note that the mouth of the Mhlathuze estuary is excluded.



Figure A-7: Areas of interest to this study.

Table A-3: Summary of areas (A, B and C) assessed

Area	Beach	Alongshore length	Transects	Transect incremental direction
A	Far-Southern	7 km	70	South to North
B	Central	4 km	40	South to North
C	Northern	3 km	30	South to North

A-3.1 AREA A

The area to the south of the estuary mouth has experienced significant accretion over the years. Figure A-8 illustrates the overall shoreline changes in Area A, with transect index 0 located in the south and transect index 70 situated at the estuary mouth. Figure A-9 presents the relative shoreline changes over time for each transect, where the colour blue represents the southernmost points, and orange corresponds to the estuary mouth.

Several general observations can be made from these figures. Most notably, substantial accretion has occurred, with the most pronounced changes, up to 150 metres relative to 1986, found near the estuary mouth. This accretion gradually decreases moving southward, eventually transitioning to areas with little to no change approximately 6 km south of the estuary mouth. Beyond this point, erosion becomes evident and continues for roughly 4 km (not shown in the figures), before stabilizing with minimal change.

It is important to note that Figure A-8 and Figure A-9 display yearly average shoreline positions, which have been smoothed to reduce visual noise and allow for a more intuitive interpretation.

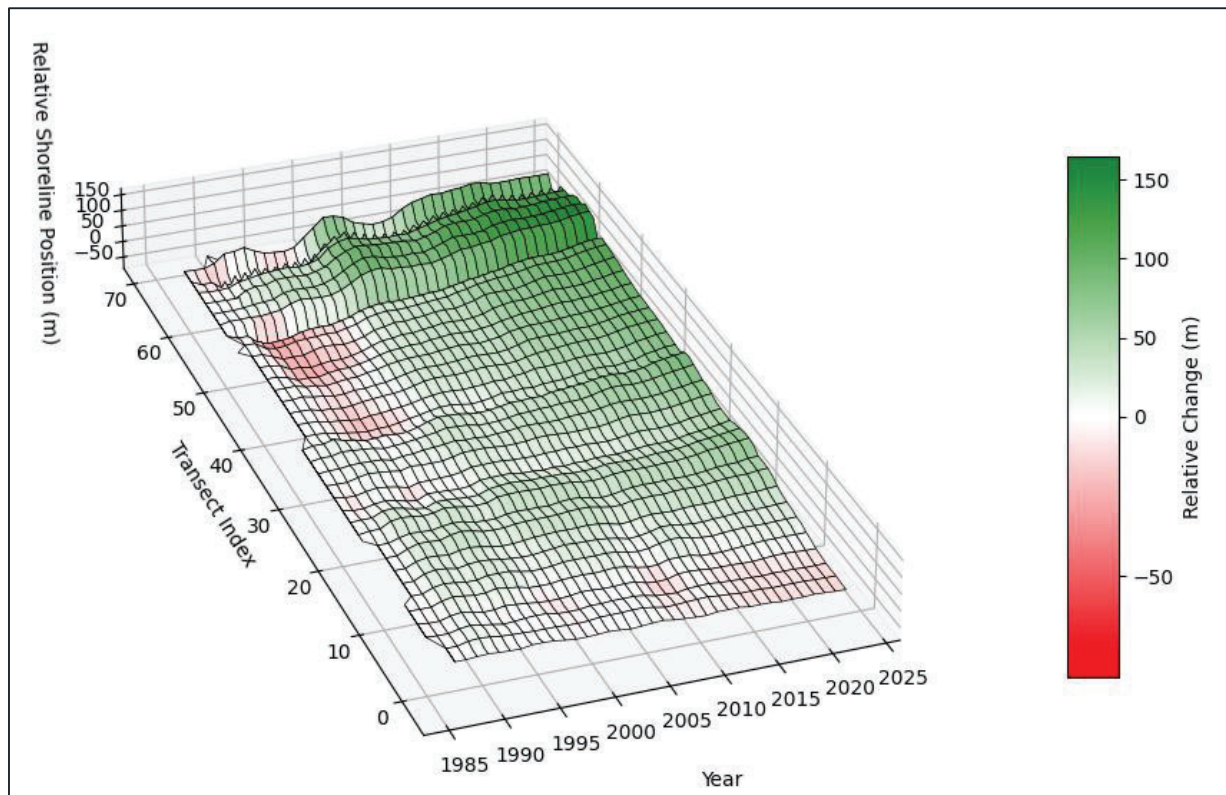


Figure A-8: Overall shoreline change at area A (green – accretion; red – erosion) (transect index 0 – far south; transect index 70– estuary mouth).

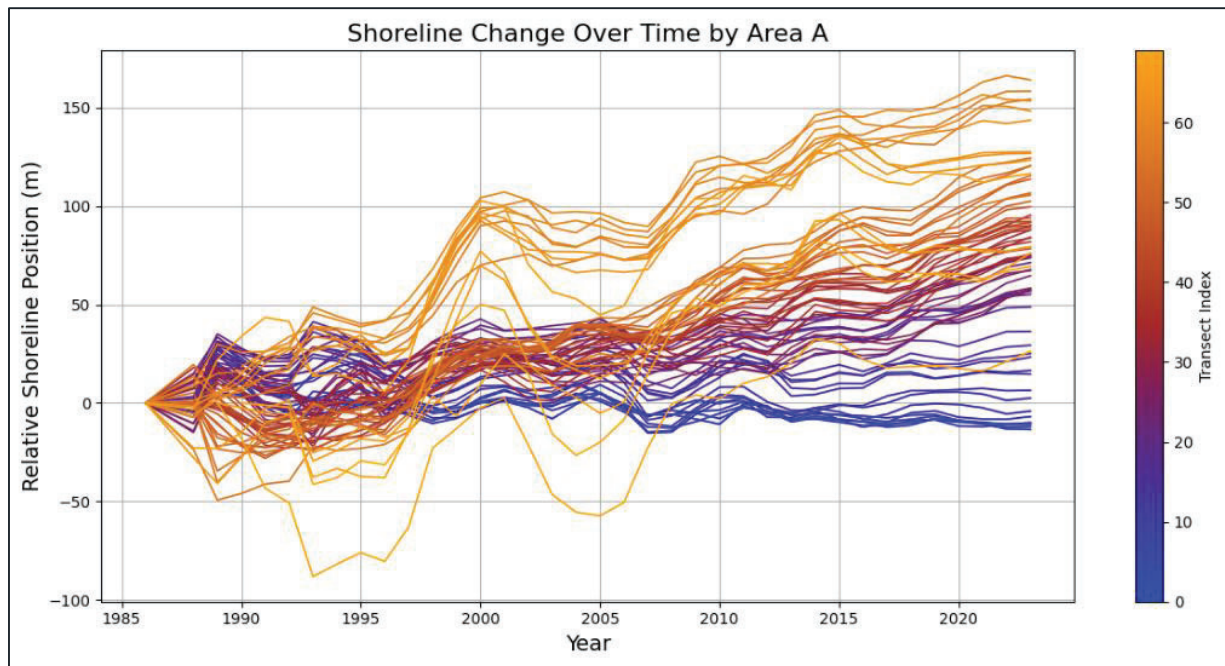


Figure A-9: Relative shoreline change per transect over time at area A (blue – far south; orange – estuary mouth).

A-3.2 AREA B

The area to the north of the estuary mouth has experienced both significant accretion and erosion over the years. Figure A-10 illustrates the overall shoreline changes in Area B, with transect index 0 located at the estuary mouth and transect index 40 situated at the south breakwater. Figure A-11 presents the relative shoreline changes over time for each transect, where the colour blue represents the southernmost points at the estuary mouth, and orange corresponds to the south breakwater. Figure A-12 shows the overall shoreline changes of Area A and B combined, with transect index 0 located in the south and increasing northward to the south breakwater. The extreme shoreline dynamics near the estuary mouth can be seen, as compared to the other areas further from the mouth.

Several general observations can be made from these figures. Most notably, substantial erosion occurred across the entire area between 1986 and 1995, with shoreline retreat of up to 75 metres. This was followed by significant accretion from 1995 to 2000, reaching up to 100 metres in some areas. Between 2000 and 2005, a contrasting pattern emerged, with erosion observed in the northern sections and continued accretion in the south. The shoreline remained relatively stable from 2010 to 2017. From 2018 to 2023, significant accretion resumed, with changes of up to 100 metres near the estuary mouth.

It is important to note that Figure A-10, Figure A-11 and Figure A-12 display yearly average shoreline positions, which have been smoothed to reduce visual noise and allow for a more intuitive interpretation.

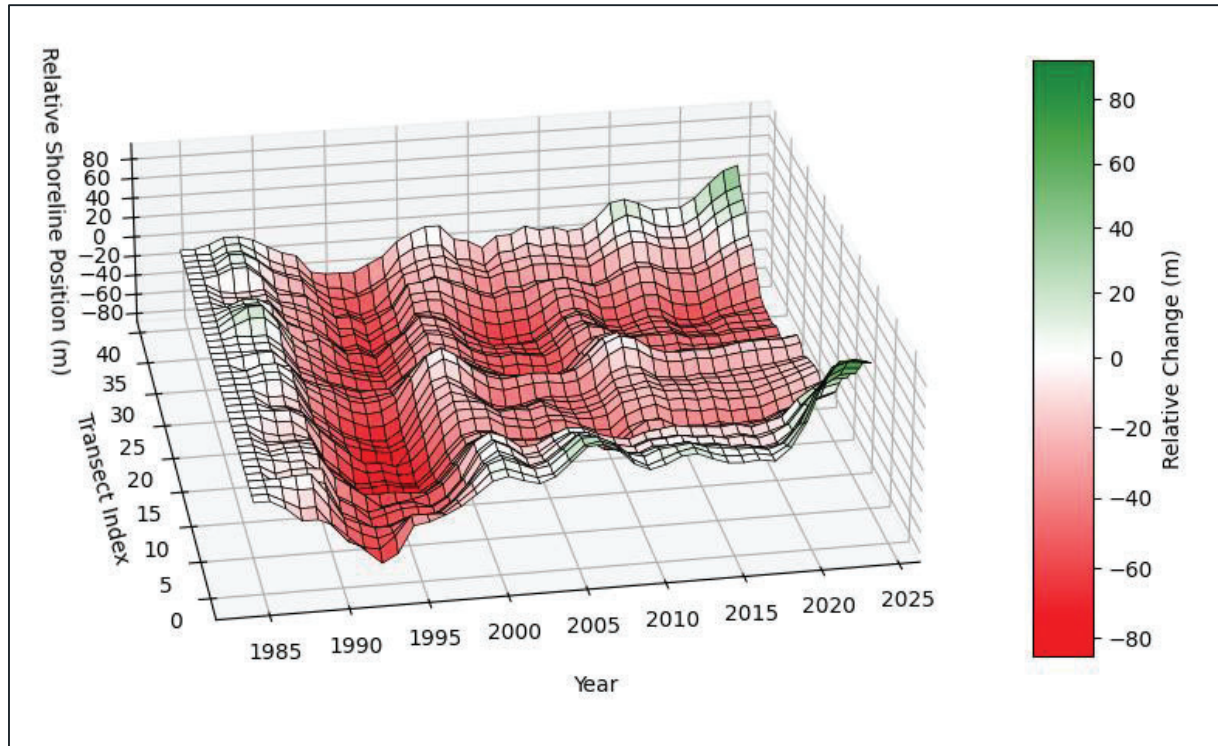


Figure A-10: Overall shoreline changes at area B (green – accretion; red – erosion) (transect index 0 – estuary mouth; transect index 40– south breakwater).

