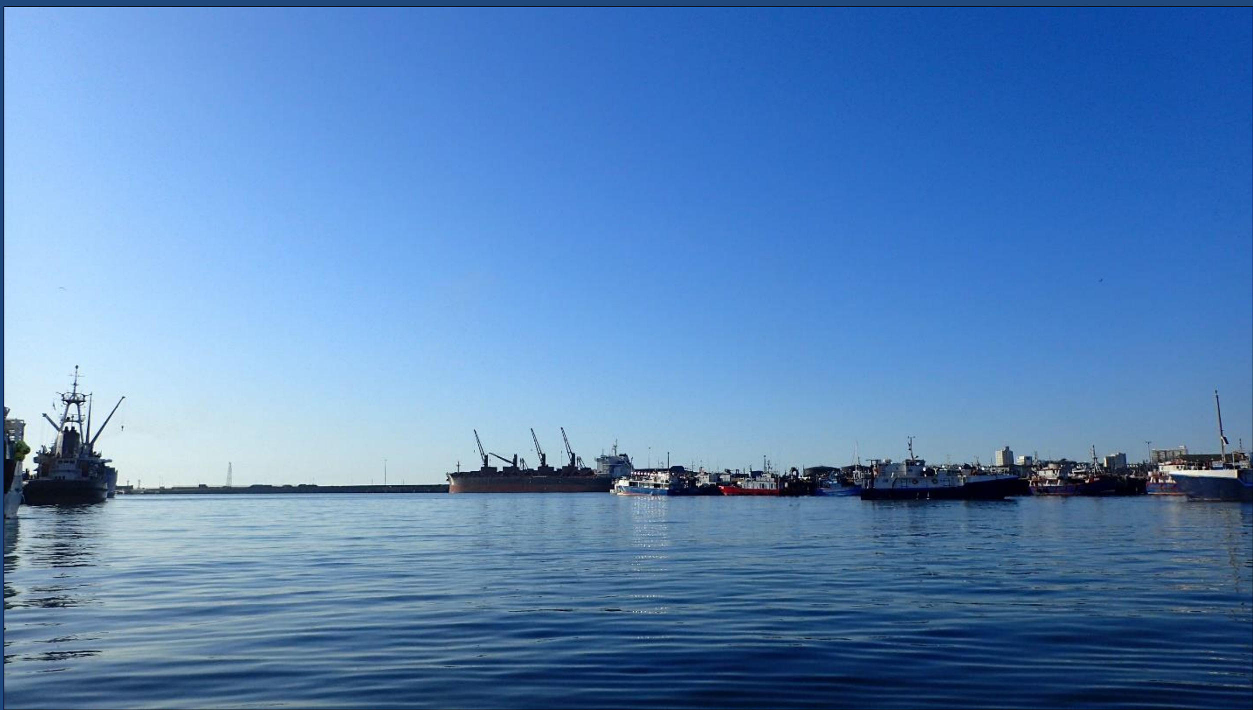
Old Tug Jetty Sheet Pile Quay Wall Rehabilitation, Port of Port Elizabeth

Marine Ecology Specialist Study and Environmental Impact Assessment



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Contents

1. General Introduction

Transnet National Ports Authority has identified the need to rehabilitate the sheet pile quay wall at the Old Tug Jetty in the Port of Port Elizabeth. The rehabilitation is needed because parts of the sheet pile wall are in an advanced state of deterioration, which has led to erosion of fill material that has in turn contributed to subsidence of the quay apron behind the wall. Although the sheet pile wall and quay area are safe for use in their current state, ongoing deterioration will compromise the structural integrity and eventually safety for use of the quay area. Transnet National Ports Authority thus intends to rehabilitate the sheet pile wall and quay area before it reaches such an advanced state of deterioration it is no longer safe for use. Should the need arise, Transnet National Ports Authority may also consider a deck-on-pile extension to the rehabilitated sheet pile wall, which will allow deeper draught vessels access to this part of the port. In both proposed projects the dredging of sediment will be required. The dredged sediment will be disposed at the registered dredged spoil disposal site in Algoa Bay.

Due to the nature of the proposed project it requires Environmental Authorisation in terms of the Environmental Impact Assessment Regulations, 2014 as amended (2017). Transnet National Ports Authority appointed Abantu Environmental Consultants (Pty) Ltd to undertake the Environmental Impact Assessment (EIA) process. Abantu Environmental Consultants (Pty) Ltd appointed the Council for Scientific and Industrial Research (CSIR) to undertake this Marine Ecology Specialist Study as part of the Environmental Impact Assessment.

2. Scope of Work

The Terms of Reference for the CSIR were to:

- Briefly describe the proposed project (there are two phases), including rehabilitation options that were considered as alternatives to the preferred option.
- Describe the affected baseline environment in the Port of Port Elizabeth and Algoa Bay that might or will be impacted should the preferred option for the proposed project proceed. The description of the affected baseline environment should be based on a desktop assessment using available information in scientific papers and reports, supplemented by an assessment of sediment quality in the area alongside the Old Tug Jetty.
- Identify, describe, and assess the significance of environmental impacts that might or will arise in the port and adjacent marine environment should the preferred option for the proposed project proceed.
- Identify and describe mitigation to reduce the significance of negative impacts and enhance the benefits of positive impacts that might or will arise should the preferred option for the proposed project proceed, for inclusion in an Environmental Management Programme Report.
- Identify and describe monitoring that could or should be implemented during the construction and operational phases should the preferred option for the proposed project proceed.

3. Approach to Study

An overview of the statutory requirements and legislative and policy frameworks relevant to the proposed project are dealt with elsewhere in the Environmental Impact Assessment for the proposed project and will thus not be repeated here. The first part of this Marine Ecology Specialist Study involves a baseline description of the environment that might or will be affected by the proposed project, with the aim of providing a baseline against which to rate the significance of identified impacts. There is sufficient scientific data and information available for the Port of Port Elizabeth to provide a fairly comprehensive baseline description of the environment that might or will be impacted should the preferred option for the proposed project proceed. Important data gaps include information on currents and information on the bird community in the port. The available information includes the findings of the Long-Term Ecological Monitoring Programme for the Port of Port Elizabeth, the findings of sediment quality surveys for maintenance dredging permit applications, and studies published in scientific journals. A field survey was also made by CSIR scientists in August 2022, to verify some components of published studies, to perform a once off survey of water quality alongside the proposed project area, and to sample sediment alongside the proposed project area for grain size, total organic content, and metal analysis, and toxicity testing.

The environmental assessment was conducted in two stages. The first stage was to identify the nature of the impacts (positive or negative) that might or will arise because of the proposed project and to then assess the significance of these impacts. Impacts result from the consequences of a change acting on a resource or receptor. A resource is any environmental component affected by an impact (*e.g.* items of environmental value such as habitats). A receptor is any environmental or other defined feature (*e.g.* fauna or flora) that is sensitive to, or has the potential to be affected by an impact. The nature of the impacts depends on the degree of impact (*e.g.* its spatial extent, duration, magnitude, and whether it is reversible) and the sensitivity of the resources or receptor. For each significant impact identified appropriate secondary mitigation measures were identified and the residual impacts were assessed, considering the proposed mitigation.

Impacts were assessed for the construction and operational phases for the preferred option of the proposed project. There is no intended decommissioning for the proposed project, even though the upgraded quay in question could at some future stage be decommissioned and removed entirely. The upgraded quay will be designed for an effective 50-year service life subject to regular and effective maintenance (PRDW, 2019). Potential impacts associated with their decommissioning were thus not assessed as it is impossible to anticipate what the port and its surroundings may resemble at that time.

4. Description of the Proposed Project

4.1. Background and Need

The Port of Port Elizabeth is situated in the city of Gqeberha (formerly Port Elizabeth) on the western shores of Algoa Bay (Figure 1), on the southeast coast of South Africa. The Old Tug Jetty is situated in the southern basin of the Port of Port Elizabeth (Figure 2). The Old Tug Jetty area can be divided into two sections based on operations. The northern side is mainly used for the berthing of fishing boats and trawlers, with the back of quay area used for the transhipment of cargo and supplies. The southern side is used for the staging of boats for maintenance and repair. A fixed 4-ton crane is used for vessel handling, along with an occasional mobile crane.

The Old Tug Jetty sheet pile wall was constructed in the mid 1970's and comprises steel interlocking 'U' sheet pile sections with dead man anchors and a concrete capping beam. Transnet National Ports Authority appointed Buchule Engineers (Buchule Engineers, 2017) to perform an assessment of wet assets in the Port of Port Elizabeth. The assessment included visual inspections from the land and waterside, and where deemed necessary was supplemented by diving inspections. The waterside visual and diving inspection of the Old Tug Jetty sheet pile wall found numerous holes in the sheet piles through which backfill material is leaching (Figure 3). This has resulted in the subsidence of the back of quay area. An additional 200 mm concrete slab was added behind the wall because of present use requirements, but this was not part of the original design and has added load onto a structure that is already in a poor condition. Based on the assessment Buchule Engineers (Buchule Engineers, 2017) concluded that:

- The deterioration of the sheet pile wall is ongoing and will get progressively worse.
- Given the advanced state of deterioration the ability of the sheet pile wall to fulfil its functional requirement is uncertain.
- The progressive weakening of the steel sheet piles because of corrosion could result in a sudden failure if the holes in the piles grow unchecked.
- Doing nothing would eventually result in the abandoning or condemning of the quay due to safety concerns.

- The option rehabilitating the sheet pile wall by cladding it is fatally flawed since steel deterioration will continue, resulting in uncertainty regarding the remaining service life.
- Replacement is the only practical solution that will provide certainty with regards to the future life span of the facility.

Transnet National Ports Authority subsequently appointed PRDW to identify engineering solutions to address the deterioration on the sheet pile wall. PRDW (PRDW, 2019) considered eleven options for rehabilitating of Old Tug Jetty sheet pile wall and back of quay area, as outlined below. The options assume the existing sheet pile wall will be abandoned and buried and the back of quay area remediated. Each rehabilitation option represents a potential design alternative for the proposed project. There is no alternative location for the proposed project.

Option 1: 'Do nothing'

The 'Do Nothing' option obviously involves leaving the existing Old Tug Jetty infrastructure in its current state. Therefore, none of the potential or definite environmental impacts associated with the preferred option, as outlined below, will (have the possibility to) manifest. The 'Do Nothing' option was ruled out since although the Old Tug Jetty sheet pile wall is currently stable, in time safety factors may fall below recommended levels as the sheet piles will continue to deteriorate and the wall will inevitably need to be rehabilitated or replaced. The 'Do Nothing' option poses a risk to port operations should the quay collapse and will also have adverse environmental impacts if this were to occur.

Option 2: Steel sheet pile wall

This option involves the construction of a new steel sheet pile wall in front of the existing steel sheet pile wall. It would require excavation of the existing scour rock protection before the piles could be driven. The area between the new and existing sheet pile walls would then be backfilled and an *in-situ* concrete cap and slab cast.

Option 3: Steel tubular combi-wall

This option involves the construction of a sheet pile wall using steel tubular piles and interlocking sheet piles. The piles would be advanced through the existing scour rock protection by chiselling/excavating through the tube. The piles would have a minimal offset from the existing sheet pile wall, which would be grouted up.

Option 4: Steel sheet pile wall (offset)

In this option a steel sheet pile would be offset beyond the toe of the existing scour rock protection. This would allow the existing sheet pile to remain unaffected by the proposed construction. The area between the new and existing sheet pile walls would then be backfilled and an *in-situ* concrete cap and slab cast.

Option 5: Blockwork gravity wall

In this option a blockwork wall would be located seaward of the existing scour rock protection to avoid destabilising the existing sheet pile wall. The option would entail the construction of a stone foundation, placing the concrete blocks on the foundation, backfilling, and casting an *in-situ* concrete cap and slab.

Option 6: Caisson gravity wall

The caisson option is very similar to the blockwork structure. The caissons would be constructed in the dry, launched on one of the slipways adjacent to the Old Tug Jetty, floated into place, and submerged.

Option 7: Counterfort gravity wall

Construction of the counterfort wall would require the dredging and removal of existing scour rock protection to place a stone bed foundation. Partial relief of the backfill behind the existing sheet pile wall would probably be required during construction. Thereafter, the wall would be placed, backfilled, scour rock placed, and concrete works undertaken.

Option 8: Counterfort gravity wall (offset)

This option is similar to Option 6, the only difference being that the counterfort wall would be placed seaward of the existing scour rock protection to avoid destabilising the existing sheet pile wall.

Option 9: Counterfort and deck-on-pile hybrid

This option comprises two phases:

Phase 1: Sediment would be dredged to the top of the existing scour rock protection. A counterfort wall similar to Option 6 would then be constructed. The interim berth depth would be -5.2 m Chart Datum.

Phase 2: If there is sufficient demand for a deeper berth, the counterfort wall would be expanded by driving piles beyond the existing scour rock protection and constructing a deck-on-pile structure with the designed berth depth of -6.5 m Chart Datum.

Option 10: Blockwork counterfort hybrid

This option would entail dredging and then constructing a stone foundation for a concrete block. This would serve as a step to provide a foundation for the counterfort, which would be constructed on top of the block. This option would reduce the structure's footprint in comparison to Option 7.

Option 11: Deck-on-pile wharf

This option would entail driving piles just beyond the toe of the existing scour rock protection. Thereafter, the existing sheet pile wall would be buttressed by rock fill, and precast concrete beams and slabs would be used to construct the deck.

Based on a weighted multicriteria analysis that considered health and safety considerations, environmental considerations, constructability, localisation, maintainability, capital costs, and upgradeability, PRDW (PRDW, 2019) identified Option 9: Counterfort and deck-on-pile hybrid as the preferred option. The counterfort deck-on-pile hybrid option outscored other options by performing best at constructability, localisation, maintainability, and upgradeability. The deck-on-pile and steel tubular combi-wall scored closely at second and third respectively. The offset sheet pile wall scored overall the worst, but scored favourably for capital cost.

As discussed above the counterfort deck-on-pile hybrid structure comprises two phases. The proposed extent of each phase is illustrated in Figure 4. Conceptual engineering designs are illustrated in Figures 5 and 6. The Phase 1 counterfort wall is 259.3 m long with a maximum cope line offset of 6 m from the existing sheet pile wall, tapering as it approaches the slipways at either end. The cope level is +4 m Chart Datum, with the berth depth varying from -5.2 m Chart Datum along the north-western face sloping up and tying into the extents of the slipways. The existing sheet pile wall will be abandoned and buried, and the back of quay area will be rehabilitated. The construction process will consist of the dredging of sediment, which will be disposed at the dredged spoil disposal site in Algoa Bay (Figure 7), and then excavation a thin layer of existing scour rock protection in front of the sheet pile wall. The risk of excavating in front of the sheet pile wall still needs to be assessed in the next project phase. Thereafter, a filter fabric will be laid on top of the scour rock protection and along the vertical extents of the sheet pile wall. A stone bed will then be placed on top of the filter fabric to create a level bed for precast counterfort units. The counterfort units will then be seated on the stone bed and scour rock protection placed on their toe. The wall will then be backfilled with quarry run and concrete and civil works completed. Finally, the quay furniture will be installed.

If there is sufficient demand for a deeper berth, the structure can be upgraded by implementing Phase 2. Phase 2 entails the construction of a deck-on-pile structure in front of the counterfort wall. The deck-on-pile structure is 87.3 m long with further cope line offset of 5.8 m. The cope level is +4 m Chart Datum, with a berth depth of -6.5 m Chart Datum. The deck-on-pile length is limited to the extent illustrated in Figures 4 and 6 because it is not possible to achieve the -6.5 m Chart Datum berth depth along the approaches to the slipways as the seabed needs to rise to suit the slipway geometry. The construction process will commence with the dredging of sediment, which will be disposed at the dredged spoil disposal site in Algoa Bay. The existing quay furniture on the counterfort wall affected by the deck-on-pile structure will then be removed. Thereafter, steel tubular pile casings will be driven at the toe of the existing scour rock protection, excavated out to toe level, and then a reinforced concrete pile then cast inside. Precast pile caps will be seated on the piles. Abutments will be constructed into the counterfort units to house the precast beams and provide lateral support to the deck-on-pile structure. After placing precast beams, cope panels, and planks, the elements will be stitched together with *in-situ* reinforced concrete. Finally, the quay furniture will be installed.

The scope of the dredging works has not been finalised. The length of the existing sheet pile wall is about 207 m. If it is assumed the area to be dredged in Phase 1 will extend 12 m from the existing sheet pile wall (6 m to accommodate the quay extension and a similar distance to allow placement of scour protection rock) to a depth of 2.5 m on average below the existing seabed, then the volume of sediment that will need to be dredged is in the order of 6 200 m^3. However, this estimate is based on rudimentary calculations and assumptions. The volume that will be dredged will be finalised after the engineering design is completed but is unlikely to exceed 10 000 m^3.

4.2. Construction phase

Details on the construction methods and phasing of construction have not yet been finalised as this will depend on the final engineering design but based on similar projects elsewhere and on information provided by PRDW (PRDW, 2019) the following can be expected. The estimated construction duration is 12-15 months for Phase 1 (counterfort wall) and 9-10 months for Phase 2 (deck-on-pile structure).