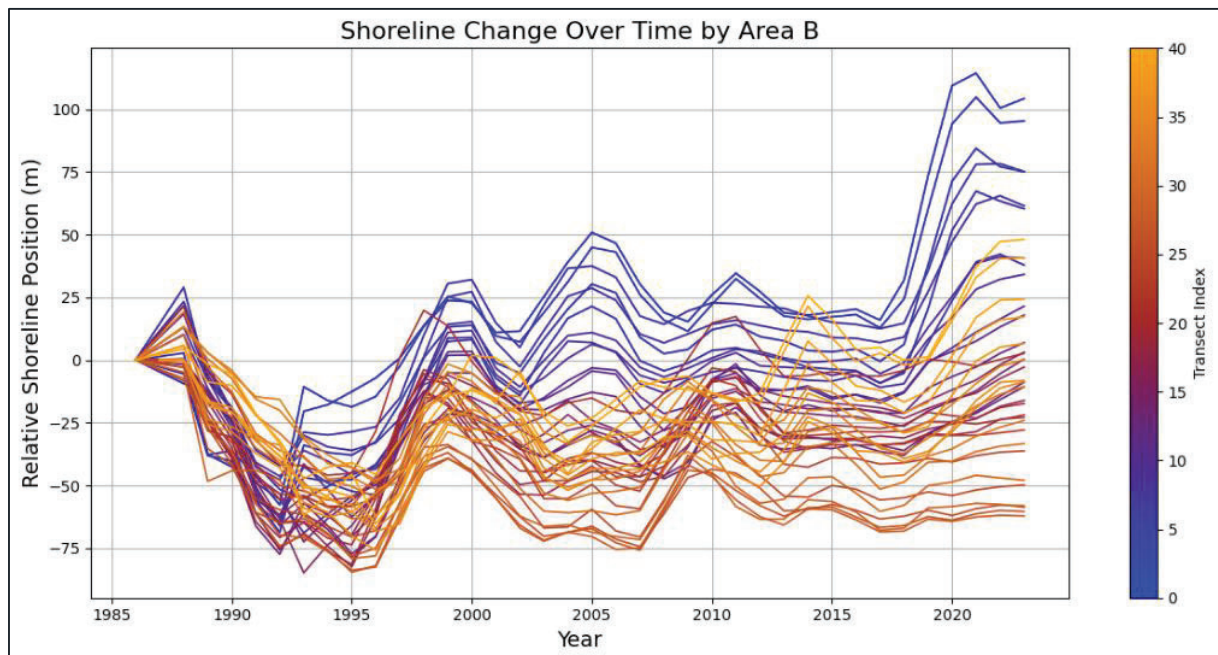


Figure A-11: Relative shoreline changes per transect over time at area B (blue – estuary mouth; orange – south breakwater).

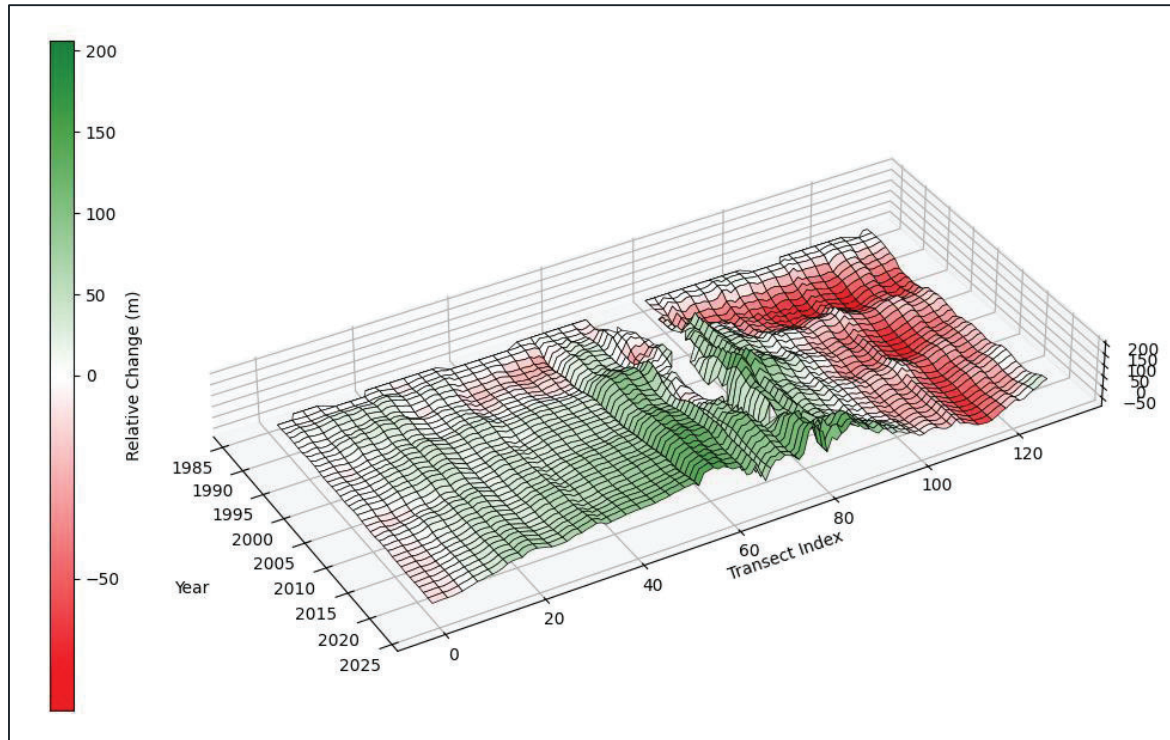


Figure A-12: Overall shoreline changes at area A and B combined (green – accretion; red – erosion) (transect index 0 – far southern beaches; transect index 120– south breakwater).

A-3.3 AREA C

Figure A-13 illustrates the overall shoreline changes in Area C, with transect index 0 located at Alkantstrand (north breakwater) and transect index 30 situated to the north. Figure A-14 presents the relative shoreline changes over time for each transect, where the colour blue represents the southernmost points at Alkantstrand, and orange corresponds to the northern areas. Figure A-15 illustrates the relative shoreline changes from the north breakwater till 10 km alongshore.

Several general observations can be made from these figures. Most notably, substantial erosion occurred across the entire area between 1990 and 1997, with shoreline retreat of up to 60 metres. This was followed by a brief accretion period from 1997 to 2000. From 2000 to 2004 the shoreline remained fairly stable. However, from 2004 to 2007 significant erosion occurred, particularly at Alkantstrand. This was followed by extreme accretion till 2010. After this accretion trend significant erosion took place till 2015 (approximately 80m at Alkantstrand). From 2015 to 2018 the shoreline remained fairly stable. However, the stable state was short lived as erosion continued from 2018 onward. From Figure A-15 it is seen that the extreme erosion at the northern beaches of Richards Bay only occurred at extreme rates till approximately 7 km alongshore north from the breakwater; however, some minor erosion trends are still observed for these far north areas.

It is important to note that Figure A-13, Figure A-14 and Figure A-15 display yearly average shoreline positions, which have been smoothed to reduce visual noise and allow for a more intuitive interpretation.

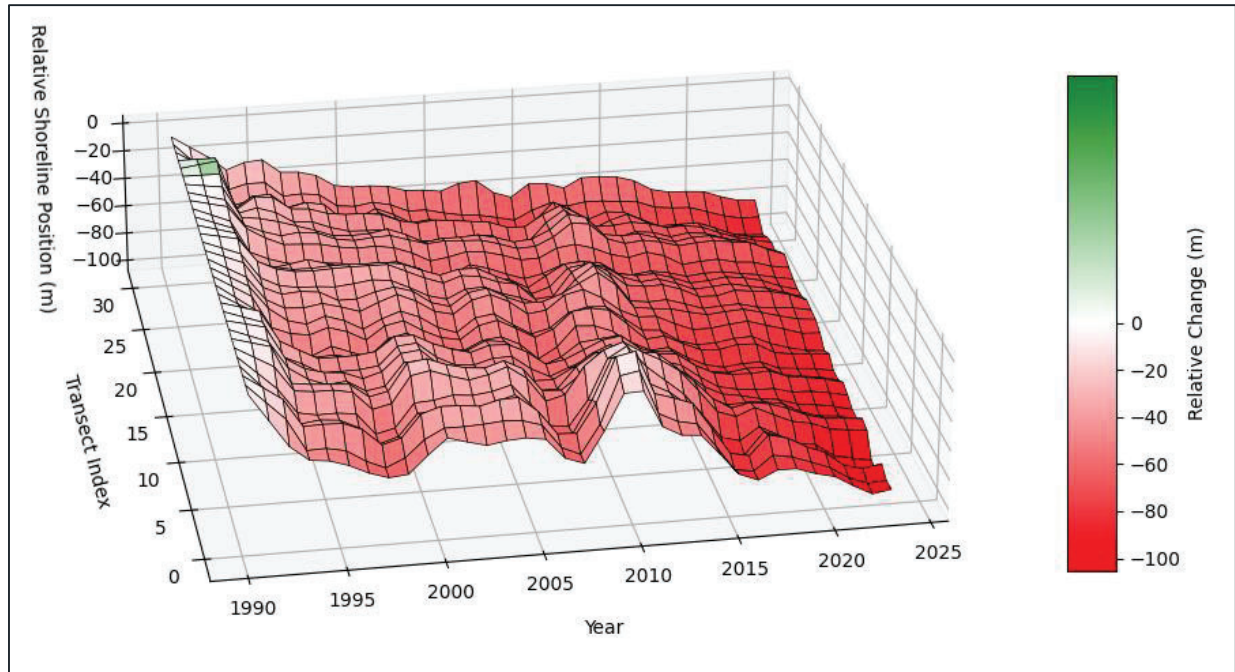


Figure A-13: Overall shoreline changes at area C (green – accretion; red – erosion) (transect index 0 – north breakwater; transect index 30 – northern beaches).

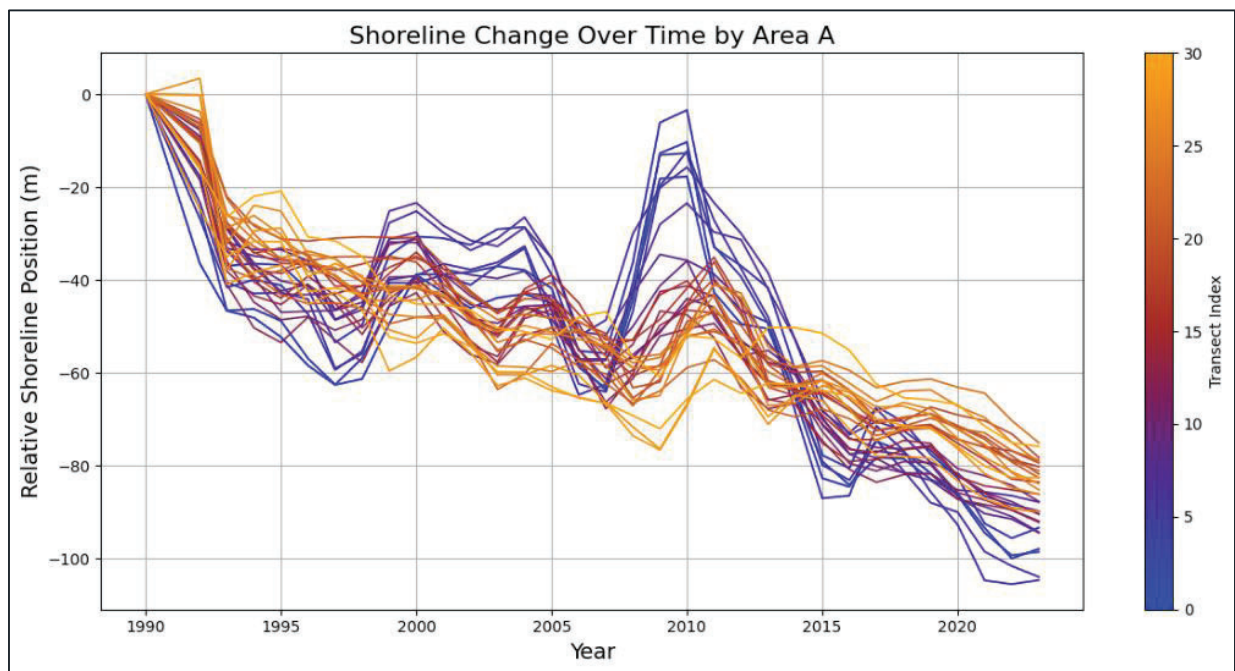


Figure A-14: Relative shoreline changes per transect over time at area C (blue – north breakwater; orange – northern beaches).

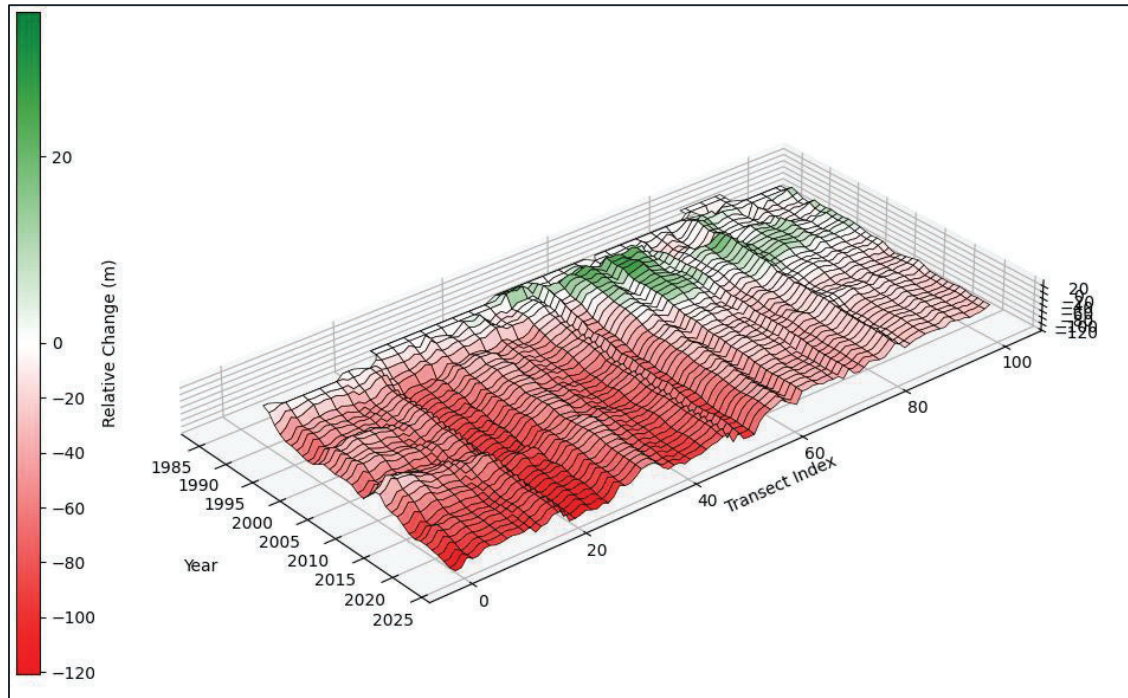


Figure A-15: Overall shoreline changes at area C and beyond (green – accretion; red – erosion) (transect index 0 – north breakwater; transect index 100– northern beaches).

A-4 COMPARISONS OF SHORELINE CHANGE

As mentioned, the aim of this study is to determine whether the historically dredged material deposited on the offshore mound has an observable, quantifiable, and distinct impact on the shoreline that can be confidently identified. To assess such impacts, the following comparisons are made:

- (i) Historical shoreline changes at Area C (northern beaches) are compared to the northern beach disposal volumes from Table A-2;
- (ii) Historical shoreline changes at Area C (northern beaches) are compared to the offshore disposal volumes from Table A-2;
- (iii) Historical shoreline changes at Area A (far-southern beaches) are compared to the offshore disposal volumes from Table A-2;
- (iv) Historical shoreline changes at Area A (far-southern beaches) are compared to estuary runoff volumes;
- (v) Historical shoreline changes at Area B (Central Beach) are compared to the offshore disposal volumes;
- (vi) Historical shoreline changes at Area B (Central Beach) are compared to estuary runoff volumes;
- (vii) Anecdotal historical shoreline changes at selected locations.

A-4.1 HISTORICAL CHANGES AT AREA C VERSUS DISPOSAL VOLUMES ONTO NORTHERN BEACHES

Here historical shoreline changes at Area C (northern beaches) are compared to the northern beach disposal volumes from Table A-2.

Figure A-16 illustrates the historical shoreline position changes in relation to the volume of material disposed onto the northern beaches. The data used in this graph assumes that the dredge volumes labelled as 'Actual sand' in TNPA (2025) represent material disposed of on the northern beaches, as previously indicated in Table A-2. Notably, the shoreline positions in Figure A-16 are no longer smoothed using moving averages (as was done in previous sections) as this method can distort the accurate interpretation of shoreline changes in relation to the studied metric.

As expected, the disposal of dredged material on the northern beaches has a significant impact on the adjacent shoreline. In years where only small quantities of dredged material were disposed of (e.g., 1996, 2009, 2010, 2013, 2014, 2020, 2021), notable erosion was observed either immediately or within one to two years. It is important to note that the dredge disposal volumes are reported by financial year (from March of one year to February of the next), meaning the precise timing of significant disposal events within a given year is not captured. Nevertheless, the observed erosion occurring a year or two after low-disposal years aligns with expectations of shoreline response to these beach nourishing activities.

This outcome is consistent with (or confirms) reported volumes from CSIR (2004a, b; 2005a, b; 2015) and TNPA (2025), particularly considering the disruption of longshore sediment transport rendering sand bypassing as the primary source of sediment for the northern beaches.

Conversely, in years where disposal exceeded 800 000 m³ (e.g., 1998, 2001, 2007, 2008, 2016, 2017), the shoreline typically exhibited signs of accretion or stabilization. As previously discussed, longshore sediment transport at the northern beaches is highly variable and can exceed 1 million m³ per year. Additionally, occasional southward transport has been documented. Therefore, even high disposal volumes (e.g., >800 000 m³/year) may not uniformly result in accretion, as a detailed sediment transport model is needed to accurately assess the transport dynamics in any given year. Furthermore, CSIR (2006 in 2008) reported that in order to halt erosion on the northern beaches and either slightly accrete the shoreline or maintain its position at the time, a sand bypassing rate between 900 000 and 1 000 000 m³/year would be required. The study found that applying a constant bypassing rate of 950 000 m³/year would result in shoreline accretion of approximately 85 m near Alkantstrand and 5 m at the northern municipal boundary. However, they also noted that due to a substantial sand supply deficit, estimated at around 300 000 m³/year, that had accumulated over the preceding decades, recovery of the northern beaches would be slow, even with this increased supply. When compared with Figure A-16, their predictions appear to be accurate, particularly when considering the shoreline response in 2007 and 2008, as well as the observed threshold of >800 000 m³/year required to achieve a state of shoreline stability or accretion.

That said, in 2007 and 2008, disposal volumes exceeded 1 million m³, with over 1.4 million m³ deposited in 2008 alone. These volumes likely surpassed the net annual longshore transport for the year, and the significant shoreline accretion observed after these years supports this inference. Thus, despite some uncertainty regarding the accuracy of the dredging records, the shoreline response on the northern beaches clearly correlates with the volume of dredged material disposed of directly onto the northern beaches.

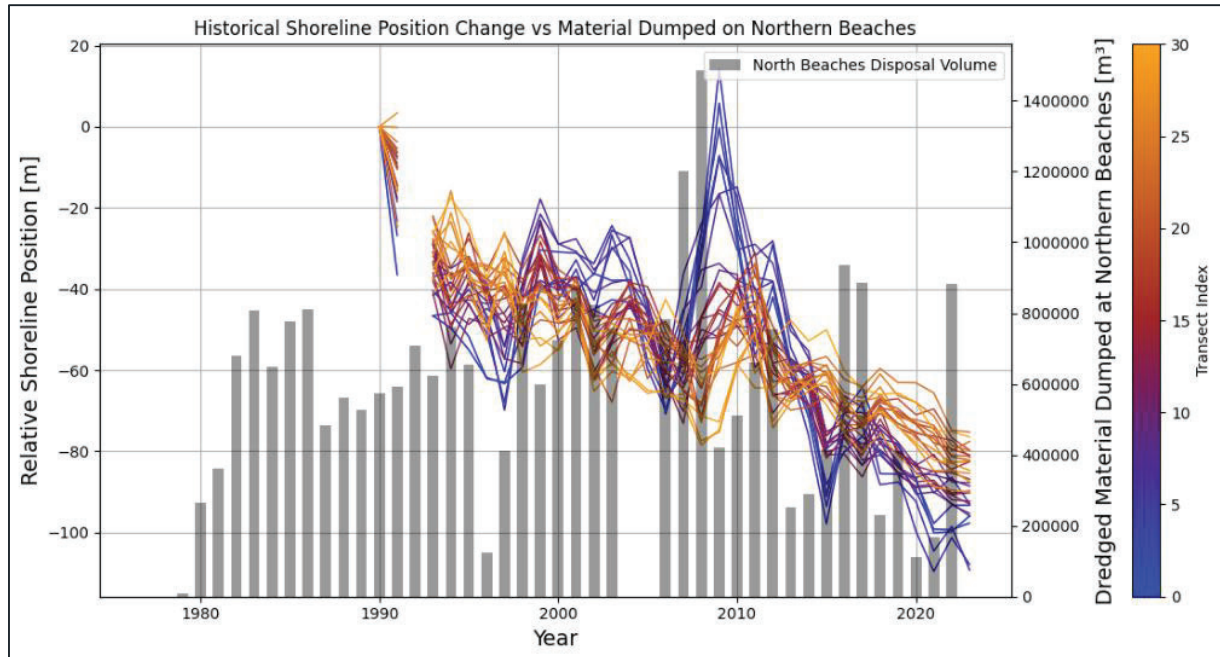


Figure A-16: Historical shoreline position change at the northern beaches (Area C) compared to the volume of material dumped on the northern beaches (blue – north breakwater; orange – northern beaches).

A-4.2 HISTORICAL CHANGES AT AREA C VERSUS DISPOSAL VOLUMES ONTO THE OFFSHORE DISPOSAL SITE

Here historical shoreline changes at Area C (northern beaches) are compared to the offshore disposal volumes from Table A-2.

Figure A-17 illustrates the historical shoreline position changes at the northern beaches in relation to the volume of material dumped offshore. The data used in this graph assumes that the dredge volumes labelled as 'Actual silt' in TNPA (2025) represent material disposed of at the offshore dumpsite, as previously indicated in Table A-2. Notably, the shoreline positions in Figure A-17 are no longer smoothed using moving averages (as was done in previous sections) as this method can distort the accurate interpretation of shoreline changes in relation to the studied metric.

No notable correlation is observed between offshore disposal volumes and shoreline changes of the northern beaches. Consider the years 1998, 2006, and 2014—all three had extremely low offshore disposal volumes. In 1998, the shoreline remained relatively stable, with limited accretion occurring in the following year. In contrast, 2006 experienced significant erosion, followed by extreme accretion the next year. For 2014, the shoreline was relatively stable within the year but underwent severe erosion the year after. These three scenarios, despite similarly low offshore disposal volumes, resulted in very different shoreline responses.

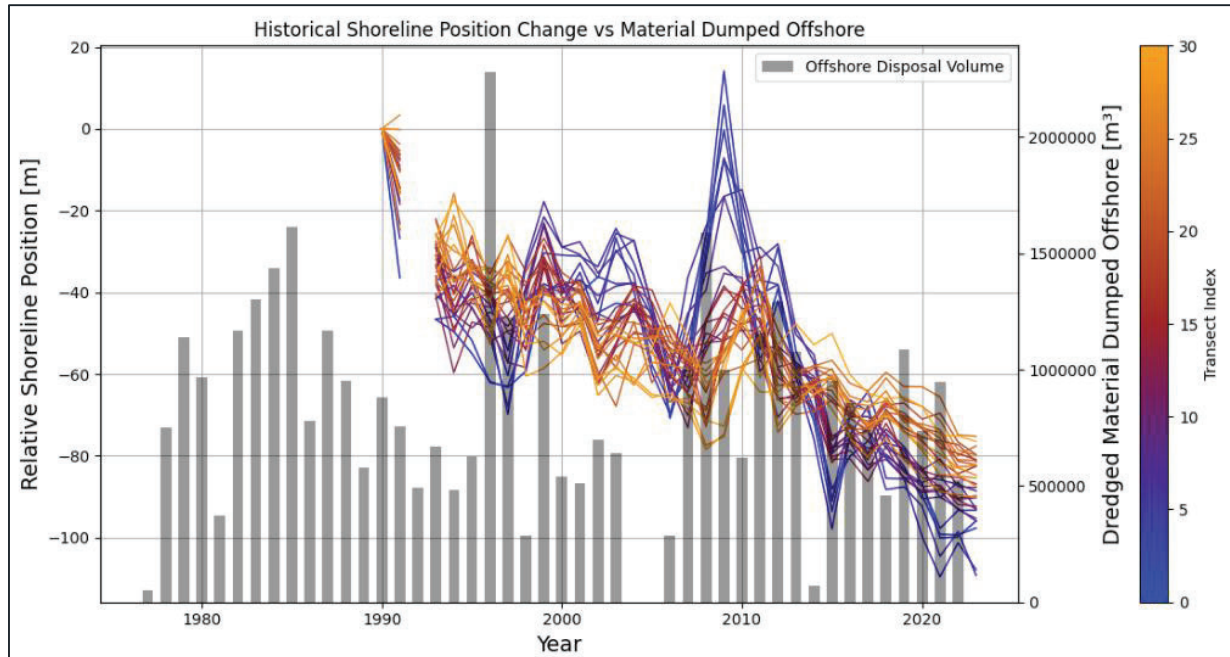


Figure A-17: Historical shoreline position change at the northern beaches (Area C) compared to the volume of material dumped offshore (blue – north breakwater; orange – northern beaches).