Decommission of Old Tug Jetty sheet pile wall

Self-explanatory.

Contractor site establishment

The contractor site will need to be established, including providing temporary office space, temporary ablution facilities, laydown areas and stockyards for materials and vehicles, and so on. The position of the contractor site/s has not been finalised. The site will be accessed via existing roads and no new road infrastructure is required.

Construction hours and duration

Generally, construction works will be conducted between ~7 am to 5 pm, Monday to Friday. Work on weekends is not anticipated, but might be required at times when certain materials are delivered to the site or certain components of the construction must be completed in a continuous process or fixed time. It is estimated the Phase 1 will require ~12-15 months, and Phase 2 ~9-10 months to complete. However, these periods are subject to revision once the engineering design and construction method have been finalised.

Construction

A breakdown of the possible construction sequences for Phase 1 and Phase 2 provided by PRDW (2019) is outlined below.

Phase 1: Counterfort wall

- Dredge to appropriate level and remove a thin layer of existing rock fill in front of the sheet pile wall.
- Place filter fabric on top of rock fill and along vertical extents of the existing sheet pile wall.
- Place stone bed layer on the filter fabric to create a level bed for the precast counterfort units.
- Cast counterfort units in a casting yard.
- Remove all the existing quay furniture and demolish existing structures that obstruct the new works.
- Place pre-cast counterfort units.
- Install scour protection rock on top of the counterfort unit toes.
- Backfill the area between the counterfort wall and the existing sheet pile wall with quarry run.
- Place filter fabric on top of quarry run backfill.
- Remove quay apron concrete surface.
- Undertake pavement layer works.
- Install civil services.
- Cast concrete capping beam and cope panel.
- Install quay furniture.
- Paving to final levels and services fit out.

Phase 2: Deck on pile structure

- Site establishment.
- Partially decommission Old Tug Jetty counterfort wall.
- Procurement of materials – steel pile casing assumed to be imported.
- Dredge to appropriate level.
- Remove all the existing quay furniture – store for reuse on the new structure.
- Pile installation
    - Install guide frame with required temporary support.
    - Drive tubular pile casing to level.
    - Remove material pile using an auger, grab, and airlift.
    - Insert reinforcing cage into pile.
    - Tremie concrete to fill pile.
- Install scour protection rock.
- Prepare counterfort capping beam to receive deck on pile primary beam.
- Place and grout into position precast pile cap.
- Deck installation
    - Place precast primary beam seated on counterfort wall and pile cap.
    - Place precast slab planks between primary beams.
    - Hang and brace precast cope panel in position using a construction frame.
    - Pour *in-situ* concrete to stitch precast elements together and form capping beam and deck slab.
- Install quay furniture.
- Paving to final levels and services fit out.

Construction site decommissioning

After completion of the construction works for either phase the contractor site offices, laydown yards and so on will be removed and the construction area cleared for handover to Transnet National Ports Authority.

Commissioning

The rehabilitated/constructed structures will be commissioned by Transnet National Ports Authority.

4.3. Operational phase

No substantial changes to the use of the area are anticipated following rehabilitation. The only impacts associated with the operational phase of the proposed project that were assessed are thus those associated with an altered geometry of the sheet pile wall on hydrodynamic conditions, ecological and hydrodynamic impacts posed by the deck-on-pile structure, and the permanent loss of open water and sediment habitat.

4.4. Decommissioning phase

There is no intended decommissioning phase for the project as the rehabilitated Old Tug Jetty structures will be designed for a 50-year service life, subject to regular and effective maintenance (PRDW, 2019). It is impossible to anticipate what the port and its surroundings will resemble at that time. Impacts associated with the decommissioning of the proposed structures were thus not assessed.

5. Description of Baseline Environment

5.1. Physical environment

5.1.1. Physical description of the Port of Port Elizabeth

The Port of Port Elizabeth is situated in the city of Gqeberha (formerly Port Elizabeth) on the western shores of Algoa Bay (Figure 1), on the southeast coast of South Africa. The port is surrounded by urban areas on its landside (Figure 1). The Baakens River, a small (~23 km length and ~20 km^2 catchment) river that rises and falls in Gqeberha flows into the western part of the port (Figure 2). Due to its small size and catchment the baseflow of the Baakens River is usually low, but it can come down in spate during periods of high rainfall. Surface runoff (stormwater) is directed to the port from port areas and surrounding urban areas through stormwater outfalls that discharge at various positions in the port.

The Old Tug Jetty quay area, the proposed project site, is situated in the southern basin of the port (Figure 2). The name is somewhat misleading since the Old Tug Jetty in fact comprises a jetty in the traditional sense that is anchored to a quay area. It is the quay area that is the focus of the proposed project. The quay area is roughly trapezoidal in shape. There are slipways for small vessels at either side of the quay area, while the southern leading jetty for the vessel repair slipway is situated slightly to the north of the quay area. The Old Tug Jetty and south side of the southern leading jetty are used for the berthing of fishing vessels and trawlers. Two or three fishing vessels and trawlers may tie up alongside one another due to space limitations. The unoccupied quay apron behind the sheet pile wall is very narrow as built structures encroach onto the quay edge (Figure 2). The Algoa Bay Yacht Club mooring area is situated near the southern extremity of the quay area.

5.1.2. Climate

The climate in Gqeberha area is warm temperate, but variable (Stone, 1988). The mean air temperature ranges from a low of ~7°C in winter to a high of ~26°C in summer (Stone, 1988). The primary wind axis in Algoa Bay is west-southwest to east-southeast, with north-northwest winds occurring for a short part of the year (Schumann and Martin, 1991; CSIR, 2021; see http://wavenet.csir.co.za/abay/spp.html; Figure 8). The calmest periods occur in May and June, with strongest winds in October and November (CSIR, 2021). The area is often characterised by gale force winds that can start suddenly from the southwest (the so-called buster). Gale force winds also blow from the southeast, but these usually increase in strength progressively. Rainfall is distributed throughout the year but with peaks in autumn (May to June) and spring (August to September), resulting in a bimodal rainfall pattern (Coetzee *et al*., 1996). The area has an annual average rainfall of approximately 400-800 mm (Coetzee *et al*., 1996). However, the area is quite often characterised by long periods of below average rainfall, as is currently the case.

5.1.3. Tides and Currents

Tides in the Gqeberha area are semi-diurnal microtidal with a dominant M_2 tide, that is, there are two high tides and two low tides within an approximately 25 hr period. The tidal period is 12 hrs and 25 min, with a slight diurnal inequality (Schumann *et al*., 1996). The Mean High Water Spring tide is +1.86 m relative to Chart Datum, Mean Low Water Spring tide is +0.21 relative to Chart Datum, and the Highest Astronomical Tide is +2.12 relative to Chart Datum (CSIR, 2014).

No information could be found in the scientific literature on currents in the Port of Port Elizabeth. However, these are expected to be weak, driven predominantly by tidal flows (there will be some influence on currents by wind).

5.1.4. Bathymetry and substrate

The bathymetry of the Port of Port Elizabeth is maintained fairly constant by maintenance dredging to ensure safe navigation conditions for vessels. The area near the Old Tug Jetty quay area is relatively shallow, being about -2.0 -3.0 m Chart Datum in the shallower parts to about -4-4.5 m Chart Datum in the deeper parts (Figure 9).

The bottom across most of the Port of Port Elizabeth is 'soft' in type, that is, it is comprised of unconsolidated sediment. In some parts of the port, most notably near Berths 102 and 103, the substrate is a mix of sediment and sandstone-like gravel. The most spatially comprehensive recent analysis of the grain size of sediment was performed in August 2019 by the CSIR, when the sediment was sampled at 28 positions (hereafter called stations) in and near the port (Figure 10). The grain size of the sediment sampled is provided in Table 1, while its texture based on the contribution of gravel, sand, and mud is illustrated in Figure 11. The grain size of the sediment varied widely across the port. The mud fraction, for example, contributed between 1.30-85.31% of the bulk weight of the sediment, that is, the sediment ranged from sandy to muddy. The sediment at most stations was texturally classified as mud, sandy-mud, or muddy-sand. Mud was the dominant grain size class at 15 stations, fine-grained sand at nine stations, and medium grained sand at two stations. The sediment at none of the stations was strictly defined as mud (*i.e.* mud size sediment contributing >90% of bulk sediment weight). Gravel, very coarse-grained and coarse-grained sand were generally poorly represented (Table 1).

In August 2022, sediment was sampled at the stations provided in Figures 12 and 13 for this Environmental Impact Assessment and for the Long-Term Ecological Monitoring Programme for the Port of Port Elizabeth. The grain size and total organic content of the sediment is provided in Table 2. Photos of the sediment sampled at stations alongside and near the Old Tug Jetty quay area are provided in Figure 14. The sediment at each site was dominated by mud sized material. The sediment at Stations PE1 and PE3 was slightly anoxic, but this was not pronounced as evident in the colour of the sediment and the only feint aroma of hydrogen sulphide detected in the field. Previous surveys have, however, provided evidence for the sediment being anoxic at Station PE1.

Other surveys, including surveys for the Long-Term Ecological Monitoring Programme for the Port of Port Elizabeth and for maintenance dredging permit applications, examined the grain size of sediment at fewer stations in the port compared to the surveys made in 2019 and 2022. The findings of these studies support the findings the surveys made in 2019 and 2022.

In summary, the mud is the dominant grain size class in sediment across a large part of the Port of Port Elizabeth. The Baakens River is probably an important source of fine-grained sediment to the port, but sediment undoubtedly also enters the port from other sources. The dominance of mud in the sediment across most of the port shows that current speeds in the port are low, allowing this fine-grained material to settle on the bottom.

5.1.5. Water quality

Transnet National Ports Authority has commissioned a Long-Term Ecological Monitoring Programme for the Port of Port Elizabeth. The water quality component of the monitoring programme has generated sufficient data to allow a good description of the main physical, chemical, and biological properties of the water column in the port (CSIR, 2016, 2017, 2018, 2019, 2020). The discussion below is based on water quality measurements made for the monitoring programme between 2015-2019 (CSIR, 2016, 2017, 2018, 2019, 2020). Water quality surveys were made in summer and winter each year, at the stations shown in Figure 15. The temperature, salinity, pH, dissolved oxygen concentration, turbidity, and chlorophyll-*a* concentration was measured *in situ* using an automated water quality monitoring instrument. Other water quality indicators were measured in surface water samples returned to the laboratory for analysis, including faecal indicator bacteria, salinity, pH, and total suspended solids, nutrient and metal concentrations. The Long-Term Ecological Monitoring Programme has generated a large amount of data, but it is not necessary to discuss in detail the findings for each water quality indicator in this assessment. Rather, the focus below is on the findings for key water quality indicators most relevant to the proposed project.

The influence of the Baakens River inflow on water quality in the port is evident in numerous water quality indicators. Perhaps the clearest and most consistent evidence for this influence is provided by salinity, an example of which is provided in Figures 16 and 17. The salinity depression is usually evident in the uppermost part of the water column. The salinity of bottom water usually approximates that for seawater. The restriction of low salinity water to the upper part of the water column reflects the fact that freshwater is less dense than seawater and thus tends thus to 'float' on seawater as it is gradually diluted, and that the inflow of freshwater via the Baakens River was low relative to the volume of water in the port at the time of the surveys.

Dissolved oxygen is a particularly important indicator of water quality since almost all aquatic organisms rely on a good supply of oxygen for their survival. Figures 18 and 19 provide examples of the dissolved oxygen concentration trend through the water column and across the port. The minimum and maximum dissolved oxygen concentration measured in surface and near-bottom water in the port in surveys between 2015-2019 was 2.71 $mg.l^{-1}$ and 9.40 $mg.l^{-1}$ respectively, while the 10^{th} percentile and median concentration were 6.04 $mg.l^{-1}$ and 7.16 $mg.l^{-1}$ respectively. The dissolved oxygen concentration in the port was thus usually quite high and was sufficient to sustain healthy populations of most forms of aquatic life (usually regarded as a concentration ≥5 $mg.l^{-1}$). The lowest dissolved oxygen concentrations were measured in one survey in the summer of 2019. The dissolved oxygen concentration at this time was also low at stations in the marine environment, suggesting that the low concentrations were the consequence of a large-scale oceanographic phenomenon that also affected the port, such as upwelling, rather than a problem that was restricted to the port.

The turbidity of the water column in the port is usually low. The highest turbidity is usually recorded in the low part of the water column (Figures 20 and 21), which undoubtedly reflects the resuspension of sediment by currents and vessel movements. The minimum and maximum suspended solids concentration measured in surface water in the port in surveys between 2015-2019 was 2 $mg.l^{-1}$ and 17 $mg.l^{-1}$ respectively, while the median and 75^{th} percentile were 5 $mg.l^{-1}$ and 7 $mg.l^{-1}$ respectively. The suspended solids concentration was thus usually low to very low. The suspended solids concentration and turbidity in parts of the port will increase markedly when the flow in the Baakens River is high. The suspended solids concentration and turbidity also increase markedly when vessels are berthed or de-berthed due to tugboat propeller wash and when the port area is maintenance dredged (Figures 22 and 23). The Long-Term Ecological Monitoring Programme avoids to the extent possible the influence of port activities such as vessel berthing and de-berthing and dredging on the water column turbidity and suspended solids concentrations when water quality measurements are made, as these are temporary (albeit important) impacts. The turbidity and suspended solids concentration in the water column during these events will be far higher than those measured for the Long-Term Ecological Monitoring Programme.

The 50^{th} and 75^{th} percentile of *E. coli* bacteria colony forming unit counts was 85 and 31 respectively, and for faecal streptococcus bacteria was 20 and 10. In other words, the colony forming unit counts were usually very low. However, the counts at some stations were periodically very high. The highest faecal indicator bacteria counts in surface water in the port were recorded in the southern basin near or relatively near the Baakens River inflow and near the Dom Pedro Quay (Stations 1, a, and 3 in Figure 24). The high counts near the Baakens River inflow probably reflect the inflow of sewage contaminated water via the river.

Nutrient concentrations, exemplified by dissolved inorganic nitrogen and orthophosphate in Figure 25, were variable over the period 2015-2019 (CSIR, 2016, 2017, 2018, 2019, 2020). The concentrations were usually low, but periodically high, most often at stations in the southern basin (Figure 25). The high nutrient concentrations in the southern basin probably reflect the inflow of sewage contaminated water via the Baakens River. The microalgal biomass in the port as deduced from the chlorophyll-*a* concentration, was typically low (Figure 26).

Metal concentrations in the water column for the period 2015-2019 (CSIR, 2016, 2017, 2018, 2019, 2020)were typically very low to moderate (for some metals the concentration was usually below the method detection limit, or too low to measure accurately in the laboratory). The concentrations of some metals, most notably copper and zinc, periodically exceeded the updated South African Water Quality Guidelines for Coastal Marine Waters (DEA, 2018) (Figure 27). Evident in Figure 27 is that the mercury concentration exceeded the water quality guideline. However, it must be noted the recommended mercury guideline in the updated South African Water Quality Guidelines for Coastal Marine Waters is extremely low, at 0.016 $\mu g.l^{-1}$. For comparison, the existing water quality guideline for mercury is at 0.4 $\mu g.l^{-1}$. All mercury concentrations are lower than the existing guideline.

The findings for numerous water quality indicators analysed in the Long-Term Ecological Monitoring Programme for the Port of Port Elizabeth were included in an index to rate water quality in the port for the period 2015-2019 (CSIR, 2016, 2017, 2018, 2019, 2020). Water quality was always rated good or excellent apart from some stations in the southern basin (Figure 28). In these instances the fair or marginal water quality rating was largely a consequence of high faecal indicator bacteria counts.

5.1.6. Sediment quality

The total organic content is a measure of the amount of particulate organic matter present in sediment. The organic matter may come from natural sources, such as the decomposing remains of plants and animals, or from anthropogenic sources, such as wastewater. Particulate organic matter is an important food source for many animals, such as benthic invertebrates that live in and on sediment (the infauna and epifauna respectively). If the mass-loading of particulate organic matter in sediment exceeds the rate at which it can be consumed by benthic invertebrate infauna and epifauna or degraded by bacteria, this can lead to the development of very low dissolved oxygen concentrations (hypoxia) or in extreme cases the lack of oxygen (anoxia) in sediment porewater (*i.e.* water between grains of sediment) and at the sediment-water interface. The depletion of dissolved oxygen usually comes about by bacteria that decompose particulate organic matter proliferating to such a degree they consume oxygen in the water at a rate faster than it can be replenished. As the dissolved oxygen concentration falls certain bacteria begin to reduce sulphate from the water column to fuel their metabolism, producing hydrogen sulphide as a by-product. Hydrogen sulphide is toxic to most forms of aquatic life at moderate to high concentrations. However, some bottom-dwelling invertebrates (*e.g.* capitellid polychaetes) thrive under, and their increased abundance is commonly used as an indicator of these conditions (*e.g.* Tomassetti and Porrello, 2005). As the input of particulate organic matter increases from natural to moderate levels the presence of these species demonstrates the transition from an oxic to hypoxic state. As the degree of particulate organic matter accumulation increases further, even sulphide-tolerant invertebrates are unable to survive and the sediment becomes progressively lifeless, until only single celled organisms such as protozoa, ciliates, and flagellates that can live in sulphide-rich sediment remain (Fenchel and Riedl, 1970). This results in the severe disruption of sediment-dwelling communities, with ripple-like impacts through an aquatic ecosystem (Pearson and Rosenberg, 1978; Diaz and Rosenberg, 1995; Gray *et al.*, 2002). The total organic content of sediment thus provides important information towards understanding factors that might influence the structure and composition of benthic biological communities.