Conversely, the years 1996 and 2008 saw large volumes of sediment disposed offshore. In 1996, the shoreline remained relatively unchanged during the year and the year that followed. However, 2008 experienced substantial and ongoing accretion. These examples further support the notion that there is no consistent relationship between offshore disposal volumes and shoreline change.

Based on these observations, it is suggested that while offshore disposal of dredged material may have some influence on the northern beaches, the magnitude and nature of its impact on shoreline response remain unclear and are likely minimal. Nonetheless, its influence appears significantly less than that of sand bypassing activities, as discussed previously.

A-4.3 HISTORICAL CHANGES AT AREA A VERSUS DISPOSAL VOLUMES ONTO THE OFFSHORE DISPOSAL SITE

Here historical shoreline changes at Area A (far-southern beaches) are compared to the offshore disposal volumes from Table A-2.

Figure A-18 illustrates the historical shoreline position changes at the far-southern beaches in relation to the volume of material dumped offshore. The data used in this graph assumes that the dredge volumes labelled as 'Actual silt' in TNPA (2025) represent material disposed of at the offshore dumpsite, as previously indicated in Table A-2. Notably, the shoreline positions in Figure A-18 are no longer smoothed using moving averages (as was done in previous sections) as this method can distort the accurate interpretation of shoreline changes in relation to the studied metric.

The relative shoreline position change at the far-southern sections of Area A (indicated as 'blue' in Figure A-18) has remained largely stable over the past 40 years, especially when compared to the more dynamic northern areas. Accretion gradually increases from approximately 0 m at the southern edge of the study area ('blue' transects) to around 80 m at a location approximately 3 km south of the estuary mouth ('brown' transects). This accretion trend from the 'blue' to 'brown' transects appears consistent on a year-to-year basis, without significant deviations from the historical pattern.

In contrast, the 'orange' transects, located just south of the estuary mouth, exhibit highly dynamic shoreline behaviour. However, when comparing offshore disposal volumes with shoreline position changes, there is no indication that offshore disposal is the primary driver of these fluctuations near the estuary mouth.

Looking at specific years with minimal offshore disposal, 1998, 2006, and 2014, no consistent shoreline response (either erosion or accretion) is observed during those years or in the following one to two years. Similarly, years with high offshore disposal volumes, 1996, 2008, and 2012, also show no clear or common effect on shoreline behaviour.

These observations suggest that other factors exert a far more significant influence on shoreline changes in this region, to the extent that any direct impact from offshore mound disposal is obscured. It is likely that sediment inputs from the estuary and the direct placement of dredged material onto nearby beaches (as discussed in earlier) have a much more substantial effect on shoreline dynamics in this area. Therefore, while offshore disposal of dredged material may have some influence on the far-southern beaches, its impact on shoreline response remains unclear and is likely minimal at most.

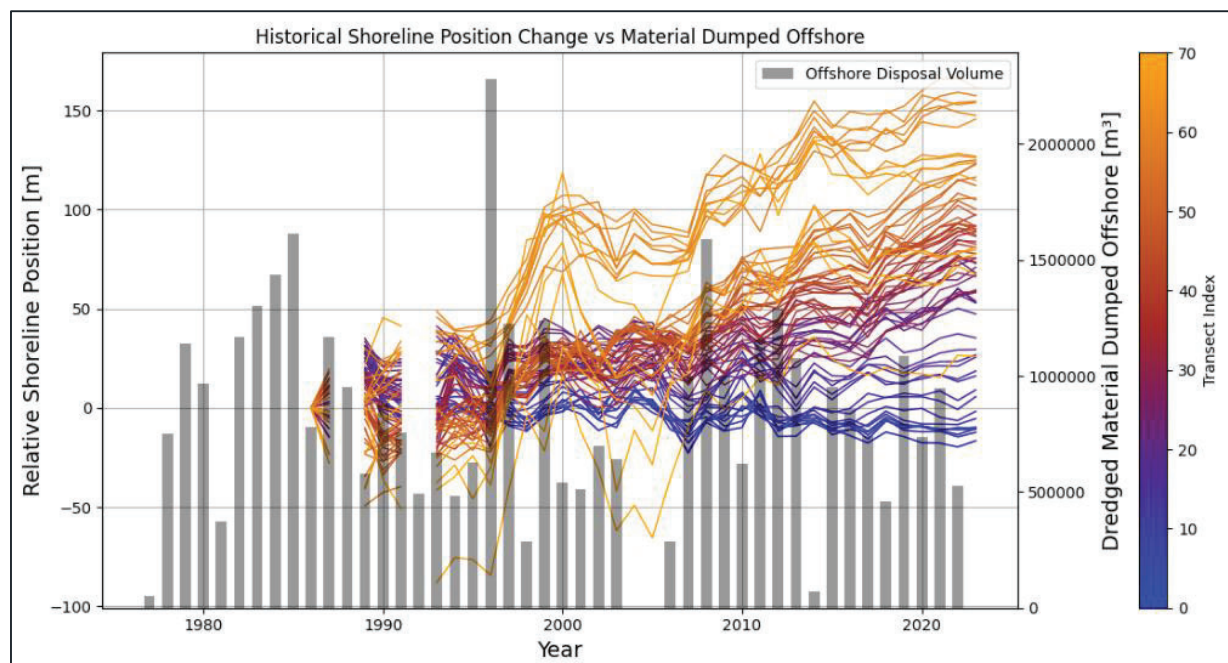


Figure A-18: Historical shoreline position change at the far-southern beaches (Area A) compared to the volume of material dumped offshore (blue – far south; orange – estuary mouth).

A-4.4 HISTORICAL CHANGES AT AREA A VERSUS POSSIBLE ESTUARINE RUNOFF VOLUMES / SEDIMENT INPUTS

Here historical shoreline changes at Area A (far-southern beaches) are compared to estuary runoff volumes and possible associate sediment inputs (Table A-1; Figure A-5)

Figure A-19 illustrates the historical shoreline position changes at the far-southern beaches in relation to the annual runoff volume from the Mhlathuze River. The data used in this graph is described in earlier sections. Notably, the shoreline positions in Figure A-19 are no longer smoothed using moving averages (as was done in previous sections) as this method can distort the accurate interpretation of shoreline changes in relation to the studied metric.

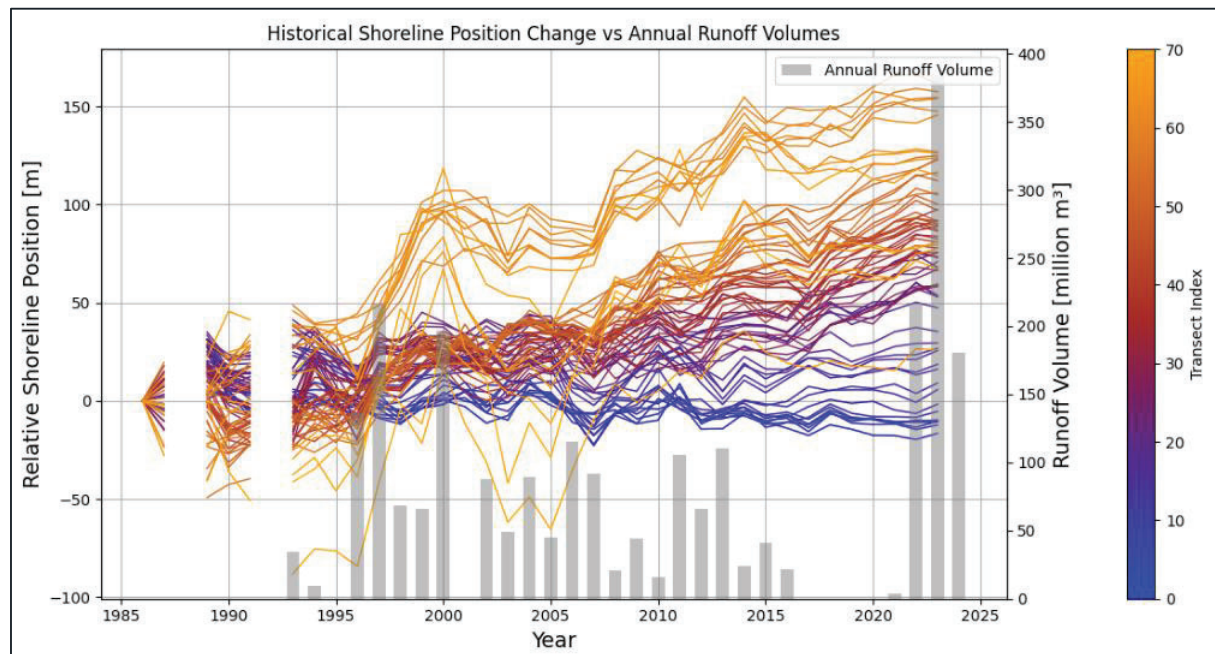


Figure A-19: Historical shoreline position change at the far-southern beaches (Area A) compared to the annual runoff volumes of the Mhlathuze River.

Although annual river runoff does not necessarily correspond to an equivalent trend in sediment yield, it is reasonable to expect that shoreline transects located near the estuary mouth (*i.e.*, the 'orange' transects) may exhibit some correlation with river runoff or notable hydrological events. However, upon examination of Figure A-19, there is no clear or consistent trend that directly links shoreline changes with variations in runoff volumes. For example, the relatively high runoff observed in 1997 and 2000 does not appear to result in a distinct similar shoreline response among the 'orange' transects. There is however a broader accretion during this period, possibly associated with the large volumes of sediment discharged onto the beaches between 1996 and 1998 from capital dredging activities associated with the dredging of the 600 series basin in the Port of Richards Bay (as mentioned in Cyrus *et al.*, 2008). Similarly, periods of comparatively low runoff, such as 2008–2010 and 2014–2016, do not consistently correspond with either erosive or stable shoreline conditions although the shorelines did undergo minimal changes during these periods (relatively stable condition).

Higher runoff volumes do not necessarily lead to a stable or accretionary shoreline state, and lower runoff volumes do not uniformly result in erosion or a stable shoreline state. Satellite imagery indicates that the estuary mouth is highly dynamic, with noticeable northward migration over time. This movement generates complex morphological features such as cusps, gullies, and irregular nearshore sediment patterns, which may help explain abrupt accretion or erosion events (e.g., 2001–2004). Additionally, uncertainty regarding the precise location of dredged material disposal, particularly whether it was placed along the central or far-southern beach (as discussed in earlier sections), further obscures potential correlations between shoreline change and runoff volumes. Lastly, the quality of the gauge data from DWS (2025) is fairly poor with gaps or erroneous logged data through the recorded period, which contributes to further uncertainty.

A-4.5 HISTORICAL CHANGES AT AREA B VERSUS DISPOSAL VOLUMES ONTO THE OFFSHORE DISPOSAL SITE

Here historical shoreline changes at Area B (Central Beach) are compared to the offshore disposal volumes from Table A-2.

Figure A-20 illustrates the historical shoreline position changes at the Central Beach in relation to the volume of material dumped offshore. The data used in this graph assumes that the dredge volumes labelled as ‘Actual silt’ in TNPA (2025) represent material disposed of at the offshore dumpsite, as previously indicated in Table A-2. Notably, the shoreline positions in Figure A-20 are no longer smoothed using moving averages (as was done in previous sections) as this method can distort the accurate interpretation of shoreline changes in relation to the studied metric.