Many organic chemicals, such as hydrocarbons, and certain metals, such as cadmium and mercury, also preferentially adsorb (attach) onto particulate organic matter in sediment. The variation in the amount of particulate organic matter can thus often explain trends in the concentration of these chemicals in sediment. Adsorption to particulate organic matter also controls the bioavailability of chemicals, rendering them less toxic than were they to be in an unbound form in the sediment porewater or in the water column.

It is not possible to determine if there is an excess amount of particulate organic matter in sediment by comparing the total organic content amongst sediment samples because particulate organic matter accumulates in sediment in areas where the current strength is weak and is winnowed from sediment in areas where the current strength is strong. The amount of particulate organic matter in sediment will thus vary naturally depending on the prevailing conditions, but in uncontaminated sediment is typically lowest in sandy sediment and highest in muddy sediment. CSIR scientists have defined a baseline model that identifies the range in the total organic content that should be found in relatively uncontaminated sediment in the Port of Port Elizabeth. The baseline model can be used to identify if sediment has a total organic content exceeding the baseline. The baseline model is provided in Figure 29, with the total organic content in sediment sampled in the Port of Port Elizabeth in August 2022 superimposed. If the total organic content falls within the baseline model prediction limits, then the sediment is identified as not enriched with particulate organic matter. If the total organic content exceeds the upper prediction limit of the baseline model (i.e. the upper dashed line), then the sediment is identified as enriched. The total organic content in sediment sampled in some parts of the Port of Port Elizabeth in August 2022 was enriched with particulate organic matter, including at Stations PE1 and PE3 alongside the Old Tug Jetty quay area. In fact, the sediment at these stations was significantly enriched by particulate organic matter. The source of the particulate organic matter is uncertain, but may include fish processing factory wastes as Station PE3 was immediately alongside a offloading and processing area. Interestingly, despite the high total organic content the sediment was not anoxic (see Figure 14). The total organic content of sediment in the port was also analysed for the Long-Term Ecological Monitoring Programme for the period 2015-2019. The findings support those for the sediment analysed in August 2022 and are thus not discussed in detail here.

Many types of anthropogenic chemicals tend to accumulate in sediment rather than remain in solution in the water column. As a result, the concentrations of contaminants in sediment are usually several orders of magnitude higher in sediment than in the water column. If there is continued input, the concentrations of chemicals in sediment may eventually reach a state where they become toxic to sediment-dwelling organisms. Numerous studies on metal concentrations in sediment in the Port of Port Elizabeth have been performed in the last 20 years. The most recent survey was performed by the CSIR in August 2022 (CSIR, unpublished data). Sediment was sampled at 18 stations in the port, including alongside and near the Old Tug Jetty quay area (Figures 12 and 13). The sediment was analysed for its grain size, total organic content, and the concentrations of 15 metals. The toxicity of the sediment was also tested using the sea urchin embryo-larvae test under a sediment-water interface testing regime. The grain size of the sediment was discussed in Section 5.1.4 above. The findings of other studies are not discussed below as they were performed so long ago the findings no longer reflect the contemporary situation (*e.g.* Fatoki and Mathabatha, 2000), while the findings of more recent studies are consistent with the findings for the August 2022 study.

It is not possible to determine if sediment is contaminated by metals by comparing metal concentrations amongst sediment samples because metals occur naturally in sediment and their concentration varies depending on the sediment grain size. To identify if sediment is metal contaminated the factors that control the natural concentrations of metals in sediment must be compensated for before naturally occurring concentrations can be discriminated from potentially anthropogenically enhanced (contaminated) concentrations. CSIR scientists have defined baseline models for 15 metals that identify the range of concentrations for the metals that should be found in relatively uncontaminated sediment in the Port of Port Elizabeth. The baseline models are used in the same way as discussed above for the total organic content baseline model. The baseline models are also used to compute an Enrichment Factor for each metal concentration. An Enrichment Factor indicates how many times a metal concentration is higher than the baseline. An Enrichment Factor <1 means the concentration falls within the baseline range while one that is >1 means the concentration exceeds the baseline and the sediment is referred to as being enriched by the metal. An Enrichment Factor of 2, for example, means a metal concentration is two times higher than the baseline concentration expected in relatively uncontaminated sediment. Metal enrichment does not imply contamination as there are biogeochemical processes that can lead to the natural enrichment of metals in sediment, although this is usually relevant to only a few metals. The higher an Enrichment Factor, the more metals there are enriched in sediment, and the closer enriched sediment is to known or strongly suspected anthropogenic sources of metals the more likely it is the enrichment reflects contamination.

The number of metals that were enriched in sediment at each of 18 stations sampled in the Port of Port Elizabeth in August 2022 (see Figures 12 and 13) is provided in Figure 30. The Enrichment Factors for individual metals in the sediment are provided in Figure 31. The sediment sampled alongside or near the Old Tug Jetty quay area was enriched by the most, or amongst the most metals. The sediment at one or more of these stations was most significantly enriched by cadmium, copper, manganese, and zinc. The implication is that sediment alongside and near the Old Tug Jetty quay area is contaminated by the above metals. These findings can be compared to the findings of surveys for the Long-Term Ecological Monitoring Programme for the Port of Port Elizabeth for the period 2015-2019. The positions of the stations where sediment was sampled for the latter monitoring programme are provided in Figure 32. The Enrichment Factors for individual metals and the number of metals that were enriched in sediment at each station are provided in Figures 33 and 34. The sediment at each station was enriched by at least one metal at some point in the period 2015-2019. The most frequent enrichment was usually at Stations 1, 2, 3, and 7. The magnitude of enrichment, as indicated by the Enrichment Factors, was very low at most stations. The highest magnitude of enrichment for many metals was for sediment sampled at Station 2 near the Old Tug Jetty quay area, while manganese usually presented the highest Enrichment Factors (*i.e.* the most significant metal contaminant of sediment was manganese). Cadmium, copper, manganese, lead, and zinc were always enriched in sediment sampled at Station 2.

There are clearly anthropogenic sources of certain metals in the area near Station 2 and the Old Tug Jetty quay, which probably includes vessel repair operations in the area but also probably the leaching of metals from antifouling coatings on vessel hulls. The loss of manganese ore particles during its loading onto vessels or from the manganese ore storage area in the port clearly accounts for the manganese contamination of sediment.

Sediment sampled between 2015-2019 for the Long-Term Ecological Monitoring Programme for the Port of Port Elizabeth was analysed for a range of organic chemicals and butyltins in addition to metals. Polycyclic aromatic hydrocarbons were found to be nearly ubiquitous in sediment, but the concentrations were usually low (Figure 35). The highest concentrations were found in sediment sampled at Station 2 near the Old Tug Jetty quay area. The sediment at most stations was contaminated by the organochlorine pesticides dieldrin and DDT and its metabolites. Dieldrin was found sporadically in sediment, at a low concentration (Figure 35). DDT and its metabolites (collectively referred to as DDX) were found in the sediment at most stations, but not in each survey. The concentrations were low to moderate (Figure 35). The sediment at each station sampled in the port was contaminated by polychlorinated biphenyls, but not necessarily in each survey (Figure 35). The most significant contamination was found in the northern basin, most notably at Station 9. The sediment sampled at Station 2 near the Old Tug Jetty quay area had amongst the highest total concentrations. Kampire *et al*. (2015) also polychlorinated biphenyls in sediment sampled at each of nine sites in the Port of Port Elizabeth, but at lower concentrations than those reported in Figure 35. However, the findings are not directly comparable since Kampire *et al*. (2015) analysed for a smaller suite of congeners. The sediment sampled at each station for the Long-Term Ecological Monitoring Programme was contaminated by butyltins, but not necessarily in each survey (Figure 35). The most significant contamination, as exemplified by tributyltin, was evident for sediment sampled at Station 2 near the Old Tug Jetty quay area. Tributyltin was historically widely used as the active biocide in antifouling coatings applied to the hulls of vessels and to the surfaces of other submerged manmade structures to limit the growth of marine fauna and flora (a process termed fouling). The use of tributyltin has been banned in most countries. It is probable the butyltin concentrations in sediment sampled at Station 2 reflect the inclusion of antifouling coating flakes sloughed from vessels berthing there or undergoing repairs on the quayside.

The findings for various sediment quality indicators in the Long-Term Ecological Monitoring Programme for the Port of Port Elizabeth were included in a sediment quality index to classify sediment quality in the port for the period 2015-2019. The index classifies sediment quality into five categories, namely excellent, good, fair, marginal, or poor. The sediment quality classification at most stations was variable amongst surveys (Figure 36). At Station 2 near the Old Tug Jetty quay area the sediment quality was classified marginal or poor. It is important to note that the criteria used to classify sediment quality sediment through the index were far more conservative than the sediment quality guidelines used in South Africa or elsewhere in the world (the criteria were one-half the guideline values). If the sediment quality guidelines used in South Africa or elsewhere in the world were included in the index than the sediment quality at most stations would be rated good or excellent, but fair in some surveys for Station 2.

The Department of Forestry, Fisheries and the Environment has defined sediment quality guidelines that it uses to decide if sediment identified for dredging in South African ports is suitable for open water disposal. However, there are only guidelines for metals. There are three guidelines, known as the Warning Level, Level I and Level II. The Warning Level provides a warning of incipient metal contamination but is not used for decision-making. Sediment with metals at a concentration below the Level I is considered suitable for open water disposal. Sediment with metals at a concentration between the Level I and Level II is considered cause for concern, with the degree of concern increasing as the concentrations approach the Level II. Further testing may be requested to determine if metals in the sediment pose a toxic risk to sediment-dwelling organisms, but in practice this has not been implemented. Sediment with metals at a concentration exceeding the Level II is considered unsuitable for open water disposal unless other evidence (*e.g.* toxicity testing) shows the metals are not toxic to sediment-dwelling organisms due, for example, to the metals being present in metal flecks or metal-impregnated paint flakes and the entire concentration thus not being in a bioavailable form.

Three copper and two zinc concentrations in sediment sampled in the Port of Port Elizabeth August 2022 exceeded the Warning Level, in each case at one of the stations alongside or near the Old Tug Jetty quay area (Figure 37). No metal concentrations exceeded the Level I or Level II. These findings suggest there is a low probability that metals in the sediment were adversely affecting sediment-dwelling organisms through toxic effects. The sediment is thus considered suitable for open water disposal. As a point for comparison, no metal concentrations in sediment sampled for the Long-Term Ecological Monitoring Programme for the Port of Port Elizabeth in the period 2015-2019 exceeded the Level I or Level II.

The South African sediment quality guidelines do not provide guidelines for chemicals other than metals. The concentrations of organic chemicals must thus be compared to guidelines used elsewhere in the world. The sediment quality guidelines are like the South African guidelines in that they also define two guidelines, which have a similar narrative intent as the South African Level I and Level II in the context of estimating the likelihood of toxic effects to sediment-dwelling organisms. In two surveys, the total polycyclic aromatic hydrocarbon concentration in sediment sampled at Station 2 near the Old Tug Jetty quay area exceeded the lower of sediment quality guidelines commonly used to estimate the toxicological implications of chemicals in sediment in North American coastal waters, but all concentrations were well below the upper guideline. The DDX concentrations in sediment sampled at numerous stations in several surveys exceeded the lower of two sediment quality guidelines commonly used to assess the potential toxicological significance of these chemicals in sediment in North American coastal waters but were below the upper guideline. The total polychlorinated biphenyl concentration in the sediment sampled at a few stations in several surveys exceeded the lower of two sediment quality guidelines commonly used to assess the potential toxicological significance of these chemicals in sediment in North American coastal waters but were well below the upper guideline. The tributyltin concentrations in sediment sampled at Station 2 near the Old Tug Jetty quay area exceeded the lower, and occasionally the upper of two sediment quality guidelines used to assess the potential toxicological significance of these chemicals in sediment in parts of Europe. The comparison of organic chemical concentrations to sediment quality guidelines thus suggests a possibility for toxic effects to sediment-dwelling organisms.

The concentrations of chemicals in sediment are not a good predictor of toxic effects to sediment-dwelling organisms because contaminants can be complexed to various phases in sediment to a degree that this essentially renders them non-bioavailable and thus unable to exert a toxic effect. It is for this reason that the sediment sampled in the Port of Port Elizabeth in August 2022 was tested for toxicity to sea urchin embryo-larvae, using a sediment-water interface testing regime. The sediment at 13 of the 18 stations was not toxic to sea urchin embryo-larvae (Figure 38). The sediment at four of the remaining five stations was very slightly toxic, and at one station was marginally toxic. The sediment at one station sampled alongside the Old Tug Jetty quay area was very slightly toxic (Figure 38).

5.2. Biological environment

5.2.1. Phytoplankton

van Zyl (2017) sampled the phytoplankton community at seven stations in the Port of Port Elizabeth at monthly intervals for a 14-month period. The phytoplankton community was generally dominated by diatoms. There was no seasonality in phytoplankton abundance. Fewer phytoplankton cells were found in Port of Port Elizabeth compared to stations sampled in the Port of Ngqura, but the number of cells was higher than at station sampled in Algoa Bay.

The CSIR measured chlorophyll-*a* concentrations in the port for the Long-Term Ecological Monitoring Programme for the Port of Port Elizabeth, as discussed above (CSIR, 2016, 2017, 2018, 2019, 2020). Chlorophyll-*a* is used as surrogate for phytoplankton biomass. The chlorophyll-*a* concentration in the Port of Port Elizabeth (see Figure 26) is similar to the range of ~1-6 $\mu g.l^{-1}$ recorded in the western part of Algoa Bay near the Port of Port Elizabeth by Schumann and Campbell (1999) and Campbell (2000). The chlorophyll-*a* concentration is periodically high, showing that on occasion phytoplankton in the port reach bloom status.

5.2.2. Macroalgae

No information on macroalgae in the Port of Port Elizabeth could be found in the scientific or other literature. A visual survey of the port for the purposes of this Environmental Impact Assessment revealed that macroalgae are virtually absent in the area near the Old Tug Jetty quay area and are almost exclusively restricted to floating structures elsewhere in the port (*e.g.* walk-on moorings, yacht hulls), but even in these cases their species diversity, abundance, and growth is sparse. The reason is uncertain but might reflect a high degree of grazing and poor light regimes in the water column. The ports primary production is thus almost exclusively driven by phytoplankton in the water column.

5.2.3. Zooplankton and nektonic invertebrates

No information on zooplankton or nektonic invertebrates in the Port of Port Elizabeth could be found in the scientific or other literature.

5.2.4. Ichthyoplankton

No surveys on ichthyoplankton in the Port of Port Elizabeth could be found in the scientific or other literature.

5.2.5. Sediment benthic invertebrate communities

Benthic macrofaunal communities were analysed in the sediment sampled at 12 stations in the Port of Port Elizabeth in surveys between 2015-2019 for the Long-Term Ecological Monitoring Programme for the Port of Port Elizabeth (CSIR, 2016, 2017, 2018, 2019, 2020). The stations where the sediment was sampled are identical to those where sediment was sampled for physical and chemical analysis (see Figure 32). The fauna were identified to the family level. The station nearest the Old Tug Jetty quay area is Station 2. The benthic macrofaunal community at virtually all stations was dominated by annelid worms, with gastropods and/or ostracods contributing importantly at many stations. An example of the fauna recorded, their abundance, and their contribution to the total abundance is provided for the 2019 survey of the Long-Term Ecological Monitoring Programme in Figures 39 and 40. The abundance, number of taxa, and species diversity of the benthic macrofaunal communities sampled for the period 2015-2019 are provided in Figure 41. As is evident in Figures 39 and 40, there was little difference in the number of taxa recorded and the species diversity amongst stations, but the total abundance varied quite widely amongst surveys at some stations and between certain stations in different surveys. There is thus no clear evidence that the chemical contamination of sediment is of such a magnitude that this is adversely impacting on the benthic macrofauna.

5.2.6. Biological communities on hard substrates

No information on biological communities that colonise hard structures in the Port of Port Elizabeth could be found in the scientific or other literature. Hard structures in the port are encrusted by a range of fauna, including barnacles, mussels, sponges, bryozoans, and ascidians. The encrusting fauna on the sheet pile wall at the Old Tug Jetty is rather depauperate when compared to communities on hard structures elsewhere in the port, but especially when compared to pile on jetties (Figure 42) and on walk-on moorings at the Algoa Bay Yacht Club. The reason the communities are so different is uncertain, but in the case of the sheet pile wall might reflect a toxic impact due to the corrosion of the metal sheet pile or that the fauna prefer not to colonise metal for some other reason.

Loureiro *et al*. (2021) recorded 20 fauna that colonised plastic settlement plates deployed from walk-on moorings at the Algoa Bay Yacht Club in the port, including porifera (sponges), annelid worms, barnacles, bryozoans, and ascidians. Ten of the taxa recorded were identified as alien. Peters *et al*. (2017) recorded a further three alien species in the port by scraping the fauna from hard structures and later identifying them in the laboratory. It is unlikely these studies have documented the total number of alien species that have colonised hard structures (and indeed other habitats) in the port. However, apart from the mussel *Mytilus galloprovincialis* none has become invasive.

5.2.7. Fish

No surveys on fish in the Port of Port Elizabeth could be found in the scientific or other literature. Dicken (2010) sampled the fish community in the pre-operational Port of Ngqura using tackle. Although the Port of Ngqura is relatively far from the Port of Port Elizabeth, some of the fish recorded by Dicken (2010) in the Port of Ngqura could reasonably be expected to frequent the Port of Port Elizabeth. Dicken (2010) recorded 47 species of fish distributed across 27 families, most of which were marine as opposed to estuarine species.

Fish recorded include Cape stumpnose, pufferfish, kob, elf, garrick, subtropical kingfish, and queen mackerel. The study highlighted an unexpected abundance and diversity of shark species in the port, including bronze whalers, hammerheads, various cat sharks, dusky sharks, and gully sharks. The dolosse provided a habitat within which the highest number species were recorded (43 species) in comparison to the quay wall (24 species) and sandy shore (21 species). In terms of abundance the former substrates were equal with the shore habitat being less productive. As stated above, the fish recorded by Dicken (2010) were sampled using tackle. This sampling approach will obviously not sample species that as adults are small, such as gobies, as well as herbivorous fish that are generally not partial to being caught using tackle (*e.g.* several mullet species – only one species was recorded).

Although a fish survey for this Environmental Impact Assessment was not performed since it would have had to be destructive in type (*i.e.* through netting or using fish toxins), two large rays were observed from a walk-on mooring at the Algoa Bay Yacht Club near the Old Tug Jetty quay area. Juvenile and post-larval fish were also evident alongside some hard structures in the port, showing the port does play a nursery role. Discussions with the skippers of small vessels in the port revealed that rays are common in this part of the port. Sharks are also known to frequent the port, but the species could not be verified. A spotted grunter Please diwas observed in the area where the Baakens River flows into the port and these fish might be quite common in the port considering they target burrowing prawns whose burrows were evident in this area.

5.2.8. Marine reptiles

No information on marine reptiles (*e.g.* turtles) in the Port of Port Elizabeth could be found in the literature. Turtles are known to enter the port, but the species are uncertain and are not regularly sighted (Peter Deyzel, personal communication).

5.2.9. Birds

No information on birds in the Port of Port Elizabeth could be found in the scientific or other literature. During the field survey for this Environmental Impact Assessment a number of birds were observed in the port, although not near the Old Tug Jetty quay area. The birds included Cape cormorants, Kelp gulls, terns, and a heron. Of these, Kelp gulls were by the most common. African penguins reportedly periodically enter the port, although not often (Peter Deyzel, personal communication).

5.2.10. Marine mammals

No surveys on marine mammals in the in the Port of Port Elizabeth could be found in the scientific or other literature. Dolphins are known to enter the port but are not regularly sighted (Peter Deyzel, personal communication).

5.3. Dredged spoil disposal site in Algoa Bay

Phase 1 and Phase 2 of the proposed project require the dredging of sediment near the Old Tug Jetty quay area. The scope of the dredging works has not been finalised. The dredged sediment will be disposed at a registered dredged spoil disposal site in Algoa Bay.

Currents at and near the dredged spoil disposal site are probably weak on average. Schumann *et al*. (2005) recorded an average current velocity at 12 m depth ~1 km off the Papenkuils River mouth inshore of the dredged spoil disposal site of ~0.04 $m.s^{-1}$ and an apparent maximum velocity of ~0.15 $m.s^{-1}$. Calm conditions (<0.01 $m.s^{-1}$) occurred about 9.5% of the time. The currents were found to largely flow parallel to the coast (north-south), with the dominant flow to the north. However, Schumann *et al*. (2005) also reference the findings of another study in the same area that showed a largely southerly current flow. It should, however, be noted that current measurements were made for a short period of 46 days and probably do not reflect the trend for currents through the year. However, the weak current speeds are consistent with the higher mud fraction present in sediment in the sheltered western part of Algoa Bay, including at the dredged spoil disposal site.

The CSIR sampled sediment at three stations on the dredged spoil disposal site and at two stations nearby in 2017 (Figure 43). The sediment at each station was dominated by fine-grained sand, with the next most dominant grain size class being medium-grained sand. Mud was interestingly poorly represented, contributing ≤1.4% at all stations (Table 3). The currents at the dredged spoil disposal site are thus strong enough to winnow mud from dredged sediment disposed at the site. The total organic content of the sediment was low and fell within the range for a baseline model defined for the Port of Port Elizabeth (Table 3). The sediment at two stations, one on the dredged spoil disposal site and one nearby was very slightly enriched by manganese but not other metals (Figure 44). In comparison, the sediment at 15 of the 18 stations sampled in the Port of Port Elizabeth on the same date was enriched by one to five metals, although in most cases only by one metal (Figure 44). The concentrations of polycyclic aromatic hydrocarbons analysed in the sediment from each station were below the method detection limit. In comparison, polycyclic aromatic hydrocarbons were found in sediment at each station sampled in the Port of Port Elizabeth at the same time. The sediment on and near the dredged soil disposal site was thus minimally contaminated by chemicals, which probably reflects the erosion and dispersion of contaminated dredged sediment from the site by currents over time.

There is no information on biological communities at and near the dredged spoil disposal site. Masikane (2011) investigated the structure and composition of benthic macrofaunal communities at the 10 m water column depth at six stations in Algoa Bay, one of which was situated off the Papenkuils River inshore of the dredged spoil disposal site. Masikane (2011) performed two surveys at these stations, one in 2008 and another in 2009. The sediment at the Papenkuils River station was found to be comprised of a higher fine-grained fraction and to have a higher total organic content compared to other stations. In both surveys the benthic macrofaunal community at the Papenkuils River station was dominated by polychaetes, followed either by amphipods or bivalves. Decapoda were also an important component of the community. In contrast, the benthic macrofaunal community at other stations was dominated by amphipods. Masikane (2011) concluded that the primary factor influencing the difference in the community structure and composition at the Papenkuils River station compared to other stations was the discharge of effluent from the river. Many species of polychaete worms are known to tolerate and in some cases flourish in areas influenced by effluent discharge.

5.4. Recreational use

The Port of Port Elizabeth is home to sailing and ski boat (fishing) clubs. The ski boat and sailing clubs also have restaurants and bar facilities that overlook the port. There is also a popular seafood restaurant that overlooks the mouth of the Baakens River.

6. Assessment of Environmental Impacts

6.1. Impact assessment procedure

The approach outlined below was followed to rate the significance of environmental impacts that could or will occur during the construction and operational phases of the proposed project. As stated elsewhere, impacts associated with the decommissioning phase of the proposed project were not considered.

The typical approach for rating the significance of identified environmental impacts in South Africa is to assign scores to criteria (*e.g.* duration, spatial extent) that are used to rate an impacts significance. A scoring approach has several limitations and was not followed strictly in this assessment. For example, a disturbance might occur over the long period, but its effect might be a negligible change from the baseline with little consequence on ecological receptors and processes. Conversely, a disturbance might occur over a short period, but if it coincides with the breeding period of a bird species for example and the effect is to cause the birds to avoid their breeding habitat the consequence may be long-term due to their failure to reproduce. In either case the duration of the impact is assigned a score that does not reflect the consequence of the impact. In this environmental impact assessment the significance rating for identified impacts was thus based on an assessment of the effects and consequences of impacts rather than a formulaic scoring approach.

Status: Environmental impacts were rated in terms of their status – they can either be positive, negative, or neutral:

Definition
Positive: the environment overall will benefit from the impact.
Negative: the environment overall will be adversely affected by the impact.
Neutral: the environment overall not be affected, either negatively or positively by the impact.

Nature of the impact: Environmental impacts were rated in terms of whether they are direct or indirect:

Direct impacts are impacts that are caused directly by the activity and generally occur at the same time and place as the activity. These impacts are usually associated with the construction, operation, or maintenance of an activity and are generally obvious and quantifiable. An example of a direct impact is the loss of a biological communities in sediment by dredging.
Indirect impacts of an activity are changes that may occur because of the activity, but with a degree of separation in time and/or space. These types of impacts thus include potential impacts that do not manifest immediately when the activity is undertaken, or which occur at a different place because of the activity. An example of an indirect impact is the displacement of birds from an area due to noise.

Reversibility of impacts: Environmental impacts were rated in terms of their reversibility, which is the likelihood the affected parameters, resources, or processes will return to the baseline:

Definition
Reversible: the effect is reversible when the impact ends.
Irreversible: the effect will not cease when impact ends or is permanent.

Spatial extent: Potential environmental impacts were rated in terms of the geographical area that might or will be affected:

Definition
Site specific (generally within ~250 m of proposed project site or activity)
Local area (within the confines of the Port of Port Elizabeth, or within a few kilometres of an activity)
Regional (within Algoa Bay)
National (extending over a greater scale than regional, but within South Africa's territorial waters)
International (global)

Duration: Potential environmental impacts were rated in terms of the period during which the impact will be experienced or perceived or that it will take for impacted parameter, resources, or processes to return to the baseline:

Definition
Temporary (<~1 month)
Short-term (~1-6 month)
Medium-term (~6-24 month)
Long-term (~2-5 years)
Permanent (>5 year, or leading to a permanent change)

Intensity: Potential environmental impacts were rated in terms of the anticipated severity of the impact:

Negative Impacts

Definition
Severe: The disturbance will cause a total loss of, or very major alteration to, key elements/features/ of the existing baseline conditions, such that the post-development character, composition and/or attributes will be fundamentally changed and may be lost from the site altogether; and/or loss of a very high proportion of the

known population or range of the element/feature.
High: The disturbance will cause a major loss or major alteration to key elements/features of the existing baseline conditions such that the post-development character, composition and/or attributes will be fundamentally changed; and/or loss of a high proportion of the known population or range of the element/feature.
Moderate: The disturbance will cause a loss or alteration to one or more key elements/features of the existing baseline conditions, such that the post-development character, composition and/or attributes will be partially changed; and/or loss of a moderate proportion of the known population or range of the element/feature.
Low: The disturbance will cause a small shift away from existing baseline conditions. The change arising from the loss/alteration will be discernible, but the underlying character, composition and/or attributes of the existing baseline condition will be similar to pre-development circumstances or patterns; and/or having a minor effect on the known population or range of the element/feature.
Minor: The disturbance will cause a very slight change from the existing baseline condition. The change is barely distinguishable, approximating to the 'no change' situation; and/or having negligible effect on the known population or range of the element/feature.

Positive Impacts

Definition	Score
Potential net improvement in human welfare.	8
Potential to improve environmental quality – air, soil, water. Improved individual livelihoods.	4
Potential to lead to Economic Development.	2
Potential positive change – with no other consequence.	1

Probability: Environmental impacts were rated in terms of the probability of occurring:

Definition
Highly Unlikely (highly unlikely to occur but theoretically possible).
Unlikely (unlikely to occur, but a not negligible probability).
Possible (less likely than not to occur, but still appreciable).
Probable (likely to occur).
Definite (unavoidable impact that will occur).

Confidence: The degree of confidence in the ratings was assessed as:

Low
Medium
High

Impact significance rating: The significance rating for impacts was determined by a combination of the above impact characteristics.

Significance Rating	Significance Rating
These impacts will result in such large (usually permanent and irreversible) changes and/or occur over such large areas and/or affect very sensitive natural resources they constitute a fatal flaw unless mitigated by a change in the project scope. The impacts are thus critical to the decision-making process.	Fatally flawed
The impacts will result in major alteration to the environment even with the implementation of appropriate mitigation and are highly relevant to decision-making. These impacts tend to occur at the longer term or wider spatial scale, or at a high intensity compared to other impacts.	High
The impact will result in moderate alteration of the environment and can be reduced or avoided by appropriate mitigation and will only have an influence on the decision-making if not mitigated. These impacts tend to occur at the medium-term or are significant at the local scale.	Medium
The impact may result in minor alterations of the environment and can be easily avoided by implementing appropriate mitigation and will not have an important influence on decision-making. These impacts tend to be short term or temporary and/or occur at site-specific or local scale.	Low
The impact may result in very minor alterations of the environment and can be avoided through the implementation of mitigation, but does not necessarily require mitigation.	Very Low

Mitigation of impacts

- Where negative impacts are identified, mitigation to avoid, prevent, or reduce the impacts are recommended. Where no mitigation is possible or required this is stated. It must be noted that several details for the proposed project are yet to be finalised, including the final engineering design and construction and dredging methods. The recommended mitigation should thus be expanded upon as necessary in an Environmental Management Programme Report that should be formulated for the project, when these details are finalised.
- Where positive impacts are identified, measures are provided to potentially enhance positive impacts.
- The significance of impacts is assessed both before and after the implementation of recommended mitigation. The scenario "without mitigation" considers all management actions already proposed as part of the project description. "With mitigation" assesses the significance rating of the impact considering any additional recommended management actions.

Cumulative effects

Cumulative effects refer to effects of past, present, or reasonably foreseeable future projects or activities that could have an incremental effect via the same pathway and could, therefore, result in a change of greater of lesser significance than the significance of effects assessed for the proposed project in isolation. For example, the proposed project and another project might both generate noise that will disturb birds, leading to a greater or wider scale disturbance of birds in the area.

Monitoring of the impacts

Monitoring measures are recommended for identified impacts when considered necessary.

6.2. Assumptions and limitations

The Environmental Impact Assessment process is not a precise science and relies on the expertise and experience of impact assessors and specialist scientists. A measure of professional judgement is thus involved in assessing the significance of identified impacts associated with an activity. It is assumed the professional judgement of the specialist scientist that assessed the significance of identified impacts is valid.

The emphasis of the Environmental Impact Assessment process is on identifying and assessing 'significant' impacts. It is not possible to identify and assess all impacts that might arise from a proposed project. It is assumed the identified impacts and the assessment of their significance addresses more complex interactions in the environment that might arise because of an impact but are not specifically discussed or assessed.

At this stage several components of the proposed project have not yet been finalised, including:

- A detailed engineering design.
- A detailed geotechnical survey.
- A detailed method of construction, including how often vibratory versus percussive piling will be used, how often drilling will be performed during piling, whether support vessels will be used, the degree of concrete mixing onsite, and the extent of demolition of existing structures that will be required to allow the project to proceed.
- A detailed contractor site plan, including where hazardous and construction materials will be stored and handled.
- The spatial extent of the dredging footprint, the method of dredging, and the method of dredged sediment disposal.

Much of the above information and detail will probably only be finalised shortly before the proposed project is implemented. In the absence of a final engineering design, construction site plan, and methods of construction it is assumed the impacts identified and assessed cover the range of possible scenarios that might arise due to the proposed project.

There is a limited amount of information for some components of the affected physical and biological environment in the Port of Port Elizabeth. It is assumed the specialist's assessment of impacts that might affect these components of the affected environment are valid.

It is assumed the mitigation measures identified are reasonable, feasible, and will be implemented, or that adequate and effective alternate mitigation that might be identified will be implemented, and that the implementation of mitigation will enhance the significance of positive impacts and limit the significance of negative impacts as intended and assumed.

It is assumed that any significant changes made to the proposed project will be communicated to the CSIR to allow for the reassessment of impacts, should this be necessary.

6.3. Impacts screened from further assessment

Several environmental impacts that might or will arise as a result of the proposed project were not assessed, including:

- Impacts to environmental processes or resources that do not directly affect the Port of Port Elizabeth or Algoa Bay. For example, the need to dispose of construction and demolition waste will impact on landfills by reducing their useful life and may result in an increase in the volume of traffic and possible road congestion. However, these impacts were not considered as the focus is on the Port of Port Elizabeth and dredged spoil disposal site in Algoa Bay.
- The impact of artificial light on ecological processes was not considered because there is already considerable artificial lighting in the proposed project area and the proposed project is not anticipated to lead to a significant increase in artificial lighting.
- Impacts of the proposed project on tourism and recreational use of the Port of Port Elizabeth were not assessed.
- There is a possibility the disposal of dredged sediment at the dredged spoil disposal site in Algoa Bay could indirectly impact on a bivalve aquaculture operation near the Port of Port Elizabeth. However, this seems unlikely as dredged sediment has been disposed for many years at the dredged spoil disposal site with no apparent impact attributed to the disposal. Other sources of disturbance nearer the aquaculture site probably have a greater impact on the aquaculture operation, meaning it will be impossible to separate these impacts from those associated with dredged sediment disposal.
- There is a possibility that dredging vessels could strike dolphins or whales on their way to and from the dredged spoil disposal site in Algoa Bay. However, this seems unlikely as no reports of dolphins and whales being impacted by dredging vessels between the port and dredged spoil disposal site appear to have been reported in the past.