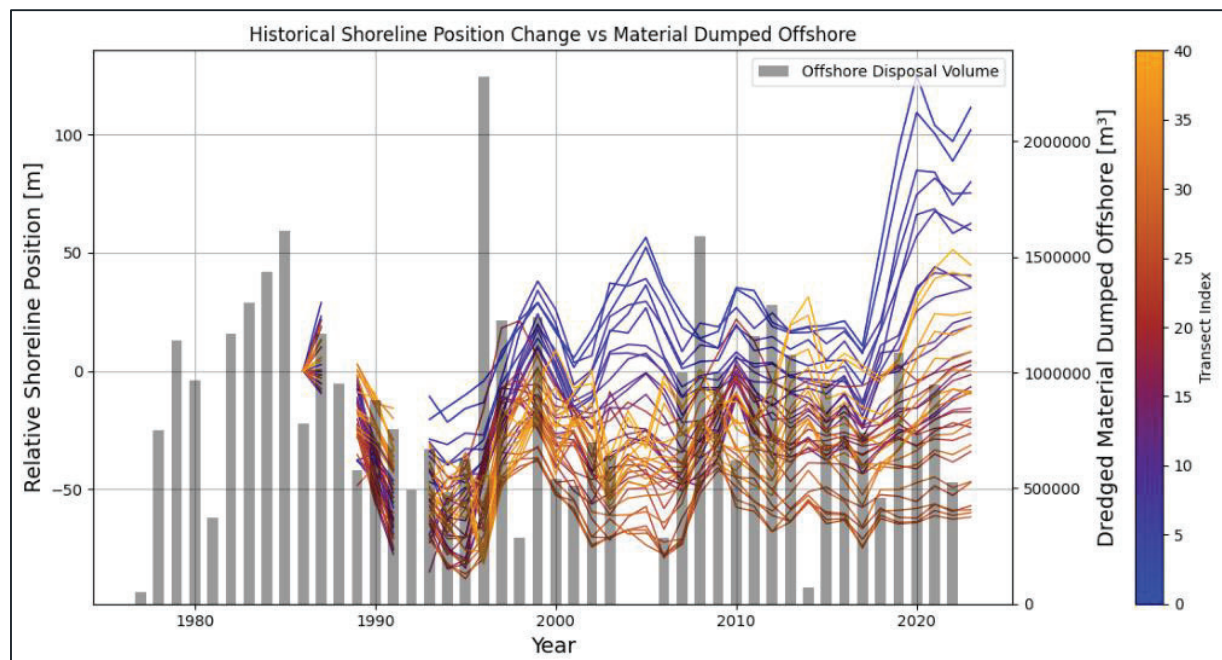


Figure A-20: Historical shoreline position change at the Central Beach (Area B) compared to the volume of material dumped offshore (blue – estuary mouth; orange – south breakwater).

Several key events related to offshore sediment disposal and shoreline response can be observed over the historical period, with some patterns suggesting possible linkages. Firstly, the gradual reduction in offshore-dumped material, from just under 1 million m³/year in 1988 to approximately 500 000 m³/year between 1992 and 1995, appears to correspond with shoreline erosion observed during that period.

In 1996, a substantial volume of sediment (>2 million m³/year) was deposited on the offshore disposal mound, and a notable phase of shoreline accretion followed. In 1997, offshore disposal remained high (>1 million m³/year), and accretion continued, particularly along the Central Beach areas. In contrast, 1998 had minimal offshore disposal, while 1999 significantly increased. The accretion starting in about 1996 and peaking in 2000 occurred all along the beaches between the Mhlathuze Estuary mouth and the south breakwater. Therefore, is likely to have been more a consequence of the large dredge material discharges directly onto the beach between 1996 and 1998 associated with the capital dredging and disposal activities for the 600 series basin occurring at that time (as mentioned in Cyrus *et al.*, 2008). From 2000 to 2004, offshore disposal volumes stabilized between 500 000 and 600 000 m³/year, a relatively low level, during which Central Beach erosion resumed.

Observed shoreline changes nearer the estuary mouth during the period 2004 to 2007 coincided with a period that there was a significant disposal of dredged material on the offshore disposal site (~ 3.8 million m³). There is a possibility that these changes could be indicative of effects of mounding of this material and associated inshore wave climate and consequential shoreline change. In addition, the flow records for the Mhlathuze Estuary are partly missing or are recorded as “greater than” (meaning that the actual volume is higher than what was recorded), thus the possibility that the shoreline accretion could be associated with increase sediment inputs for the estuary cannot be ruled out. This could possibly be resolved by looking at rainfall records for this period to determine whether this was likely to be a high flow period in 2005 and 2006 when the flow records for the Mhlathuze River contains some uncertainty. The fact that maintenance dredging volumes are not reported in Table A-2 for the period 2005 to 2006, further complicates the interpretation of these data.

Interestingly, from 2008 onwards, shoreline positions remained relatively stable, with occasional localized accretion near the estuary mouth (“blue” transects) and the south breakwater (“orange” transects), despite frequent high offshore disposal volumes. In 2014, almost no material was deposited offshore, and shoreline conditions remained largely unchanged.

From 2017 onward, significant accretion, particularly around the estuary mouth and to a lesser extent towards the south breakwater, was observed. This is likely linked to the estuary’s northward migration, as evidenced by satellite imagery, which may have induced complex sediment dynamics in the nearshore zone. The lesser accretion observed towards the south breakwater may be indicative of potential redistribution of sediments associated with changing inshore wave conditions due to the accumulation and mounding of material on the disposal site that occurred between 2007 and 2022 (see Figure 6-16 in Section 6 and discussions in WSP, 2025). The mound that developed during this period resulted in waters shallower than -13 m CD being measured on the mound during the 2022 bathymetry survey of the disposal site.

Overall, a general relationship appears to exist between offshore disposal volumes and shoreline changes: large volumes of offshore-dumped sediment may induce accretion, while prolonged periods of minimal dumping may lead to shoreline stabilisation or even minimal erosion. However, this relationship is not straightforward and is influenced by several additional factors.

It is important to note that these interpretations remain speculative due to several uncertainties, as below (to name a few):

- Uncertainty in actual beach placement volumes and location of historical on-beach dredge disposal.
- Dumping location sensitivity: The precise placement of offshore-disposed material may affect the shoreline response.
- Influence of the sand trap: Its performance may alter nearshore accretion and erosion, as discussed in earlier sections, further obscuring offshore disposal effects.
- Uncertainty in reported dredge volumes, location and period

A-4.6 HISTORICAL CHANGES AT AREA B VERSUS POSSIBLE ESTUARINE RUNOFF VOLUMES / SEDIMENT INPUTS

Here historical shoreline changes at Area B (Central Beach) are compared to estuary runoff volumes Table A-2.

Figure A-21 illustrates the historical shoreline position changes at the Central Beach area in relation to the annual runoff volume from the Mhlathuze River. The data used in this graph is described in earlier sections. Notably, the shoreline positions in Figure A-21 are no longer smoothed using moving averages (as was done in previous sections) as this method can distort the accurate interpretation of shoreline changes in relation to the studied metric.

As previously mentioned, annual river runoff does not necessarily correspond to an equivalent trend in sediment yield, it is reasonable to expect that shoreline transects located near the estuary mouth (*i.e.*, the 'blue' transects) may exhibit some correlation with river runoff or notable hydrological events. However, upon examination of Figure A-19, there is no clear or consistent trend that directly links shoreline changes with variations in runoff volumes. This was also the case for the discussion on Figure A-19 earlier. For example, the relatively high runoff observed in 1997 and 2000 does not appear to result in a distinct similar shoreline response among the 'blue' transects. However, as noted in Section A-4.5 above, the accretion starting in about 1996 and peaking in 2000 occurred all along the beaches between the Mhlathuze Estuary mouth and the south breakwater, and therefore is likely to have been more a consequence of the large dredge material discharges directly onto the beach between 1996 and 1998 associated with the capital dredging and disposal activities for the 600 series basin occurring at that time (as mentioned earlier in this report by work from Cyrus *et al.*, 2008).

As mentioned in the previous section, Section A-4.5, observed accretion nearer the estuary mouth during the period 2004 to 2007 coincided with a period that there was a significant disposal of dredged material on the offshore disposal site (~ 3.8 million m³). There is a possibility that these changes could be indicative of effects of mounding of this material and associated inshore wave climate and consequential shoreline change. However, the flow records for the Mhlathuze Estuary are partly missing or are recorded as "greater than" (meaning that the actual volume is higher than what was recorded), thus the possibility that the shoreline accretion could be associated with increase sediment inputs for the estuary cannot be ruled out. This could possibly be resolved by looking at rainfall records for this period to determine whether this was likely to be a high flow period in 2005 and 2006 when the flow records for the Mhlathuze River contains some uncertainty.

Furthermore, periods of comparatively low runoff, such as 2008–2010 and 2014–2016, do not consistently correspond with either erosive or stable shoreline conditions although the shorelines did undergo changes during these periods. As noted in Section A-4.5 above, from 2017 onward, significant accretion, particularly around the estuary mouth and to a lesser extent towards the south breakwater, was observed. This is likely linked to the estuary’s northward migration, as evidenced by satellite imagery, which may have induced complex sediment dynamics in the nearshore zone. The lesser accretion observed towards the south breakwater may be indicative of potential redistribution of sediments associated with changing inshore wave conditions due to the accumulation and mounding of material on the disposal site that occurred between 2007 and 2022 (see Figure 6-16 in Section 6 and discussions in WSP (2025)). The mound that developed during this period resulted in waters shallower than -13 m CD being measured on the mound during the 2022 bathymetry survey of the disposal site.

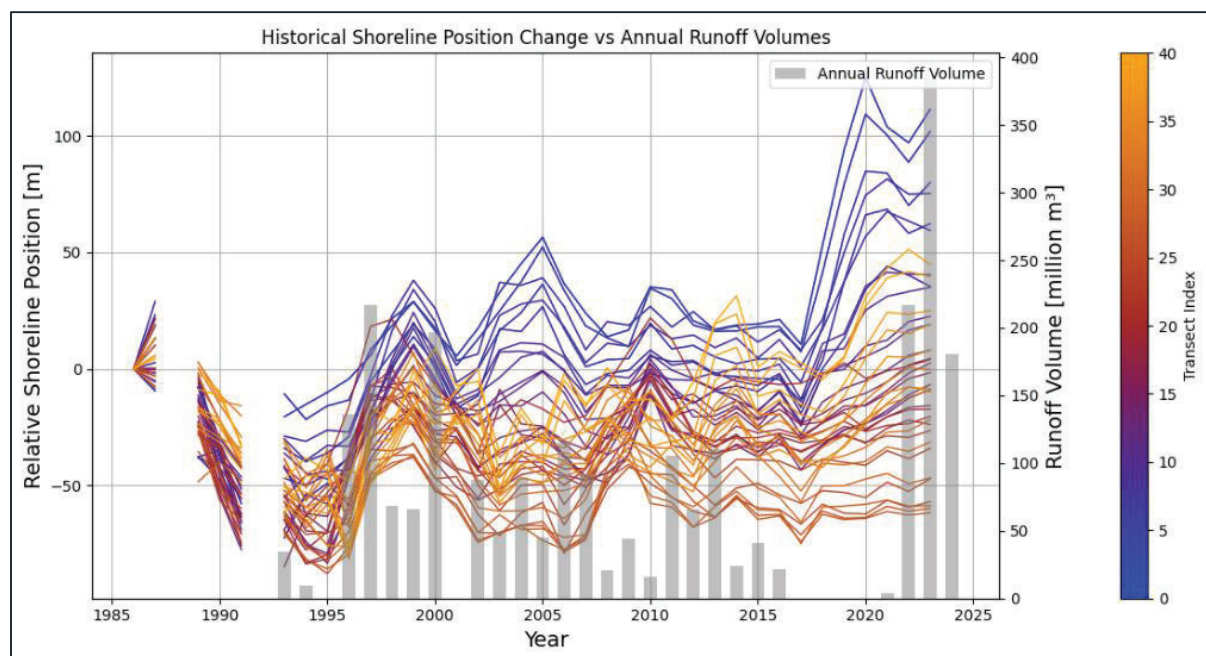


Figure A-21: Historical shoreline position change at Central Beach (Area B) compared to the annual runoff volumes of the Mhlathuze River (blue – estuary mouth; orange – south breakwater).