6.2. Impact identification, description, and assessment

6.2.1. Construction phase impacts

1. Impacts due to the ingress of non-hazardous solid waste into the port

Construction for the proposed project will generate non-hazardous solid waste that, if not properly managed, will enter the aquatic environment in the Port of Port Elizabeth and pose an environmental risk. Plastic and other solid waste that washes up on estuary and marine shorelines and floats in water is also unsightly and affects tourism and recreation. Especially problematic from an environmental perspective is the ingress of non-biodegradable waste into aquatic ecosystems, such as plastic bottles, plastic bags, plastic food wrappers, polystyrene food containers, plastic strapping tape, and synthetic rope and cord. Plastic and small items of solid waste are often light enough to be blown by wind or washed by surface (rain) runoff into aquatic ecosystems. Plastic and other low density solid waste does not immediately sink to the bottom and can be transported over extremely large distances by ocean currents. The spatial extent of the impacts caused by solid waste are thus potentially international. Floating plastic waste, including small plastic particles, can be mistaken for food and be ingested by marine mammals, seabirds, sea turtles, fish, and invertebrates. The ingestion of solid waste can have a variety of adverse effects on fauna, including but not limited to ulceration or laceration in the digestive tract leading to infection or internal bleeding, blockage of the digestive tract resulting in reduced nutrient uptake, and retention of ingested waste and reduction of the urge to feed (NOAA Marine Debris Program, 2014a; 2016). Marine fauna can also become entangled in solid waste, which can reduce the swimming and feeding abilities of the fauna and may result in injury or mortality (NOAA Marine Debris Program, 2014b). Solid waste also provides a site for the attachment of encrusting (fouling) fauna (*e.g.* barnacles) that can potentially be transported in this way to and colonise areas well outside their natural range, where they may become invasive (Lewis *et al*., 2005; Allsopp *et al.*, 2006; Gregory, 2009; NOAA Marine Debris Program, 2017). Plastic also leaches constituent chemicals as it breaks down, such as plasticisers, which can present a toxic risk to fauna and flora (Thompson *et al*., 2009). Plastic waste that sinks to the bottom can smother benthic habitat, causing the death of or displacing invertebrate fauna and flora.

Responsible construction companies generally implement measures to limit the release of solid waste from their construction sites into the surrounding environment. It is nevertheless **probable** that non-hazardous solid waste will enter the Port of Port Elizabeth without effective waste management at the proposed construction site. The amount would probably be quite small, but the implications (intensity) of non-hazardous waste in the marine environment is potentially **high** because it can pose a risk to threatened, vulnerable and endangered species. The potential for non-hazardous solid waste to enter the port will persist for the duration of construction (*i.e.* medium term), but many forms of non-hazardous solid waste (such as plastic items) are essentially non-biodegradable (or at least take a very long time to degrade) and may be transported over very large distances by ocean currents. The extent of this impact is thus potentially **international** and the duration **permanent** (or at least long-term). This impact is thus largely **irreversible**. The significance rating for this impact without mitigation is thus **HIGH**.

Impact assessment without mitigation					
Impact	Impacts due to the ingress of non-hazardous solid waste into the port				
Status	Positive		Negative		
	The ingress of non-hazardous solid waste into the estuary will lead to a deterioration in habitat quality and will adversely affect biological communities.				
Nature	Direct	Indirect	Reversible	Irreversible	
	The ingress of non-hazardous solid waste into the port will lead directly to a deterioration in habitat quality. The deterioration in habitat quality will indirectly adversely affect biological communities. The impact is irreversible because it will be impossible to recover non-hazardous solid waste that enters the port and sinks to the bottom or that is rapidly dispersed by currents. Furthermore, plastic items are essentially non-biodegradable and will continue to pose a risk for an extended period.				
Extent	Site specific	Local	Regional	National	International
	The impact potentially has an international spatial extent because solid waste could be dispersed from the port by currents and may then be transported over very large distances in the marine environment.				
Duration	Temporary	Short-Term	Medium-Term	Long-Term	Permanent
	The impact is essentially permanent because some forms of solid waste, such as plastic litter, takes a very long time (decades) to degrade in the aquatic environment and will thus continue to pose a risk for an extended period.				
Intensity	Minor	Low	Moderate	High	Severe
	Non-hazardous waste in the marine environment can pose a risk to threatened, vulnerable, and endangered species, and the intensity is thus high.				
Probability	Highly Unlikely	Unlikely	Possible	Probable	Definite
	Non-hazardous solid waste will probably enter the port in the absence of effective waste management.				
Confidence	Low	Medium	High		

	The confidence that non-hazardous solid waste will enter the port in the absence of effective waste management is high.				
Significance	Very Low	Low	Medium	High	Fatally flawed

Mitigation

Recommended mitigation for this impact is outlined below. The personal experience of the CSIR scientist that prepared this report is that litter arising from some construction sites does escape into and impact on the environment, even if mitigation is implemented. This is because the mitigation is not always effective and because upset conditions not considered when planning and implementing mitigation do occur. Furthermore, construction personnel fail to appreciate the significance that non-hazardous solid waste poses in aquatic environments and thus simply do not take adequate measures to avoid its ingress into these systems. However, with mitigation it should be possible to reduce the probability of non-hazardous solid waste entering the port from probable to unlikely. The intensity will nevertheless remain high since even a small amount of non-hazardous waste can have an impact on threatened, vulnerable and endangered species. The significance rating for this impact with mitigation is thus **LOW**.

Impact assessment with mitigation					
Impact	Impacts due to the ingress of non-hazardous solid waste into the port				
Mitigation	• The construction contractor must provide comprehensive and compulsory environmental awareness training for the site workforce. The training must sensitise construction personnel to the negative environmental impacts of non-hazardous solid waste (especially plastic waste) on the marine environment and the consequent need to limit the ingress of such waste into the port. Environmental awareness training should be ongoing through the life of the project for the workforce involved in the project since inception and must be provided to contractor personnel appointed and brought onsite after project inception (*e.g.* sub-contractors). • A reduce, reuse, recycle waste philosophy should be followed at the construction site. • The intentional disposal of non-hazardous solid waste into the port must be strictly prohibited. Procedures to remove personnel from site if they have received environmental awareness training yet intentionally dispose of non-hazardous solid waste into the port should be formulated, and if necessary, implemented. • Construction personnel must be encouraged to collect plastic litter and other non-hazardous solid waste they see in the construction area, even if it does not originate from the construction site. • If necessary, litter sweeps should be carried out across the construction site. • If non-hazardous solid waste from the construction site enters the port this must be recovered immediately where practicable. This might be difficult from the quayside, but pool cleaning nets can be used for this purpose if a construction support vessel is available. • Onsite temporary storage areas for non-hazardous solid waste must be clearly demarcated, signposted, and maintained. These should ideally be situated as far as practicable from the water's edge. • Bins, skips, and/or other receptacles for the temporary storage of non-hazardous solid waste must be sealed and secured to avoid them becoming a source of litter in the port, noting the proposed project area is often characterised by gale force winds that can blow plastic and other light non-hazardous solid waste from unsealed receptacles, and can blow light waste receptacles over. • Non-hazardous solid waste receptacles must be vermin proof. • Non-hazardous solid waste must be regularly removed from the construction site and disposed at a registered waste disposal site in accordance with national and local waste legislation, using a licensed waste disposal contractor. The waste contractor must provide proof the waste was disposed at a registered waste disposal site. The contractor should keep such records onsite for the benefit of an Environmental Control Officer. • Non-hazardous solid waste receptacles must not be washed onsite unless the wash water is captured and disposed to sewer. The washing water must not be allowed to enter surface runoff channels or stormwater drains as these will flow to the port.				
Nature	Direct	Indirect	Reversible	Irreversible	
Extent	Site specific	Local	Regional	National	International
Duration	Temporary	Short-Term	Medium-Term	Long-Term	Permanent

Intensity	Minor	Low	Moderate	High	Severe
Probability	Highly Unlikely	Unlikely	Possible	Probable	Definite
Confidence	Low		Medium		High
Significance	Very Low	Low	Medium	High	Fatally flawed

Potential for cumulative effects

The ingress of non-hazardous solid waste into the port by construction activities will add to the burden of such solid waste entering the port from the surrounding urban area, including via the Baakens River. It is, however, not possible to assess of the significance of this possible cumulative effect as the amount of waste entering the port is unknown.

Recommended monitoring

The construction Site Manager, appointed independent Environmental Control Officer, and/or the local Transnet National Ports Authority environmental specialist must audit the construction site against the mitigation recommended above and/or that which is included in an Environmental Management Programme Report prepared by the contractor or an appointed consultant and approved by Transnet National Ports Authority, by regularly (ideally daily in the case of the Site Manager or nominated representative) walking through the construction site. If there is evidence for litter or other solid waste entering the port the procedures, checks, and controls in the Environmental Management Programme Report should be reviewed and revised to eliminate the source of litter or any other solid waste entering the port.

2. Environmental deterioration due to spillages from portable toilets

Sanitation facilities will obviously be required for use by construction personnel. It is assumed the contractor will provide portable sanitation facilities, but if reasonable access to existing facilities in the area is possible this would be preferred. If portable sanitation facilities are provided onsite there is the possibility these might leak or overflow and faecal material and chemicals used in the toilets might find their way into the estuary, either directly or via surface (stormwater) runoff. The chemicals used in these toilets are toxic to aquatic biological communities.

It is **possible** waste from portable toilets could reach the port with no mitigation. The possibility will persist for the duration of construction, but a spill or leak from a toilet at any time would have a **temporary** impact as the toxic chemicals and other waste would be diluted and dispersed quite rapidly and adverse impacts would thus be limited to a small area. The spatial extent is thus **site-specific** and the intensity **low**. This impact is fully **reversible** as any waste that might reach the estuary would degrade over time. The significance rating for this impact without mitigation is thus **VERY LOW**.

Impact assessment without mitigation					
Impact	Environmental deterioration due to spillages from portable toilets				
Status	Positive		Negative		
	The ingress of waste from portable toilets into the port will lead to a deterioration in water and sediment quality that will in turn negatively affect biological communities.				
Nature	Direct	Indirect	Reversible	Irreversible	
	The ingress of waste from portable toilets will lead directly to a deterioration in water and sediment quality that will indirectly adversely affect biological communities. The impact is reversible because toxic chemicals used in portable toilets will disperse, dilute, and degrade in the estuary.				
Extent	Site specific	Local	Regional	National	International
	The impact is site-specific because any waste from portable toilets that does enter the port will invariably be dispersed and diluted to non-toxic concentrations within a short distance from the site of entry.				
Duration	Temporary	Short-Term	Medium-Term	Long-Term	Permanent
	The spillage of waste from portable toilets could occur throughout the construction period. The possible acute toxicity of portable toilet waste in the estuary would, however, occur over a 'very short' timescale as the waste will invariably be rapidly dispersed and diluted to non-				

	toxic concentrations in the water column. The duration is thus temporary.				
Intensity	Minor	Low	Moderate	High	Severe
	The intensity is moderate because the chemicals used in portable toilets are toxic to aquatic biological communities.				
Probability	Highly Unlikely	Unlikely	Possible	Probable	Definite
	The ingress of portable toilet waste into the port is unlikely as these toilets are generally properly sited and regularly cleaned on well managed construction sites. It is also unlikely that any toilet waste that did enter the port would have a significant impact on ecological processes.				
Confidence	Low		Medium		High
	The confidence that portable toilet waste is unlikely to enter the port nor to have a significant impact on water and sediment quality and hence on ecological processes should it do so is high.				
Significance	Very Low	Low	Medium	High	Fatally flawed

Mitigation

No mitigation is required considering the **VERY LOW** significance rating for this impact. However, it is good practice to implement mitigation to further reduce the potential for and implications of environmental impacts. Recommended mitigation for this impact is outlined below. With appropriate mitigation the potential for this impact can virtually be eliminated. The significance rating for this impact with mitigation remains **VERY LOW**.

Impact assessment with mitigation					
Impact	Environmental deterioration due to spillages from portable toilets				
Mitigation	• Portable toilets must be maintained in a good, clean condition. • Portable toilets must be regularly checked for signs of leaks. Should a leak be found a sorbent material must be used to contain and absorb the waste. The portable toilet should be removed and replaced as soon as is practically possible and the sorbent material used to clean the leaked waste must be treated as hazardous waste and disposed accordingly. • Portable toilets must be placed in areas where there is little possibility of them being toppled over by the gale force winds that are common in the proposed project area. If necessary, portable toilets must be secured to the ground to avoid them being toppled over by wind or any other cause. • Portable toilets must be placed in areas where there is little possibility of potential leaks or overflows reaching the port. Portable toilets should not be positioned near surface (stormwater) runoff drains or surface water drainage areas as these will inevitably lead to the port. If these controls are not possible then portable toilets must have secondary containment. • Portable toilet waste must be regularly removed from site by a licensed waste disposal contractor and disposed at a permitted wastewater treatment works. The waste disposal contractor must provide proof of that the waste was disposed at a registered wastewater treatment works. The contractor should keep such records onsite. • If other forms of temporary sanitary facilities are provided onsite, such as showers, the water must either be adequately contained in storage devices until it can be removed from the site or these must be connected to the existing sewer infrastructure.				
Nature	Direct	Indirect	Reversible	Irreversible	
Extent	Site specific	Local	Regional	National	International
Duration	Temporary	Short-Term	Medium-Term	Long-Term	Permanent
Intensity	Minor	Low	Moderate	High	Severe
Probability	Highly Unlikely	Unlikely	Possible	Probable	Definite
Confidence	Low		Medium		High
Significance	Very Low	Low	Medium	High	Fatally flawed

Potential for cumulative effects

The ingress of waste from portable toilets to the port would add to the burden of contaminants entering the port from the surrounding urban area and port activities.

Recommended monitoring

The construction Site Manager (or nominated representative), appointed independent Environmental Control Officer, and/or the local Transnet National Ports Authority environmental specialist must audit the construction site against mitigation identified above and/or that which is included in an Environmental Management Programme Report that is prepared by the contractor or an appointed consultant and is approved by Transnet National Ports Authority, by regularly (ideally daily in the case of the Site Manager or nominated representative) walking through the construction site. It is strongly recommended that all parties routinely take photographs of the construction site to document the occurrence or absence of leaks from portable toilets on the site.

3. Impacts to soil, sediment, and geology

The Port of Port Elizabeth is underlain by Quaternary alluvial sand, gravel, cobbles, and boulders. This material is underlain, at depth, by the Peninsula Formation of the Table Mountain Group. According to Le Roux (2000), the Ordovician-aged Peninsula Formation consists of light grey, medium- to course-grained quartzite with minor lenticular shale layers. The quartzite is typically well bedded. Deposition of the Peninsula Formation is believed to have occurred on a shallow marine shelf. No large faulting is known to occur in the area.

The sub-surface geology in the construction footprint is unknown, but geotechnical surveys for the recently completed leading jetties rehabilitation project near the Old Tug Jetty quay area provides an understanding of the possible geology in the construction footprint. Jeffares and Green (2015) drilled six boreholes to depths of -23.00 to -35.30 m relative to mean sea level in the leading jetties area. Alluvium/fill dominated all boreholes and was mainly comprised of sub-angular to rounded gravel, cobbles, and minor boulders of quartzitic sandstone and gravelly sand. Alluvial, silty clay was encountered in part of one borehole. None of the boreholes terminated in rock, which can be attributed to the Port of Port Elizabeth being underlain by an alluvial/fill deposit of considerable thickness.

The proposed project will lead to the permanent loss or disturbance of sediment and rock in the construction footprints. The disturbance and loss will occur through piling and projection of the new quay area ~6 m further into the port than the current sheet pile wall. Other geological resources may be disturbed and removed from site during the rehabilitation of the sheet pile wall or for piling for the deck-on-pile structure. Geological material will be brought onsite for the Old Tug Jetty sheet pile wall rehabilitation and deck-on-pile structure construction and will alter the existing soil and sediment composition. Sediment will be removed by dredging. The surface sediment on the port bottom in the construction footprints is not of a high ecological value because on its rarity as similar material is present elsewhere in the port, and it has no apparent commercial value. The area of geological material that will be lost is small in the context of similar material in the wider port area. The proposed dredging will not substantially or adversely modify unique geological or physical features within the port, not will the disposal of dredged sediment nor at the dredged spoil disposal site in Algoa Bay.The proposed construction works are unlikely to lead to geological instability in the area, nor to seismic activity, based on similar works during the rehabilitation of the leading jetties to the north of the proposed project site not causing such effects. It must, however, be reiterated that nothing is known about the sub-surface geology in the construction footprint and this impact might need to be re-assessed when the findings of geotechnical surveys are available.

Geological material in the construction footprints will thus be impacted by dredging and construction. However, the intensity will be **minor** as little material will be disturbed or lost and the material has no commercial value. The impact will be **site-specific**. Although the impact to some geological resources will be **permanent** as they will be covered the significance rating for this impact without mitigation is **VERY LOW**.

Impact assessment without mitigation

Impact	Impacts to soil, sediment, and geology				
Status	Positive		Negative		
	The disturbance and loss of geological resources is negative.				
Nature	Direct	Indirect	Reversible	Irreversible	
	Geological resources will be directly impacted. The impact is irreversible because the rehabilitated quay will be designed for a 50-year service life, and some resources will be removed from the port.				
Extent	Site specific	Local	Regional	National	International
	The impact is site specific because the impacted geological resources will be restricted to the construction footprint or dredged spoil disposal site.				
Duration	Temporary	Short-Term	Medium-Term	Long-Term	Permanent
	The impact to some geological resources will be permanent.				
Intensity	Minor	Low	Moderate	High	Severe
	The intensity is minor because the impacted geological material has no special value.				
Probability	Highly Unlikely	Unlikely	Possible	Probable	Definite
	Geological resources will be impacted. However, this is highly unlikely to have any significant effect biophysical processes.				
Confidence	Low	Medium	High		
	The confidence that geological material will be impacted is high.				
Significance	Very Low	Low	Medium	High	Fatally flawed

Mitigation

No mitigation is required considering the **VERY LOW** significance rating for this impact. However, it is good practice to implement mitigation to further reduce the potential for and implications of environmental impacts. Recommended mitigation for this impact is outlined below. With appropriate mitigation the potential for this impact can virtually be eliminated. The significance rating for this impact with mitigation remains **VERY LOW**.

Impact assessment with mitigation					
Impact	Impacts to soil, sediment, and geology				
Mitigation	As little geological material should be removed or brought onto the construction site as possible, and the geological material disturbed should be restricted to the minimum.				
Nature	Direct	Indirect	Reversible	Irreversible	
Extent	Site specific	Local	Regional	National	International
Duration	Temporary	Short-Term	Medium-Term	Long-Term	Permanent
Intensity	Minor	Low	Moderate	High	Severe
Probability	Highly Unlikely	Unlikely	Possible	Probable	Definite
Confidence	Low	Medium	High		
Significance	Very Low	Low	Medium	High	Fatally flawed

Potential for cumulative effects

None.

Recommended monitoring

This impact should be re-assessed based on the findings of planned geotechnical surveys in the project area, particularly in relation to piling.

4. Deterioration in water and sediment quality due to hazardous material spills and leaks

The proposed rehabilitation of the Old Tug Jetty quay area in Phase 1 and the construction of a deck-on-pile extension of the quay area in Phase 2 will require the operation and use of construction machinery, equipment, and vehicles, and the delivery of construction materials to the site by vehicle (road). Some of the construction machinery and equipment will be operated in and over water in the Port of Port Elizabeth. There is a risk the machinery, equipment, and vehicles may leak oil, hydraulic fluids, and fuel amongst other potential hazardous materials, for the accidental spillage of these same materials during the refuelling or emergency repairs to machinery, equipment, and vehicles, and for a spill through a loss of onsite containment. The hazardous materials could enter the estuary directly if there is a leak on machinery and equipment that is operated in or over water or near the water's edge, or indirectly if hazardous materials are spilled or leaked onto hard surfaces such as the quay apron and then drain directly into the estuary or are washed from hard surfaces by surface (rainfall) runoff. Leaks and spills of hazardous materials could also occur during the operation of dredgers and construction support vessels. If there is a fire onsite and the fire is doused using firefighting equipment the resultant waste will represent hazardous material that could enter the port if not properly contained and cleaned up.

Hazardous materials are so denoted because they are toxic to aquatic biological communities and thus pose an environmental risk if they enter aquatic ecosystems (in addition to presenting human health risks). The magnitude of impacts arising from hazardous material spills and leaks will depend on the nature and amount of the material released. These impacts can be acute if a 'large' amount of a hazardous material, or a particularly hazardous material enters a waterbody, resulting in the mortality of organisms and in so doing disrupting ecological processes (Hutchinson *et al.*, 2013; Wenger *et al*., 2017). Alternately, or in addition, the impact may be chronic, wherein a hazardous material affects the physiology of organisms over an extended period while accumulating in their tissue, in this way allowing contaminants to also pass through the wider ecosystem (Oleksiak, 2008; Hamilton *et al*., 2017). The larval and juvenile stages of aquatic fauna and reproductive propagules of aquatic flora are especially sensitive to contaminants and usually require a lower dosage for adverse effects to occur than adults (Costa *et al*., 2011; Limburg and Waldman, 2009; Wenger *et al*., 2017). Contamination can also affect primary production by aquatic flora, the availability of oxygen since the breakdown of chemicals is usually an oxygen demanding process, and the health of microbial communities (Lee and Lin, 2013).

It is thus **probable** hazardous materials will be spilled or leaked at the construction site for the proposed project since hydraulic lines on machinery fails from time to time and multiple refuelling events or other maintenance of vehicles and equipment, for example, increases the probability of human error. However, these are in the main likely to be small volume leaks and spills that can be adequately contained and cleaned up if they occur on land and are unlikely to have a major impact on water and sediment quality and associated biological communities in the Port of Port Elizabeth. Oil and fuel leaks during the normal operation dredging and construction support vessels are also probable, but these too are likely to release a small volume of hazardous materials into the port. Here, however, it will be impossible, or at least very difficult to retrieve and clean-up the leaked material, although these spills are also unlikely to have a major impact on water and sediment quality and associated biological communities in the port. A major spill of hazardous material is possible and would have a more significant and widespread impact on water and sediment quality in the port and potentially beyond without adequate management, and hence to affect biological communities at a **local** scale with a **high** intensity. The impact on the water column will occur over the short-term as the spilled or leaked hazardous material will dissipate due to dispersion, dilution, and degradation. However, if the hazardous material accumulates in sediment the effect may be longer lasting (years) since various biogeochemical processes can delay the degradation of hazardous chemical compounds in sediment, with the result the duration could be **long-term**. Indeed it is because of these differences in degradation that certain contaminants may be found in sediment but not in the overlying water. The impact is fully **reversible** as the hazardous materials will degrade with time, even if this may occur of a considerable period. The significance rating for this impact without mitigation is thus **HIGH**.

Impact assessment without mitigation		
Impact	Deterioration in water and sediment quality due to hazardous material spills and leaks	
Status	Positive	Negative
	The ingress of hazardous materials into the port will lead to a deterioration in water and	

	sediment quality that will in turn negatively affect biological communities.				
Nature	Direct	Indirect	Reversible	Irreversible	
	The ingress of hazardous materials will lead to a direct deterioration in water and sediment quality in the port and will indirectly adversely affect biological communities. The impact is reversible because the hazardous materials will disperse, dilute, and degrade over time.				
Extent	Site specific	Local	Regional	National	International
	The impact of most hazardous material spills and leaks that affect the port will be restricted to the immediate area of the proposed construction site. A significant volume hazardous material spill or leak could, however, affect a larger area if not quickly contained and cleaned up. The potential extent of this impact is thus local (and potentially regional).				
Duration	Temporary	Short-Term	Medium-Term	Long-Term	Permanent
	The impact of small volume hazardous materials introduced to the port would occur over a 'very short' timescale as the hazardous materials would be diluted, dispersed, and degraded in the water column. However, a significant volume hazardous material spill or leak would result in longer lasting impacts, especially if the material accumulated in sediment. The duration is thus long-term.				
Intensity	Minor	Low	Moderate	High	Severe
	The intensity of most spills and leaks will probably be minor. However, without appropriate mitigation a significant volume hazardous material spill or leak could have a more significant impact on water and sediment quality and biological communities in the port, and the intensity is thus high.				
Probability	Highly Unlikely	Unlikely	Possible	Probable	Definite
	It is probable spilled and leaked hazardous materials will enter the port without mitigation.				
Confidence	Low	Medium	High		
	The confidence that hazardous material spills and leaks will probably occur without mitigation and that these will affect water and sediment quality in the port is high as spills and leaks are inevitable at construction sites.				
Significance	Very Low	Low	Medium	High	Fatally flawed

Mitigation

Recommended mitigation for this impact is outlined below. The personal experience of the CSIR scientist that prepared this report is that spills and leaks of large volumes of hazardous materials at construction sites in ports that go on to affect large areas of the aquatic environment are rare. Implementing appropriate mitigation can reduce the probability of a major hazardous material spill or leak affecting the estuary to **highly unlikely** but will not eliminate the probability for small volume leaks and spills. Appropriate mitigation will also reduce the spatial extent, duration, and intensity to **site specific**, **short-term** (and probably temporary), and **minor**. The significance rating for this impact with mitigation is thus **VERY LOW**.

Impact assessment with mitigation	
Impact	Deterioration in water and sediment quality due to hazardous material spills and leaks
Mitigation	General • A Hazardous Material Spill Response and Contingency Plan must be developed by the Contractor/s. • The Hazardous Material Spill Response and Contingency Plan must identify appropriate response procedures in the event of a hazardous material spill on land and in water. The plan must provide specific responses for spills of different types of hazardous materials that may be handled onsite. • Hazardous materials must be stored and handled in accordance with appropriate legislation and standards, including the Hazardous Substances Act (Act No. 15 of 1973) and Occupational Health and Safety Act (No. 85 of 1993). • Hazardous material spills and leaks must be reported immediately. The contractor personnel to whom a spill or leak must be reported must be outlined in the Hazardous Material Spill Response and Contingency Plan. The plan must also outline subsequent lines of reporting as deemed necessary (*e.g.* Transnet National Ports Authority, relevant authorities). • Spill containment and clean-up kits must be readily available onsite in areas where there is a risk of a hazardous material spill or leak and must be appropriate to the type of possible

	spill or leak. • Responsible and trained personnel must be available to deal with hazardous material spills and leaks. Training/drills must be implemented to enable personnel to respond appropriately to hazardous material spills and leaks. • Appropriate methods for the disposal of cleaned up spilled material and clean-up materials must be identified in the Hazardous Material Spill Response and Contingency Plan – this material must not be disposed with 'normal' waste but rather at an appropriately licensed waste disposal site. • The intentional disposal of hazardous materials into the port or into stormwater drains and surface drainage channels is strictly prohibited. Procedures to remove contractor personnel from site if they have received environmental awareness training yet are observed intentionally disposing of hazardous waste into the port or into stormwater or other drainage channels that lead to the estuary should be formulated, and if necessary, implemented. Construction personnel must be educated that stormwater drains lead to aquatic ecosystems, and in the case of the construction site for the proposed project these will lead to the port. • All construction personnel must receive comprehensive environmental awareness training and must be sensitised to the negative environmental impacts of hazardous material spills and leaks on the environment. Environmental awareness training must be ongoing through the life of the project. • Only authorised and trained personnel must be allowed to handle hazardous materials. Landside • Develop a site drainage plan that shows the positions of sewers, surface drainage channels, and stormwater drains, including where the channels and drains flow into the port. • Only authorised and trained personnel must be allowed to refuel or lubricate construction machinery, equipment, and vehicles, and to perform emergency repairs of machinery, equipment, and vehicles onsite. Refuelling of construction machinery, equipment, and vehicles, and emergency repairs of the same onsite must take place in areas demarcated for this purpose. These areas must be as far as practically possible from the edge of the estuary, on hard topped (impermeable) surfaces, and must include measures to prevent the migration of possibly spilled or leaked hazardous material from the area (*e.g.* bunding, drip trays). If construction machinery and equipment cannot be easily removed for refuelling but this must be down from a bowser, a drip tray must be used to capture any spillage that might occur. • No routine maintenance (servicing) of construction machinery, equipment, and vehicles should be performed onsite. However, it is recognised that it might not be possible to easily move certain construction machinery and equipment that might require emergency repairs to a dedicated repair site (*e.g.* pile driving machinery). In this case emergency repairs should be allowed onsite, but the contractor and Transnet National Ports Authority must reach agreement in this regard. • Construction machinery, equipment, and vehicles must be properly maintained and regularly checked for leaks of hazardous materials. No vehicles should be allowed onsite if they have visible leaks, including the vehicles of suppliers. • Hydraulically operated machinery should ideally use a synthetic biodegradable hydraulic oil. • Hazardous material storage containers must be labelled, sealed, and stored in accordance with Material Safety Data Sheet requirements. • Only authorised and trained personnel must be allowed access to areas where hazardous materials are stored or used. Personnel with responsibilities for the use, handling, and storage of hazardous materials must be provided with competency training and environment, health, and safety training. The training should enable the personnel to perform their tasks efficiently without resulting in any contamination, as well as knowing the appropriate actions to take in response to an emergency (*e.g.* fire) or spill incidents. • All hazardous materials must be stored with adequate spill protection (bunding) in secured (locked) and covered areas to prevent wash-off of hazardous material by rainfall/surface runoff as far as is practicable (fuel bowsers, for example, might need to be stored in the open). Secondary containment (including bunding) must be appropriate

to the volume and nature of the hazardous material being stored but should at a minimum be ≥110% of the volume of the stored material. The base and bund walls must be impermeable to the material stored and of adequate capacity.

- Hazardous materials storage and handling areas should not be positioned near surface (stormwater) runoff drains or surface water drainage areas as these will lead to the estuary. If this is impossible, stormwater drains must have protection facilities.
- The volume of hazardous materials stored onsite should be kept to the minimum practicable.
- A register/inventory of chemical and hazardous materials stored/used on-site should be maintained and regularly updated.
- Construction machinery, equipment, and vehicles must not be washed onsite unless this is unavoidable, and measures are in place to retain and then remove the wash liquid (*e.g.* in conservancy tanks).
- Photographic records of hard surfaces should be maintained to provide an Environmental Control Officer (if required) with evidence that hazardous material spills and leaks have not occurred, or if they did occur were properly contained and cleaned.
- Sufficient, marked receptacles for the disposal of hazardous waste, such as oily rags, sorbent material used to clean up spills, and so must be present onsite.

<u>Waterside</u>

- Construction vessels must be properly maintained and regularly checked for leaks of hazardous materials.
- Emergency equipment to contain spills on water must be easily accessible, including floating booms.
- Fuel tanks of small vessels should not be refilled onboard, but at a dedicated site on land.

Nature	**Direct**	**Indirect**	**Reversible**	Irreversible	
Extent	**Site specific**	Local	Regional	National	International
Duration	Temporary	**Short-Term**	Medium-Term	Long-Term	Permanent
Intensity	**Minor**	Low	Moderate	High	Severe
Probability	Highly Unlikely	**Unlikely**	Possible	Probable	Definite
Confidence	Low	Medium	**High**		
Significance	**Very Low**	Low	Medium	High	Fatally flawed

Potential for cumulative effects

The ingress of hazardous materials to the port will add to the burden of contaminants entering the port from the surrounding urban area and port operations. However, with effective mitigation the additional impact posed by spilled and leaked hazardous materials should be minimal.

Recommended monitoring

The construction Site Manager (or nominated representative), appointed independent Environmental Control Officer, and/or the local Transnet National Ports Authority environmental specialist must audit the construction site against mitigation identified above and/or that which is included in an Environmental Management Programme Report that is prepared by the contractor or an appointed consultant and is approved by Transnet National Ports Authority, by regularly (ideally daily in the case of the Site Manager or nominated representative) walking through the construction site. Audits must determine if spills and leaks were reported, if proper clean-up was followed in the event of a spill or leak, and that the clean-up materials were disposed appropriately. It is strongly recommended that all parties routinely take photographs of the construction site to document the occurrence or absence of hazardous material spills and leaks, and the effectiveness of clean-up in the event of a spill or leak.

5. Ecological impacts due to the spillage of construction material and demolition debris into the port

There is the potential for various types of solid construction material and debris to be spilled into the port during construction of the counterfort wall in Phase 1 and deck-on-pile structure in Phase 2. This could include concrete debris generated during the removal of quay furniture and the breaking of the quay apron, and solid granular material used for backfilling the area between the new counterfort wall and existing sheet pile wall. Pre-cast concrete beams will be used for the various parts of the quay rehabilitation and construction of the deck-on-pile structure. However, liquid concrete will be poured over the top to bind the concrete elements together before grouting. Debris will also be removed from the tubular piles for concrete to be poured into the pile casings. There is thus the potential for wet cement and grout to be spilled into the port.

The spilled solid material will alter the physical properties of the benthic habitat, changing it from a sediment dominated one to a mixed sediment and gravel/stone type habitat. The change may impact on fauna that preferentially live in and on sediment, to the extent they may be excluded. For example, if the benthic habitat is transformed from a sediment to a gravel type habitat, burrowing animals will not be able to burrow through the material. Stones, gravel, and other hard objects spilled into the port could also crush or injure delicate benthic invertebrate epifauna when they impact the bottom. Small stones, gravel, and other solid objects will also be buffeted along the bottom by vessel propeller wash and in this way may physically damage invertebrate epifauna, although this is more likely to occur only after construction ceases since no vessels will be allowed to use Old Tug Jetty quay area during the construction period. Small stones, gravel, and other solid objects that can be buffeted in this way will probably be gradually removed over time by maintenance dredging.

Fresh concrete, cement, and grout are highly alkaline and corrosive. The excessive spillage of cementitious material and grout into the port could adversely affect biological communities by impairing water quality, most notably by altering (increasing) the pH well above that of the baseline (Fitch, 2003). The cement will harden over time and will alter the physical properties of sediment in the same way as spilled stones and solid construction debris.