Similarly to the discussion of the far-southern beach areas (Area A), higher runoff volumes do not necessarily lead to a stable or accretionary shoreline state, and lower runoff volumes do not uniformly result in erosion or a stable shoreline state. Satellite imagery indicates that the estuary mouth is highly dynamic, with noticeable northward migration over time. This movement generates complex morphological features such as cusps, gullies, and irregular nearshore sediment patterns, which may help explain abrupt accretion or erosion events (e.g., 2000–2005). Additionally, uncertainty regarding the precise location of dredged material disposal, particularly whether it was placed along the central or far-southern beach (refer to earlier sections), further obscures potential correlations between shoreline change and runoff volumes. Lastly, the quality of the gauge data from DWS (2025) is fairly poor with gaps or erroneous logged data through the recorded period, which contributes to further uncertainty.

A-4.7 ANECDOTAL HISTORICAL SHORELINE CHANGES AT SELECTED LOCATIONS

PRDW (2012) conducted an Environmental and Social Impact Assessment (ESIA) dredge disposal modelling study for Matola, Mozambique. In this study, reference is made to earlier confidential modelling studies carried out at Cape Town, which assessed the impact of dredge borrow pits using wave and shoreline modelling. Those studies found that a change in the mean significant wave height (H_{m0}) of just 25 mm offshore of the surf zone, combined with a 1° shift in mean wave direction, could result in approximately 8 metres of beach erosion over a 20-year period. Applying a linear scaling of these results, PRDW estimated a potential shoreline retreat of 1.6 metres (H_{m0} less than 3 mm change and wave direction change of less than 0.2°) at Ilha da Chefina Grande over the same duration (20 years), assuming sediment remains on the disposal site for the full 20 years. However, this predicted erosion is considered minor relative to the natural variability in wave, wind, and current conditions that typically drive shoreline changes.

Similarly, TNPA (*n.d.*) conducted a shoreline impact assessment for proposed marine infrastructure at the Port of Ngqura. The study reported that general changes in wave height were less than 30 mm, with only minimal impacts expected along approximately 5 km of shoreline northeast of the port—though even these are considered unlikely. As a result, shoreline stability impacts near the port are anticipated to be imperceptible, with no significant effects expected beyond 5 km from the port. Under storm conditions, wave height changes were limited to a maximum of 100 mm in some areas, which may cause minor impacts, although these are also deemed unlikely to be noticeable. Additional wave scenarios were assessed, all indicating similarly negligible effects on the shoreline. The nearshore wave condition changes associated with the proposed offshore dredge mound at Richards Bay (this 2025 study) fall within the same order of magnitude (typically below 20 mm change in wave height and less than 0.5° angle change) as those observed in the PRDW (2012) and TNPA (*n.d.*) studies.

When compared to the substantial shoreline changes observed in satellite-derived data (not clearly related to dredge spoil disposal activities), often exceeding 100 m over the past two decades, the impacts are expected to be minor. As in the PRDW (2012) study at Matola, the magnitude of erosion attributed to offshore disposal is likely negligible relative to the natural variability in wave, wind, and current conditions. Therefore, any such changes are likely to be masked by more dominant and impactful coastal processes.

A-5 DISCUSSION

The overview of shoreline dynamics at Richards Bay reveals a highly complex coastal system influenced by a range of natural and anthropogenic factors. Key contributors to shoreline change include port-related activities such as sand bypassing, dredging, and offshore dumping. These are compounded by longshore sediment transport dynamics, subject to changes due to storm events, as well as inputs from the Mhlathuze Estuary, which discharges just south of the port.

Shoreline positions derived from satellite imagery have revealed previously undocumented trends in shoreline evolution around the Port of Richards Bay. These observations provide an opportunity to correlate shoreline changes with variables such as offshore disposal volumes, northern beach nourishment activities, and estuary runoff volumes.

The following comparisons were made to explore these potential relationships:

- (i) Historical shoreline changes at Area C (northern beaches) versus northern beach disposal volumes
- (ii) Historical shoreline changes at Area C versus offshore disposal volumes
- (iii) Historical shoreline changes at Area A (far-southern beaches) versus offshore disposal volumes
- (iv) Historical shoreline changes at Area A versus estuary runoff volumes
- (v) Historical shoreline changes at Area B (Central Beach) versus offshore disposal volumes
- (vi) Historical shoreline changes at Area B versus estuary runoff volumes
- (vii) Anecdotal historical shoreline changes at selected locations

Of these comparisons, a clear and consistent relationship is observed only in case (i). The northern beaches (Area C) show a direct response to beach nourishment activities: when annual nourishment volumes exceed 800 000 m³, the shoreline tends to stabilize or accrete. In contrast, when volumes fall below this threshold, shoreline erosion is commonly observed. Thus, the shoreline response of the northern beaches clearly correlates with the volume of dredged material disposed of directly onto the northern beaches.

In Area B (central beach), a more generalized relationship is suggested between offshore disposal volumes and shoreline change. Larger offshore disposal volumes may contribute to accretion or redistribution of sediments along this section of the beach due to changing wave conditions, *i.e.*, potentially resulting in erosion in some areas and accretion in others, while extended periods with minimal dumping may lead to stabilization or slight erosion. However, this relationship is not linear and is likely influenced by several additional factors that may independently drive shoreline changes, potentially confounding the observed relationship and rendering the apparent link inconclusive or coincidental. Therefore, while the offshore disposal of dredged material may influence the central and far-southern beaches to some extent, its impact on shoreline response remains unclear from these historical records. Furthermore, periods of significant accretion were observed at Area B and just south of the estuary mouth (northern Area C) during documented onshore disposal activities in the area (e.g., 1996 to 1998). This suggests that the onshore disposal of dredged material may have a notable influence on shoreline position.

Further complicating the analysis is the limited availability and reliability of data on dredging and disposal activities. Detailed records of dredged volumes are scarce, and data on the precise quantities and locations of on-beach disposals, particularly along the southern beaches, are uncertain, particularly for the period prior to the 1996 beach disposals. General uncertainty regarding the quality of dredge volume and timing data (including capital dredging campaigns, maintenance dredging, and associated disposal activities) undermines efforts to isolate and attribute shoreline changes to specific disposal events.

Additionally, the combined influence of the south breakwater obstructing longshore sediment transport, the presence of the sand trap near the southern breakwater, and often highly variable sand bypassing must be considered. CSIR (2015) found that if the sand trap is not dredged regularly, accumulated sediment becomes available for redistribution by natural coastal processes, leading to potential accretion along the Central Beach up until the further south beaches and within the harbour entrance channel. These findings highlight that sediment dynamics in the vicinity of the sand trap (e.g., Central Beach) are strongly influenced by both the sand trap's operational status and maintenance practices.

Runoff from the Mhlathuze Estuary represents another variable with an uncertain influence on shoreline change. Although this study included comparisons between estuary runoff volumes and shoreline changes near the estuary mouth, the anticipated significant impact was not clearly observed. Nevertheless, the overall shoreline trends at Areas A and B suggest that the estuary does play a meaningful role in local sediment dynamics. However, the reliability of these findings is limited by the poor-quality gauge data from DWS (2025), which contains gaps and erroneous entries, thereby reducing confidence in any conclusions drawn from these comparisons.

Based on anecdotal findings presented in PRDW (2012) and TNPA (*n.d.*), and assuming that the proposed offshore disposal at Richards Bay is similar to past practices, historical erosion potentially linked to offshore disposal events appears to be relatively minor when compared to the broader natural variability in shoreline change driven by waves, wind, estuary runoff, and currents. Considering this, any erosion related to offshore disposal is likely to be obscured by more dominant coastal processes.

In summary, it is important to emphasize that these interpretations remain uncertain due to several key uncertainties:

- Incomplete and unverified records of historical dredge disposal volumes, locations, and timing
- Sensitivity of shoreline response to precise placement of offshore material
- Influence of sediment-trapping infrastructure, such as the sand trap
- Poor-quality and inconsistent estuary runoff data.

These gaps collectively hinder the ability to draw robust conclusions about the causal relationships between offshore sediment disposal and observed shoreline trends. Nevertheless, the clear correlation observed on the northern beaches highlights the importance of consistent and high-volume nourishment in maintaining shoreline stability in that zone. For the other areas, more extensive historical data collection and ongoing monitoring are essential before stronger inferences can be drawn. In the absence of such data, numerical modelling of the current scenario likely remains the most reliable tool for predicting the potential near-future impacts of offshore disposal activities.

A-6 CONCLUSION

This preliminary assessment has highlighted the complexity of shoreline dynamics at the Port of Richards Bay, where a combination of natural processes and anthropogenic activities interact to influence coastal change. Among the various drivers assessed, the shoreline response of the northern beaches shows a clear and consistent correlation with the volume of dredged material disposed of directly onto the beach; when nourishment exceeds 800 000 m³ per year, stability or accretion typically follows. In contrast, while offshore disposal of dredged material may have some influence on the central and far-southern beaches, the observed shoreline changes in these areas are less consistent and appear to be minimal or likely overshadowed by other contributing factors. The ability to draw more robust conclusions across all areas is constrained by significant data limitations, including uncertainty regarding historical dredge disposal volumes and locations, the variable influence of sediment-trapping infrastructure like the sand trap, and inconsistent estuary runoff data. While modern remote sensing has revealed previously undocumented shoreline trends, the lack of reliable and comprehensive historical datasets limits definitive interpretation. Nevertheless, the findings emphasize the effectiveness of direct beach nourishment in stabilizing vulnerable shorelines.

A-7 REFERENCES

- BKS (2013). Richards Bay Port Expansion Programme Dredge Disposal Site Selection. BKS Project No. J02031. 30 July 2013
- Coppoolse, R.C. and Schoonees, J.S. (1991). Maintenance Dredging at Richards Bay: Sensitivity Analysis of Predictive Models and the Location of an Offshore Dump Site. Proceedings: CEDA Dredging Day, Amsterdam, Netherlands, 1991.
- Coppoolse, R.C., Schoonees, J.S., and Botes, W.A.M. (1994). Physical Impacts of the Disposal of Dredger Spoil at Richards Bay, South Africa. 28th PIANC, Seville, May 1994.
- CSIR (1978). Effect of Richards Bay Harbour Development of North Beaches. CSIR Report C/SEA 7801/1 and 2, National Research Institute for Oceanology, Stellenbosch.
- CSIR (1993). Physical impacts of the disposal of dredger spoil at Richards Bay. Report No. EMAS-C 93028, Stellenbosch.
- CSIR (1999). Extension of Richards Bay Coal Terminal: Physical Effects of Dredging. CSIR Report Nr ENV-S-C 99090, Stellenbosch.
- CSIR (2001). Dredging of Berth 306 for the South Dunes Coal Terminal in the Port of Richards Bay: Numerical modelling of the physical impacts of dredging. Report No. ENV-S-C 2000-023.
- CSIR (2002). Strategic Environmental Assessment for the Port of Richards Bay.
- CSIR (2004a). Strategic Environmental Assessment: Port of Richards Bay: State of the Environment, CSIR Report No. ENV-D-C 2004-022, Durban, South Africa.
- CSIR (2004b). Strategic Environmental Assessment: Port of Richards Bay: Sustainability Framework, CSIR Report No. ENV-D-C 2004-023 Durban, South Africa
- CSIR (2004c). Evaluation of Options for the Disposal of Dredge Spoil at Richards Bay. CSIR Draft Report.
- CSIR (2005a). Strategic Environmental Assessment: Port of Richards Bay: State of the Environment Summary Report, CSIR Report No. ENV-D-C 2005-013.
- CSIR (2005b). Strategic Environmental Assessment: Port of Richards Bay: Sustainability Framework Summary Report, CSIR Report No. ENV-D-C 2005-014.
- CSIR (2006). Development setback lines for the Northern beaches, Richards Bay, and evaluation of the uMhlathuze beaches. Report CSIR/NRE/ECO/ER/2006/0048/C, Stellenbosch.
- CSIR (2008). Beach Erosion Study Northern Beaches Umhlathuze Municipality. Report No. CSIR/NRE/ECO/ER/2008/0109/C.
- CSIR (2015). Reconfiguration of the Richards Bay Sand-Trap and Related Dredging Issues. Draft Report. CSIR, PO Box 320, 7599, Stellenbosch.
- de Waal, L., K. Schoonees, A. van Tonder, Q. Hurt and M. Antoni (2007). Effect of Borrow pit dredging on shoreline stability at Richards Bay, Civil Engineering, May 22007, pp59-60.

- DWS (2025). Hydrology – Drainage Regions Station Catalogue. Available online at: <https://www.dws.gov.za/hydrology/Verified/hymain.aspx> [Accessed: 15 April 2025]
- Goussard, L. (2009). New Berth 306 expansion capacity of Richards Bay Coal Terminal< Civil Engineering, May 2009, pp8-12.
- Laubscher, W.I., Coppoolse, R.C., Schoonees, J.S. and Swart, D.H. (1991). A calibrated longshore transport model for Richards Bay. Coastal Sediments '91, Volume 1L 197-211, Seattle, Washington.
- Luger, S.A., Schoonees, J.S. and Theron, A.K. (2002). Optimising the disposal of dredge spoil using numerical modelling, p. 3155-3167. 28th ICCE, Cardiff, UK.
- Phelp, D. *et al.*, (1999). Port of Richards Bay photographic helicopter surveys of the north and south breakwaters, Stellenbosch: CSIR.
- PRDW (2012). Terminal de Carvão da Matola (TCM) Phase 4: Environmental and Social Impact Assessment – Dredge Disposal Modelling Study. Report No. 1108/00/01. June 2012.
- Ramsay, P.J. & MacHutchon, M.R. (2005). Baseline geophysical survey of the offshore physical monitoring site associated with the development of berth 306 – Richards Bay. MGS Consultancy Report, 2005-008, 24 pp.
- Ramsay, P.J. & MacHutchon, M.R. (2005). Post Disposal Geophysical Survey of The Offshore Physical Monitoring Site Associated with The Development of Berth 306 – Richards Bay. MGS Consultancy Report, 2006-002, 22 pp.
- Schoonees, J. S., Theron, A. K. & Bevis, D. (2006). Shoreline accretion and sand transport at groynes inside the Port of Richards Bay. Coastal Engineering, Volume 53, pp. 1045 - 1058.
- Schoonees, J.S. (2000). Annual variation in the net longshore sediment transport rate. Coast. Eng. 40, 141–160.
- Smith, A. M, A.A. Mather, S.C. Bundy, J. A. G. Cooper, L. A. Guastella, P. J. Ramsay and A. Theron (2010). Contrasting styles of swell-driven coastal erosion: examples from KwaZulu-Natal, South Africa, Geol. Mag. 147 (6), pp. 940–953, doi:10.1017/S0016756810000361
- Swart, D.H. (1981). Effect of Richards Bay Harbour Development on the adjacent coastline. 25th PIANC, Edinburgh, 5: 899 – 917.
- Theron, D. (2024a). Shoreline Dynamics of South Africa Using Satellite Imagery. MEng thesis. Thesis for the degree of Master of Engineering, Faculty of Civil Engineering, Stellenbosch University. Supervisor: Dr A.K. Theron. URI: <https://scholar.sun.ac.za/handle/10019.1/131764>
- Theron, D. (2024b). Shoreline Dynamics of South Africa Using Satellite Imagery. Stellenbosch University. Dataset. DOI: <https://doi.org/10.25413/sun.26779372>
- TNPA (2025). 17 Year Dredging Analysis – March 2023. Dredging volumes dataset (received from TNPA, April 2025).
- TNPA (n.d.). Scoping and Environmental Impact Assessment (EIA) for the Provision of Marine Infrastructure, Including a General Cargo Berth and Liquid Bulk Berths at the Port of Ngqura, Nelson Mandela Bay Municipality. Chapter 8: Shoreline Impact Assessment.

- Van Ballegooyen, R., Newman, B., Shabangu, P. and Jacobs, G. (2015). Port of Richards Bay capacity expansion EIA: Dredging and dredge spoil disposal modelling specialist study. Stellenbosch: CSIR, WSP.
- Van den Bossche, P., MacHutchon, M.R. and P.J. Ramsay (2007). July 2007 Multibeam Bathymetry Survey of the offshore physical monitoring site associated with the development of Berth 306 – Richards Bay, Marine Geosolutions Report no. 2007-011, 27pp.
- Van Rijn, L.C. (2014). A simple general expression for longshore transport of sand, gravel and shingle. Coastal Eng. 90 (2014) 23-29.
- WSP (2007). Development set-back line for the southern beaches of Richards Bay. (Schoonees, Lynn, Bouton). Report No WSP/CO/206509/1/June 2007, WSP & Davies Lynn & Partners, South Africa.
- Zimmermann, N., Trouw, K., Wang, L., Mathys, M., Delgado, R. and Verwaest, Toon. (2012). Longshore transport and sedimentation in a navigation channel at Blankenberge (Belgium). Coastal Engineering Proceedings. 1. 10.9753/icce.v33.sediment.111.

Appendix B

CHANGES IN EXTREME WAVE CONDITIONS



B-1 RESULTS OF THE MODELLING OF EXTREME WAVE CONDITIONS

This appendix contains the results for the modelling of a representative range of extreme wave conditions to determine how the changes in bathymetry on the dredge spoil disposal site will impact or aggravate the nearshore extreme wave conditions.

The extreme conditions selected for the model simulations comprise a representative range of extreme offshore wave conditions occurring offshore (Table B-1). To ensure that the range of wave directions are adequately represented, the highest conditions per 22.5-degree sector were selected from the available data. The selection of wave conditions per direction sector included high wave conditions with both long and short wave periods, where applicable

Table B-1: Extreme wave conditions selected for the modelling to determine how the changes in bathymetry on the dredge spoil disposal site will impact or aggravate the nearshore extreme wave conditions

Condition	H_{m0} (m)	T_p (s)	Dir (TN)
A	3.3	6.2	55
B	2.951	5.2	68.66
C	2.929	12.5	107.048
D	2.751	9	107.963
E	3.045	13.3	133.531
F	2.617	6.6	120.748
G	3.601	14.2	156.628
H	5.5	12.5	160.922
I	6	12.5	199.326
J	5.092	9.3	193.536
K	6.333	14.2	202.729
L	5.3	9	210

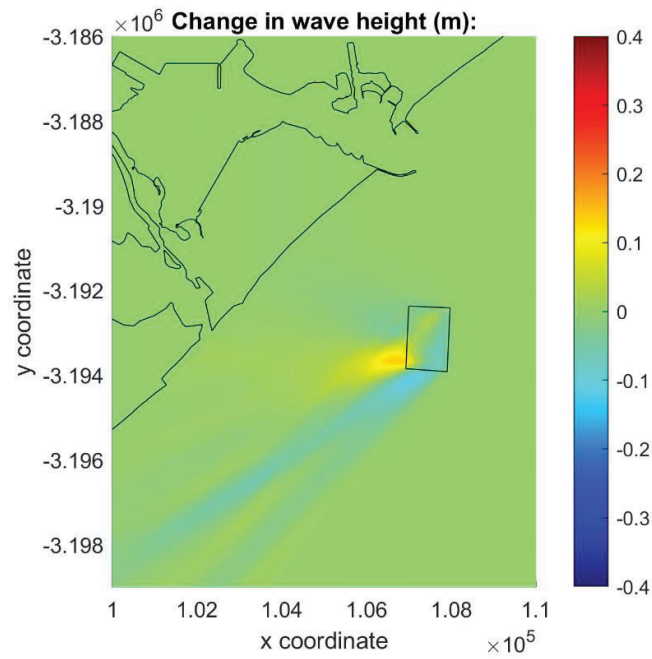


Figure B-1: Change in wave height (m) for condition A (H_{m0} : 3.3 m, T_p : 6.2 s, Dir:55 °TN)

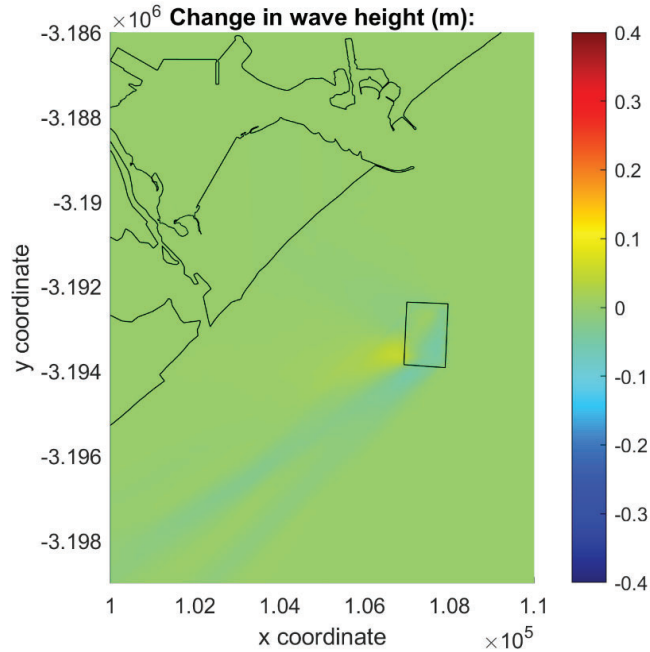


Figure B-2: Change in wave height (m) for condition B (H_{m0} : 2.951 m, T_p : 5.2 s, Dir:68.66 °TN)

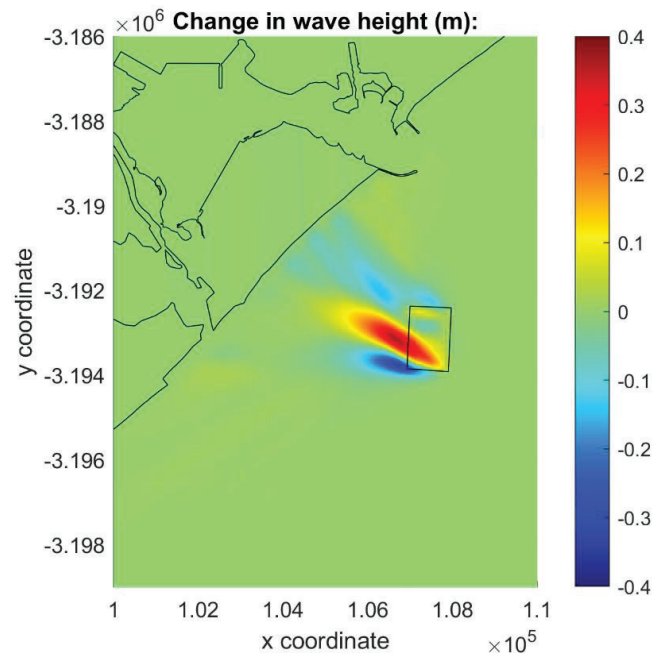


Figure B-3 – Change in wave height (m) for condition C (H_{m0} : 2.929 m, T_p : 12.5 s, Dir:107.048 °TN)

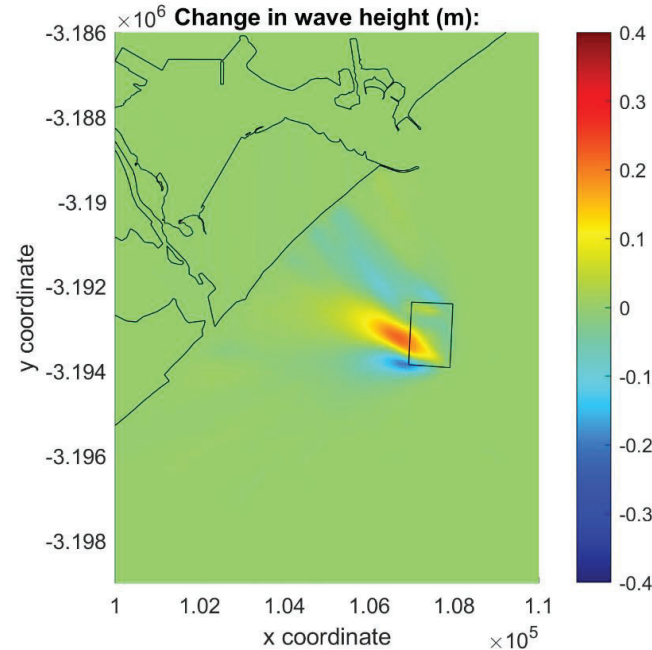


Figure B-4 – Change in wave height (m) for condition D (H_{m0} : 2.751 m, T_p : 9 s, Dir:107.963 °TN)