Construction activities will thus **probably** introduce construction material, demolition waste, and cementitious material into the port without mitigation. The material will affect the immediate area of construction activities and is thus **site specific**. It is unlikely the spilled material will be retrieved and the impact is thus **irreversible**, noting that some of the material will be removed by future maintenance dredging depending on its size. In Phase 1, benthic biological communities will be significantly impacted by dredging, counterfort wall unit placement, and scour protection rock placement in the area immediately alongside the Old Tug Jetty sheet pile wall where such losses of material would occur. Similarly for Phase 2, benthic biological communities will already have been significantly impacted by dredging and scour protection rock placement in the area immediately alongside the deck-on-pile structure where such losses of material would occur. This impact will thus be **temporary** in duration and of a **minor** intensity, resulting in a **VERY LOW** significance rating without mitigation.

<table>
<tr><th colspan="11">Impact assessment without mitigation</th></tr>
<tr><td>Impact</td><td colspan="10">Ecological impacts due to the spillage of construction material and demolition debris into the port</td></tr>
<tr><td>Status</td><td colspan="5">Positive</td><td colspan="5">Negative</td></tr>
<tr><td></td><td colspan="10">Spilled construction material or demolition debris will bury or crush benthic biological communities or cause other potential adverse environmental impacts.</td></tr>
<tr><td>Nature</td><td colspan="3">Direct</td><td colspan="2">Indirect</td><td colspan="3">Reversible</td><td colspan="2">Irreversible</td></tr>
<tr><td></td><td colspan="10">Spilled construction material or demolition debris will directly alter the nature of the substrate and in this way will indirectly impact on benthic biological communities. The impact is reversible because some of the material will probably be removed by maintenance dredging or will be covered by sediment if it is of a small size over time.</td></tr>
<tr><td>Extent</td><td colspan="2">Site specific</td><td colspan="2">Local</td><td colspan="2">Regional</td><td colspan="2">National</td><td colspan="2">International</td></tr>
<tr><td></td><td colspan="10">The impact is site specific because construction materials and demolition debris is unlikely to</td></tr>
</table>

	affect an area of more than a few meters from construction activities.				
Duration	Temporary	Short-Term	Medium-Term	Long-Term	Permanent
	The impact will temporary because the spilled material will be covered by scour protection rock.				
Intensity	Minor	Low	Moderate	High	Severe
	The intensity is minor because benthic biological communities near the Old Tug Jetty sheet pile wall or near the deck-on-pile construction area will already have been impacted by dredging and will in time also be impacted by scour protection rock placement.				
Probability	Highly Unlikely	Unlikely	Possible	Probable	Definite
	Construction activities will probably lead to the loss of construction material and demolition debris into the port, and this will probably impact on benthic biological communities, if only to a minor degree.				
Confidence	Low		Medium		High
	The confidence in this assessment is high.				
Significance	Very Low	Low	Medium	High	Fatally flawed

Mitigation

No mitigation is required considering the **VERY LOW** significance rating for this impact. Mitigation that is implemented will in any case have little effect considering scour protection rock will be placed onto the areas where construction material and demolition waste will most likely be spilled and accumulate. Nevertheless, it is good practice to implement mitigation to further reduce the potential for and implications of environmental impacts. Recommended mitigation is thus outlined below. Mitigation should be relatively easy for some construction activities but difficult for others. The significance rating of this impact with mitigation thus remains **VERY LOW**.

Impact assessment with mitigation	
Impact	Ecological impacts due to the spillage of construction material and demolition debris into the port
Mitigation	• During demolition alongside and over water, structurally adequate debris shields should be used where practicable to contain debris and prevent it from entering the water. • The intentional disposal if construction material and waste into the port must be strictly prohibited. Any construction material and waste spilled onto the quay apron must not be swept into the port but must be recovered and disposed at an appropriate waste disposal site by a licensed contractor. • Implement appropriate controls to minimise wind and surface runoff erosion of construction materials stored onsite, including soil and other fine-grained materials. If erosion from construction material stockpiles onsite becomes a problem, then these must be covered. • Where practicable and possible, minimise the amount of construction materials stored onsite that can be easily mobilised or eroded by wind and rain. • Where practicable and possible, store stockpiles of construction materials that can be easily mobilised or eroded by wind and rain as far from the water's edge as possible. • Where practicable and possible, and without unduly delaying the project, the handling of construction materials that can be easily mobilised by wind (such as soil) should be avoided when the wind speed is excessive. • Fresh concrete and cement are highly alkaline and corrosive and can cause significant water and sediment quality impairment. The use of wet concrete and cement near, over, and in the port thus requires careful control to minimise the risk of spillage. Wherever possible, pre-cast concrete structural elements should be used. • Concrete and cement batching should ideally not occur at the construction site but concrete and cement should rather be delivered in ready-mix form. It is, however, acknowledged that some batching will probably be required at the construction site. • If concrete is poured with a concrete pump, ensure that hoses and couplings are sealed and secured. • Concrete forms or tubular piles must not be filled to overflowing. • Concrete should ideally not be poured when the weather is adverse. • For concrete placed under water, fast-setting concrete should be used to limit losses from shuttering and to minimise the period over which impacts can occur. • Concrete forms must be properly sealed to prevent the loss of concrete into the port. • Concrete mixing and pouring equipment must not be washed onsite unless this

	unavoidable. In these instances the wash water must be collected in a dedicated wastewater collection system and disposed of appropriately.				
Nature	Direct	Indirect		Reversible	Irreversible
Extent	Site specific	Local	Regional	National	International
Duration	Temporary	Short-Term	Medium-Term	Long-Term	Permanent
Intensity	Minor	Low	Moderate	High	Severe
Probability	Highly Unlikely	Unlikely	Possible	Probable	Definite
Confidence	Low		Medium		High
Significance	Very Low	Low	Medium	High	Fatally flawed

Potential for cumulative effects

None.

Required monitoring

None.

6. Deterioration in water quality due to increased suspended sediment concentrations and turbidity caused of construction activities

Several (non-dredging) construction activities required for the rehabilitation of the Old Tug Jetty have the potential to or will impact on water quality, and in this way biological communities, by disturbing sediment and causing an increase in the suspended sediment concentration and associated turbidity in the water column in the Port of Port Elizabeth. These activities include, but are not limited to:

Phase 1: Counterfort wall

- Site establishment.
- Removal of scour rock protection.
- Removal of existing concrete superstructure in the quay area.
- Placing a filter fabric on top of rock fill and along vertical extents of the existing sheet pile wall.
- Placing of a stone bed layer.
- Removal of the existing quay furniture and demolish existing structures that obstruct the new works.
- Placing of counterfort units.
- Installing scour rock protection on top of the counterfort wall toe.
- Backfilling the counterfort wall with quarry run.
- Placing of filter fabric on top of the quarry run backfill.
- Undertake pavement layer works.
- Install civil services and quay furniture.

Phase 2: Deck on pile structure

- Partial decommissioning of Old Tug Jetty counterfort wall.
- Site establishment.
- Removal of quay furniture.
- Piling.
- Deck installation

Some of the existing scour rock protection for the sheet pile wall will need to be removed before quay wall construction and this will mobilise sediment into the water column. After dredging (dealt with as a separate impact) a stone bed layer will be placed on the bottom to act as a foundation for the counterfort wall. This will mobilise sediment into the water column if the stones are dropped rather than placed onto the bottom, although even in the latter case sediment can be expected to be mobilised. The stones may also have soil and dust particles adhering to them that will be 'washed' from the surface when dropped or placed in water.

A filter fabric will be placed onto the stone layer, and this will inevitably mobilise sediment into the water column when it is moved into place along the bottom. The placing of counterfort units will displace and mobilise sediment into the water column. After the counterfort wall is in place scour rock protection will be placed at its toe. This will mobilise sediment into the water column in the same way as the placing of the stone bed layer.

The counterfort wall will be constructed in front of, but not directly connected to the existing sheet pile wall. The area between the counterfort wall and existing sheet pile wall will be backfilled with a granular material. It is inevitable that during backfilling dust and soil particles adhering to the fill material will be released by as it is dropped into the area between the counterfort and sheet pile wall. This material will enter the port and contribute to the suspended solids concentration.

The existing quay apron concrete superstructure needs to be removed. This will require the breaking, cutting, and crushing of concrete and will lead to the generation of highly alkaline fine-grained cementitious dust and that will enter the port and contribute to the suspended solids concentration. It will also expose fill material that might be blown by wind or carried by surface (rain) runoff into the port. Similarly, quay furniture, including bollards, fenders, and ladders, will need to be removed from the quays to allow construction to proceed. This will also require the breaking, cutting, and crushing of concrete and will also lead to the generation of highly alkaline fine-grained cementitious dust and that will enter the port and contribute to the suspended solids concentration.

In Phase 2 piling will be required for the deck-on-pile structure. Piling creates shockwaves that mobilise fine-grained sediment into the water column.

Construction materials that might be blown by wind or eroded by rain/surface runoff will be stored temporarily onsite, such as backfill material, soil, cementitious material, and so on. The surface of the quay area is impermeable, which will heighten the potential for the wash off of these materials by rainfall/surface runoff. There is a high probability some of this material will be blown by wind into the estuary from storage areas and during handling near the water's edge.

An increase in the suspended sediment concentration and turbidity in the water column in an aquatic ecosystem above the baseline can have numerous adverse effects on biological communities. In general, the higher the concentration of suspended sediment and the longer the period of exposure above the baseline the greater the risk of adverse effects (Berry *et al*., 2003; Wenger *et al*., 2018). Many aquatic biological communities, including those in ports, can tolerate relatively short intense increases in the suspended solids concentration such as might occur during a high river discharge event associated with rainfall, but will be adversely affected if the increase is prolonged. Fish and invertebrates that live in, on, or near sediment are generally more tolerant of suspended sediment exposure than their pelagic counterparts given their natural association with sediment and the sediment-water interface, where the suspended concentration is naturally higher on average than in the water column (Sherk *et al*., 1974; Noggle, 1978; Wilber and Clarke, 2001; Berry *et al*., 2003). Fish and other mobile fauna can escape areas of high suspended sediment concentrations, but slow moving or sessile invertebrates cannot. An increase in the suspended sediment concentration and turbidity in the water column can affect the ability of fish that hunt by sight to capture their prey, affecting their foraging success or leading to a shift in their foraging strategy (Breitburg, 1988; Hecht and van der Lingen, 1992; de Jonge *et al*., 1993; Wilber and Clarke, 2001; Utne-Palm, 2002; De Robertis *et al*., 2003; Hedrick *et al*., 2006; Johansen and Jones, 2013; Wenger *et al*., 2017). The avoidance of areas of high suspended sediment concentration restricts access to normal foraging areas (Collin and Hart, 2015; Wenger *et al*., 2017). Excessive suspended sediment concentrations can clog or physically damage the feeding and respiratory organs (*e.g.* gills) of invertebrates and fish (Servizi and Martens, 1987; Kerr, 1995; Bash *et al*., 2001; Wilber and Clarke, 2001; Hess *et al*., 2015) with implications for respiratory ability, nitrogenous excretion, and ion exchange (Appleby and Scarratt, 1989; Wong, *et al*., 2013). The size of fish gills is proportional to their size, meaning the spaces between gill lamellae are smaller in larvae and juveniles. It is, therefore, likely that suspended sediment will more easily clog the gills and reduce their efficiency in smaller fish and larvae than in adult fish (Appleby and Scarratt, 1989). The eggs and larvae, and juvenile stages of fish are indeed generally more susceptible to suspended sediment than adult stages (Engell-Sørensen and Skyt, 2001; Wenger *et al*., 2017). Excessive suspended sediment concentrations can reduce the fitness and in extreme cases the survival of filter feeding invertebrates (*e.g.* mussels) that must process large amounts of sediment that is poor in organic material, causing them to use more energy than can be replaced by food intake (Widdows *et al*., 1979; Essink and Bos, 1985). Suspended sediment can also cause 'shading' that affects photosynthesis in micro- and macroalgae (Fredette and French, 2004; Wenger *et al*., 2017).

Certain construction activities for the proposed project, as discussed above, will disturb sediment, or will introduce soil and dust into the port and in this way will increase the suspended solids concentration and turbidity in the water column above the baseline. The sediment alongside the Old Tug Jetty quay area is comprised of a large amount of fine-grained material (mud) that is easily mobilised into the water column. Coarse heavy particles of sand will fall (back) to the bottom quickly (within seconds) near the point of disturbance or introduction. Fine-grained particles, such as silt and clay, have a low fall velocity and will in contrast remain in suspension for longer (hours to possibly days for very fine-grained material) and will be dispersed over a wider area depending on prevailing currents. The fine-grained sediment will eventually deposit in areas where and when the current is weakest (*e.g.* slack tide). Some of the fine-grained material could be re-mobilised by currents and be dispersed further on subsequent tides or when the current increases in strength for some other reason. Nevertheless, it is unlikely a significant amount of suspended sediment will be dispersed over a wide area and the increase in suspended sediment concentrations and turbidity is anticipated to be **site specific**. The biological communities in the Old Tug Jetty quay area, including those that have colonised quay walls and piles on deck-on-pile structures nearby, are undoubtedly habituated to periodically elevated suspended sediment concentrations and turbidity caused by vessel propeller wash and dredging. There are no known fauna and flora in the project area that are of special ecological, commercial, or social significance. Pelagic species and life stages will continue to use unaffected parts of the water column during construction. Construction will only occur during daylight hours. The increase in suspended sediment concentrations and turbidity will thus be intermittent, providing a measure of relief as the suspended sediment will disperse and settle from the water column between construction days. It is also important to consider that dredging and the removal of scour rock protection for Phase 1 will already have caused high suspended sediment concentrations and turbidity in the water column prior to other construction activities for this phase. The intensity of this impact is thus assessed as **minor** and the duration **temporary**. The impact is fully **reversible** as the mobilisation of sediment will cease when construction ceases. The significance rating for this impact is thus **VERY LOW**.

Impact assessment without mitigation					
Impact	Deterioration in water quality due to increased suspended sediment concentrations and turbidity caused of construction activities				
Status	Positive		Negative		
	An in increase in the suspended sediment concentration and turbidity above the baseline will negatively impact on water quality and in this way will negatively impact on biological communities.				
Nature	Direct	Indirect	Reversible	Irreversible	
	An increase in the suspended sediment concentration and turbidity above the baseline will directly impact on water quality. The impaired water quality will indirectly impact on biological communities. The impact is fully reversible since the mobilisation of sediment will cease when construction ceases.				
Extent	Site specific	Local	Regional	National	International
	An increase in suspended sediment concentrations and turbidity above the baseline is anticipated to be largely restricted to the area near construction activities.				

Duration	Temporary	Short-Term	Medium-Term	Long-Term	Permanent
	Increased suspended sediment concentrations and turbidity will dissipate after construction ceases on each day. The impact will thus be temporary.				
Intensity	Minor	Low	Moderate	High	Severe
	The intensity is anticipated to be minor because biological communities near the proposed project area are likely habituated to periodic increases in suspended sediment concentrations and turbidity above the baseline, and there are no fauna and flora of special ecological, commercial, or social significance in the immediate proposed project area. Furthermore, the amount of suspended sediment that is anticipated to be mobilised into suspension is small.				
Probability	Highly Unlikely	Unlikely	Possible	Probable	Definite
	Construction activities will increase the suspended sediment concentration and turbidity in the water column above the baseline. However, this is unlikely to have a major impact on water quality and on biological communities.				
Confidence	Low		Medium		High
	The confidence in this assessment is high.				
Significance	Very Low	Low	Medium	High	Fatally flawed

Mitigation

No mitigation is required considering the **VERY LOW** significance rating for this impact. However, it is good practice to implement mitigation to further reduce the potential for and implications of environmental impacts. Recommended mitigation for this impact is thus outlined below. Several details for the proposed project are yet to be finalised. The recommended mitigation should thus be expanded on in the Environmental Management Programme Report formulated for the project when these details are finalised. A sheet pile bund or coffer dam should ideally be placed around the project area to limit the release of fine-grained materials that will increase the suspended sediment concentration and turbidity in the port, but it is acknowledged that this might not be practicable for various reasons and, importantly, is not necessary considering the anticipated low significance rating for this impact. Mitigation of this impact should be relatively easy for some construction activities but difficult for others (*e.g.* piling). If mitigation is implemented the spatial extent and intensity of this impact can be reduced, but this does not alter the significance rating for this impact which thus remains **VERY LOW** with mitigation.