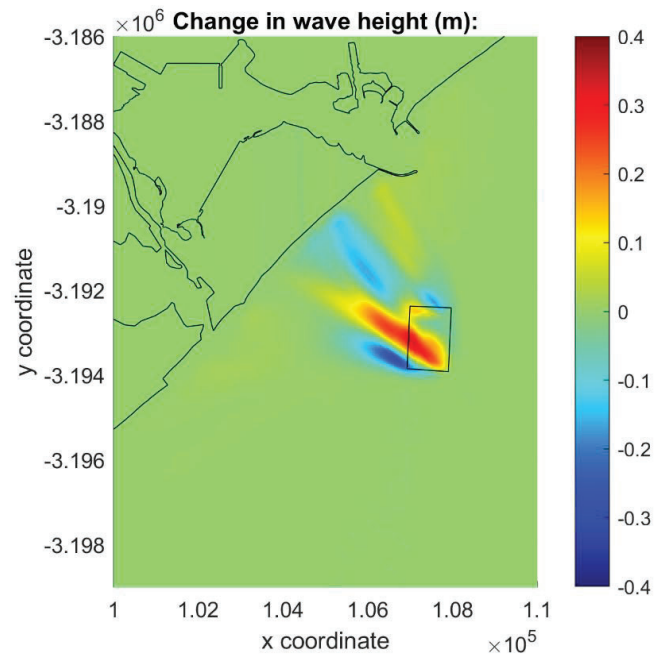


Figure B-5 – Change in wave height (m) for condition E (H_{m0} : 3.045 m, T_p : 13.3 s, Dir:133.531 °TN)

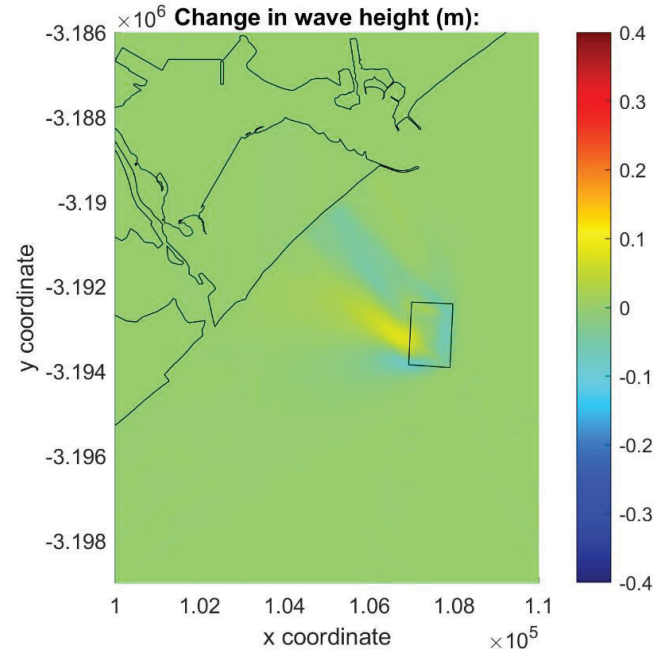


Figure B-6 – Change in wave height (m) for condition F (H_{m0} : 2.617 m, T_p : 6.6 s, Dir:120.745 °TN)

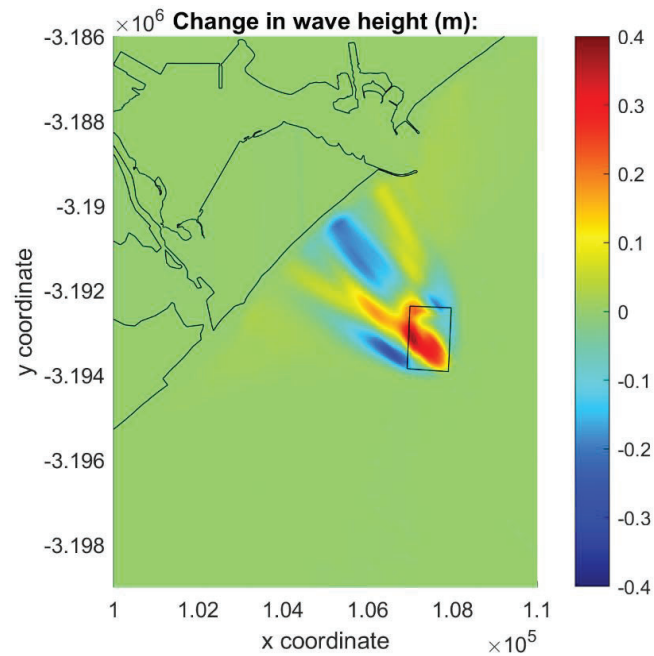


Figure B-7 – Change in wave height (m) for condition G (H_{m0} : 3.601 m, T_p : 14.2 s, Dir:156.628 °TN)

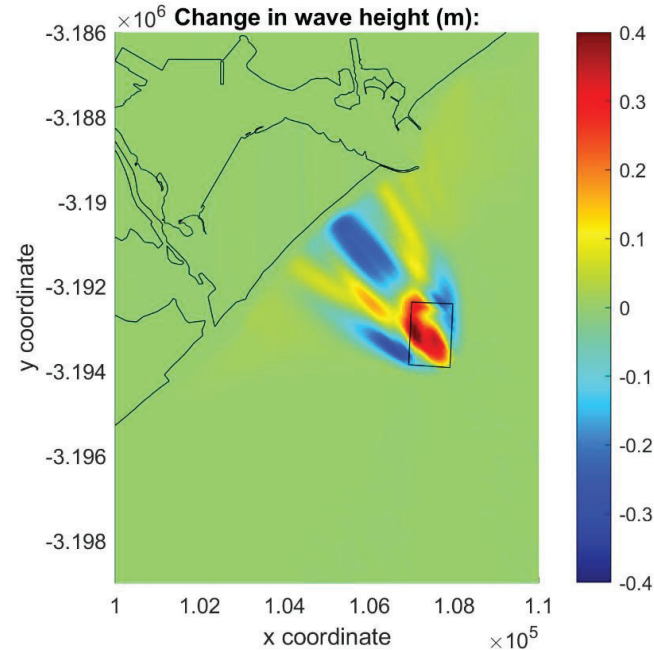


Figure B-8 – Change in wave height (m) for condition H (H_{m0} : 5.5 m, T_p : 12.5 s, Dir:160.922 °TN)

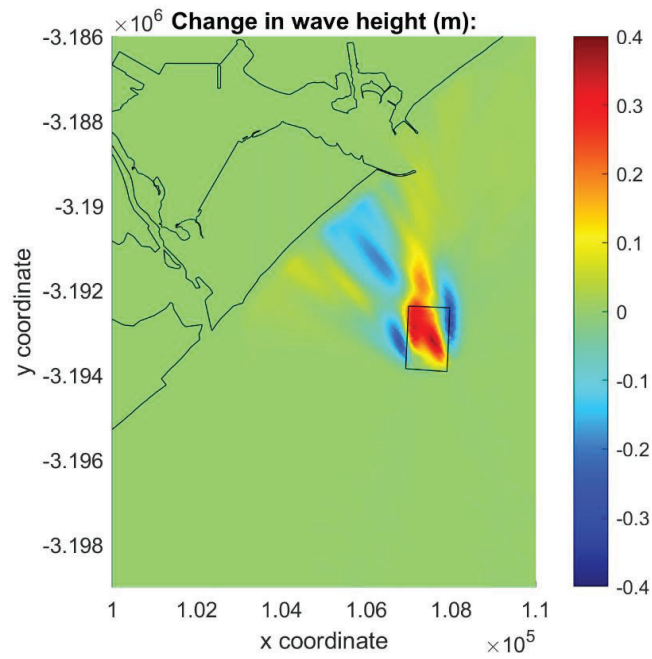


Figure B-9 – Change in wave height (m) for condition I (H_{m0} : 6 m, T_p : 12.5 s, Dir:199.326 °TN)

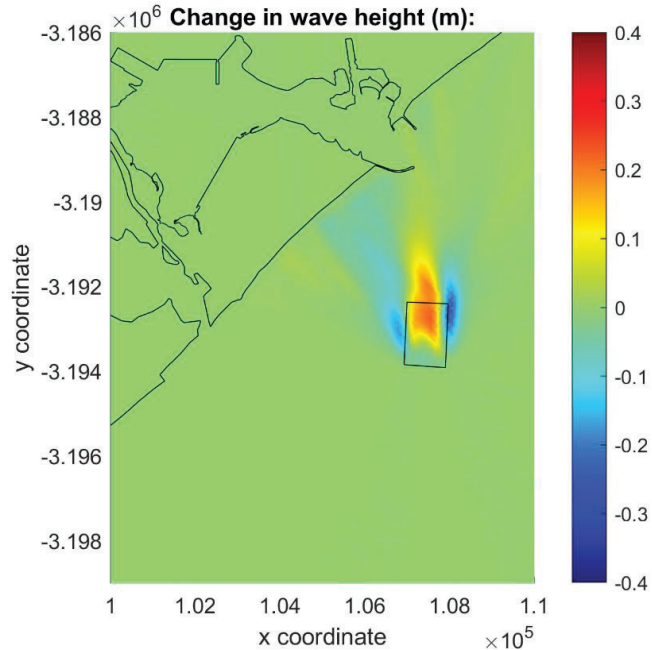


Figure B-10 – Change in wave height (m) for condition J (H_{m0} : 5.092 m, T_p : 8.3 s, Dir:193.536 °TN)

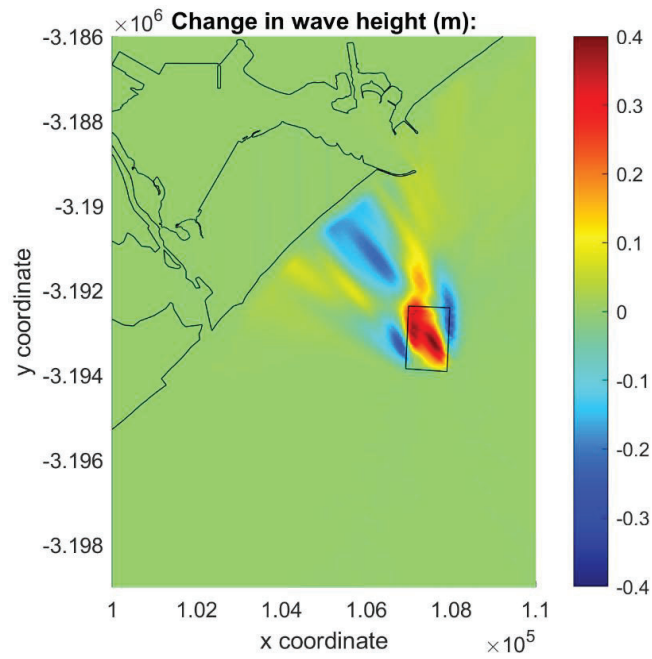


Figure B-11 – Change in wave height (m) for condition K (H_{m0} : 6.333 m, T_p : 14.2 s, Dir:202.729 °TN)

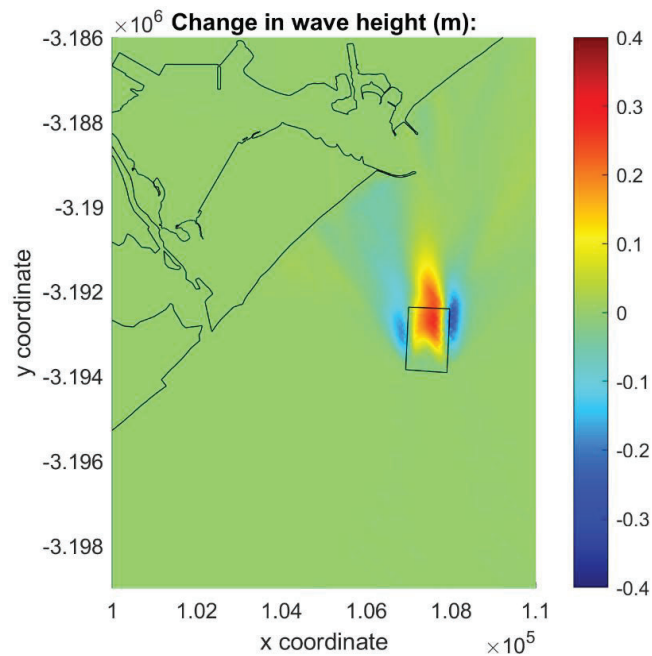


Figure B-12 – Change in wave height (m) for condition L (H_{m0} : 5.3 m, T_p : 9 s, Dir:210 °TN)



Building 1, Maxwell Office Park
Magwa Crescent West, Waterfall City
Midrand, 1685
South Africa

wsp.com

CONFIDENTIAL