Impact assessment with mitigation	
Impact	Deterioration in water quality due to increased suspended sediment concentrations and turbidity caused of construction activities
Mitigation	• During demolition works over water or near the water's edge, debris shields should ideally be used to contain debris and prevent it entering the water. • The intentional disposal of construction material and waste into the estuary must be strictly prohibited. Any construction material spilled onto the quay apron must not be swept into the water but must be recovered and reused, or must be disposed at an appropriate waste disposal site by a licensed contractor. • During demolition works over water or near the water's edge, debris shields should ideally be used to contain debris and prevent it entering the water. • Where practicable and possible, minimise the amount of construction materials stored onsite that can be easily mobilised or eroded by wind and rain. • Where practicable and possible, store stockpiles of construction materials that can be easily mobilised or eroded by wind and rain as far from the estuary edge as possible, and on level ground. Stockpiles of construction materials must not be stored near surface runoff (stormwater) drains or surface runoff drainage channels. • If losses from construction material stockpiles onsite become a problem, these must be covered with a tarpaulin or similar fabric. • Where practicable and possible, and without unduly delaying the project, the handling of construction materials that can be easily mobilised by wind (such as soil) should be avoided when the wind speed is excessive or during heavy rainfall. • If increases in suspended sediment concentrations are observed to be more frequent and wide ranging in spatial extent than predicted, construction methods must be reviewed to

	identify areas for improvement to prevent this occurrence.				
Nature	Direct	Indirect	Reversible	Irreversible	
Extent	Site specific	Local	Regional	National	International
Duration	Temporary	Short-Term	Medium-Term	Long-Term	Permanent
Intensity	Minor	Low	Moderate	High	Severe
Probability	Highly Unlikely	Unlikely	Possible	Probable	Definite
Confidence	Low	Medium	High		
Significance	Very Low	Low	Medium	High	Fatally flawed

Potential for cumulative effects

The proposed project will coincide with the berthing and de-berthing of vessels in the port. The proposed project may coincide with maintenance dredging in the port. There is a possibility that sediment mobilised by vessel propeller wash and maintenance dredging will magnify the impact of increased suspended sediment concentrations and turbidity due to construction activities for the proposed project, and *vice versa*, because vessel movements and dredging will occur very near the proposed project area. However, the cumulative impact will probably not be highly significant considering the small amount of sediment that is anticipated to be mobilised into the water column by construction activities. To mitigate this potential cumulative effect construction for the proposed project and maintenance dredging in the port should be scheduled so they do not overlap, although this is not a necessity considering the significance rating for the impact without mitigation.

Recommended monitoring

The construction Site Manager, appointed independent Environmental Control Officer, and/or the local Transnet National Ports Authority environmental specialist must verify through observations from the quay wall that construction activities are not resulting in such intense and large plumes of suspended sediment in the port that these are clearly visible from the water surface and are causing a marked increase in suspended sediment concentrations over a large area. If this is the case, the construction method/s should be reviewed to identify areas for improvement to ensure sediment is not excessively mobilised into the water column.

If construction for the proposed project coincides with water quality surveys for the Long-Term Ecological Monitoring Programme for the Port of Port Elizabeth then the turbidity of the water column could be measured at stations positioned along a gradient from very near to distant from the construction activities to provide a measure of the validity of the impact significance rating.

7. Ecological impacts due to the deposition of sediment mobilised and introduced into the water column by construction activities

The same construction activities that have the potential to directly impact on water quality and indirectly on biological communities by causing an increase in the suspended sediment concentration and turbidity in the water column (see Impact 6) will result in the deposition of suspended sediment beyond the area of disturbance or introduction. Areas of the port bottom that are directly and indirectly affected by construction activities will thus be impacted by the deposition of suspended sediment. Coarse heavy particles of sand will fall (back) to the bottom quickly (within seconds) near the point of disturbance or introduction. Fine-grained particles, such as silt and clay, have a low fall velocity and will remain in suspension for longer (hours to possibly days for very fine-grained material) and will be dispersed over a wider area depending on prevailing currents. The fine-grained sediment will eventually deposit in areas where and when the current is weakest (*e.g.* slack tide). Some of the fine-grained material could be re-mobilised by currents and be dispersed further on subsequent tides or when the current increases in strength for some other reason.

The excessive deposition of sediment can bury, smother, and crush biological communities, including benthic invertebrate infauna and poorly mobile, sessile, or sedentary epifauna, the eggs of invertebrates and fish that develop on the bottom, and in extreme cases can lead to the complete loss of benthic ecology (Miller *et al*., 2002). Most benthic invertebrate infauna live in the top 10 cm of sediment and rely on a connection (*e.g.* burrows) to the sediment-water interface for ventilation (respiration) and feeding. The 'excessive' deposition of fine-grained sediment (mud) on sandy sediment can lead to the clogging of the spaces between sand grains, displacing the fauna that live between the sand grains or retarding the exchange of oxygen with the overlying water, leading to the suffocation of benthic invertebrate fauna. Frequent repositioning to maintain a relative distance to the sediment-water interface, or the need by burrowing organisms to increase maintenance to prevent the infilling of burrows, requires that organisms shift their energy allotment from other functions, such as growth or reproduction. If the deposited sediment has a different grain size to the sediment existing before deposition it may alter the physical properties of the sediment, which can impact on bottom-dwelling fauna that prefer to live in or on sediment of a fairly specific grain size because of their need to maintain an open burrow or because of their mode of feeding, for example (Holland *et al*., 2005; Smit *et al.*, 2006; Smit *et al.*, 2008; Boon and Dalfsen, 2022). The deposition of muddy sediment on sandy sediment is generally more problematic than the reverse (Diaz and Boesch, 1977; Boon and Dalfsen, 2022). Many benthic invertebrate infauna and epifauna can migrate upwards through deposited sediment and may be relatively unimpacted by sediment deposition within reasonable limits (Maurer *et al.* 1979, 1981a, 1981b, 1982, 1986; Fredette and French, 2004; Wilber *et al*., 2007). Maurer *et al.* (1979) found that some benthic invertebrates can migrate through as much as 30 cm of deposited sediment, but other invertebrates are less tolerant of burial and smothering and may be significantly affected by even a thin layer of deposited sediment (Schaffner, 1993; Wilber and Clarke, 2007; Hendrick *et al*., 2016). The consequence of these impacts is usually an altered species diversity, abundance, and biomass of benthic invertebrate infauna and epifauna (Bolam and Rees, 2003; Bolam *et al*., 2011; Bolam *et al*., 2021), with attendant impacts to other ecosystem processes (*e.g.* fish that rely on invertebrates in the affected area as a food resource will be deprived of this resource). Biota will colonise areas where sediment has been deposited, and will recover to a species composition, abundance, and biomass comparable to that which existed before deposition provided the physical properties of the sediment are not immeasurably different as a consequence of the deposition. Depending on the intensity of sediment deposition, recolonisation may start immediately, but the recovery of benthic invertebrate communities to a comparable species composition, abundance, and biomass to that which existed before sediment deposition will take longer.

Benthic biological communities in the port area of the Port of Port Elizabeth are undoubtedly habituated to, and thus tolerant of a certain amount of sediment deposition since sediment (particularly the fine-grained fraction) in this area is regularly mobilised into suspension by vessel propeller wash and periodically by maintenance dredging (see Figures 22 and 23). Most of the sediment mobilised by these activities can reasonably be expected to settle on the port bottom, although an insignificant amount might be exported to the adjacent marine environment depending on the tidal state. Ports are known sediment depositional environments due to the usually weak currents that characterise these waters. Indeed, it is the introduced sediment and calm conditions that accounts for the need to periodically maintenance dredge the port. As discussed above, many benthic invertebrate infauna and epifauna are able to migrate through an appreciable depth of deposited sediment, although the smothering of less mobile forms and newly settled juveniles may be too much for them to tolerate and will lead their mortality. The volume of sediment that is mobilised into the water column by vessel propeller wash and maintenance dredging will undoubtedly far exceed the volume that will be mobilised into the water column in any day by construction activities. This is because construction of the new quay wall and deck-on-pile structure is likely to proceed sequentially from one end of the quay to the other. This will allow benthic invertebrate infauna and epifauna time to migrate through or otherwise deal with sediment deposited on the bottom between deposition events (which may only last a few days as construction progresses). The sediment mobilised into the water column and then dispersed to settle elsewhere is unlikely to differ substantially in terms of its grain size from bottom sediment in the greater area near the project area. As discussed elsewhere, the sediment in the Port of Port Elizabeth is dominated by mud.

Construction activities will thus mobilise or introduce sediment and dust into the water column. The sediment and dust will settle on the bottom and bury or smother benthic biological communities, with the possible attendant impacts as outlined above. Although fine-grained sediment and dust will probably be dispersed by currents over a fairly wide area, most of the sediment and dust will probably settle on the bottom near the point of disturbance or introduction. The impact is thus **site-specific**. Sediment and dust may be mobilised or introduced into the water column throughout the construction period if not properly controlled, but this will be intermittent and the effects of the deposition on biological communities are for the most part likely to be **temporary** in duration. There appear to be no benthic invertebrate infauna or epifauna in that part of the port most likely to be impacted that are of special ecological, commercial, or social significance, and impacts on other components of the biological community in the estuary that may be indirectly affected, such as through a loss of food resources due to the direct impact, are likely to be insignificant. Benthic biological communities in the area where this impact is most likely are also already disturbed by vessel propeller wash and maintenance dredging and are thus probably habituated to the impact of sediment deposition. Indeed, these communities will be substantially impacted by dredging that will precede the most intense period of construction. It is thus **unlikely** the burial and smothering of benthic biological communities will lead to a substantial loss in ecological productivity. The intensity is thus considered **low**. The impact is fully **reversible** as its potential to occur will cease when construction ceases, and fauna will colonise and migrate through, or otherwise deal with the deposited sediment over time. The significance rating for this impact is thus **VERY LOW**.

Impact assessment without mitigation					
Impact	Ecological impacts due to the deposition of sediment mobilised and introduced into the water column by construction activities				
Status	Positive		Negative		
	The deposition of sediment on the bottom in quantities above the baseline will negatively impact benthic biological communities by burial and smothering, amongst other impacts.				
Nature	Direct	Indirect	Reversible	Irreversible	
	Sediment deposited on the bottom will directly impact benthic biological communities and indirectly impact fauna that use the affected area for food or other resources. The impact is reversible because it will only persist for the construction period, and fauna will colonise or migrate through the deposited sediment.				
Extent	Site specific	Local	Regional	National	International
	Most of the mobilised or introduced sediment and dust will probably settle near the point of disturbance and introduction. The extent is thus site specific.				
Duration	Temporary	Short-Term	Medium-Term	Long-Term	Permanent
	Sediment and dust may be mobilised or introduced into the water column throughout the construction period, but this will be intermittent and the effects of the deposition on biological communities are likely to be temporary in duration.				
Intensity	Minor	Low	Moderate	High	Severe
	The intensity is anticipated to be minor because the deposition of sediment is unlikely to substantially exceed the baseline deposition rate, because benthic biological communities in the project area are undoubtedly habituated to the deposition of suspended sediment on the bottom, and because the benthic biological communities that will be directly impacted are not of special ecological, commercial, or social significance. Impacts on other components of the biological community in the port that may be indirectly affected, such as through a loss of food resources, are likely to be insignificant.				
Probability	Highly Unlikely	Unlikely	Possible	Probable	Definite
	Construction activities will mobilise or introduce sediment and dust into the water column and this will settle on the bottom, but it is unlikely this will have a significant ecological impact.				
Confidence	Low	Medium	High		
	The confidence in this impact assessment is high.				
Significance	Very Low	Low	Medium	High	Fatally flawed

Mitigation

No mitigation is required considering the **VERY LOW** significance rating for this impact. However, it is good practice to implement mitigation to further reduce the potential for and implications of environmental impacts. Recommended mitigation for this impact is thus outlined below. Mitigation should be relatively easy for some construction activities, but difficult or impossible for others (*e.g.* piling). However, with effective mitigation the intensity for this impact can be reduced to minor. The significance rating for this impact after mitigation remains **VERY LOW**.

Impact assessment with mitigation					
Impact	Ecological impacts due to the deposition of sediment mobilised and introduced into the water column by construction activities				
Mitigation	• During demolition over water, construct structurally adequate debris shields to contain debris and prevent it from entering the water. • Implement appropriate controls to minimise wind and surface runoff erosion of construction materials stored onsite, especially soil and other fine-grained materials. • Where practicable and possible, minimise the amount of construction materials stored onsite that can be easily mobilised or eroded by wind and rain. • Where practicable and possible, store stockpiles of construction materials that can be easily mobilised or eroded by wind and rain as far from the water's edge as possible, and on level ground. Stockpiles of construction materials must not be stored near surface runoff (stormwater) drains or surface runoff drainage channels. • Where practicable and possible, and without unduly delaying the project, the handling of construction materials that can be easily mobilised by wind (such as soil) should be avoided when the wind speed is excessive. • If losses from construction material stockpiles onsite become a problem, then these must be covered. • The intentional disposal of construction material and waste into the port must be strictly prohibited. • Any construction material and spilled onto the quay apron must not be swept into the port but recovered and reused, or must be disposed at an appropriate waste disposal site by a licensed contractor. • If increases in suspended sediment concentrations are observed to be more frequent and wide ranging in spatial extent than predicted, construction methods must be reviewed to identify areas for improvement to prevent this occurrence.				
Nature	Direct	Indirect	Reversible	Irreversible	
Extent	Site specific	Local	Regional	National	International
Duration	Temporary	Short-Term	Medium-Term	Long-Term	Permanent
Intensity	Minor	Low	Moderate	High	Severe
Probability	Highly Unlikely	Unlikely	Possible	Probable	Definite
Confidence	Low	Medium	High		
Significance	Very Low	Low	Medium	High	Fatally flawed

Potential for cumulative effects

The proposed project will coincide with the berthing and de-berthing of vessels in the port. The proposed project may coincide with maintenance dredging in the port. There is a probability that sediment mobilised by vessel propeller wash and maintenance dredging will magnify the impact of sediment deposition associated with the proposed project, and *vice versa*, because vessel movements and dredging will occur very near the proposed project area. However, the cumulative impact will probably not be highly significant considering the small volume of sediment that is anticipated to be mobilised or introduced by construction activities. The scheduling of construction for the proposed project and maintenance dredging so they do not overlap will avoid this cumulative impact but this is not a necessity.

Required monitoring

The construction Site Manager, appointed independent Environmental Control Officer, and/or the local

Transnet National Ports Authority environmental specialist must verify through observations from the quay wall that construction activities are not resulting in such large plumes of suspended sediment in the estuary that these are clearly visible from the water surface. If so, the construction method should be reviewed to identify areas for improvement and thus ensure sediment is not excessively mobilised into the water column.

No monitoring is required considering the **VERY LOW** significance rating for this impact. However, if construction coincides with water quality surveys for the Long-Term Ecological Monitoring Programme for the Port of Port Elizabeth, the turbidity of the water column could be measured at stations positioned along a gradient from very near to distant from construction activities to provide a measure of the validity of the impact significance rating. The Long-Term Ecological Monitoring Programme for the Port of Port Elizabeth does not measure suspended sediment (solids) concentrations in the water column, but this could be implemented in such a survey at minimal additional cost as a further measure to validate the impact significance rating. Furthermore, if construction coincides with sediment quality surveys for the Long-Term Ecological Monitoring Programme for the Port of Port Elizabeth, the analysis of benthic invertebrate communities in sediment sampled at sites near the proposed project construction footprint may provide a further and perhaps more appropriate measure of the validity of the impact significance rating.

8. Deterioration in water quality due to the release of oxygen depleting substances from sediment by construction activities

The proposed rehabilitation of the Old Tug Jetty quay area in Phase 1 and the construction of a deck-on-pile extension of the quay area in Phase 2 will disturb the port bottom and mobilise sediment into the water column. These activities include the placing of filter fabric, placing of stone bed layer, placing of counterfort units, piling, and placing of scour protection rock. The mobilisation of sediment can lead to the release of oxygen depleting substances into the water column. Oxygen depletion can occur when reduced iron, manganese, ammonia, nitrite, and hydrogen sulphide in the mobilised sediment is oxidised and by the mineralisation of exposed organic matter. The oxygen depleting substances will disperse in the water column depending on prevailing currents and the amount of sediment mobilised. A depletion in the dissolved oxygen concentration in the water column directly impacts on water quality and may indirectly affect components of biological communities that rely on an adequate supply of dissolved oxygen for their survival, depending on the magnitude of oxygen depletion and individual organism requirements and tolerances. Sessile and poorly mobile fauna that live in and on sediment in deeper water are often at the most risk because the oxygen concentration in the water column usually natural decreases from the surface to the bottom. Mobile fauna can in contrast can avoid areas of low oxygen concentration provided this does not occur through the water column over a large area.

The amount of particulate organic matter in sediment sampled alongside and near the Old Tug Jetty quay area in August 2022 was moderate to high at Stations PE1 and PE3, but within the baseline range at Stations PE2 and PE4 (Figure 29 and Table 2). The sediment at Stations PE1 and PE3 was slightly anoxic but the degree of anoxia was not pronounced, as is evident in the colour of the sediment (Figure 14) and an only feint aroma of hydrogen sulphide. In previous surveys, however, the sediment at Station PE1 was noted to highly anoxic. It is thus apparent that the amount of particulate organic matter in sediment near the Old Tug Jetty quay area is patchy and that the accumulation of this matter may, at times, lead to the sediment becoming anoxic. There is no information on nutrient concentrations in sediment porewater in the port, but this might well be elevated in parts of the area (see Impact 9).

A potential additional source of oxygen depletion associated with the proposed project is the decomposing remains of fauna that currently colonise the Old Tug Jetty sheet pile wall, which will die when construction proceeds. The most substantial risk will occur if the remains of these fauna sink to the bottom in relatively large amounts, which could lead to oxygen depletion and the development of anoxia in the sediment when they are degraded by oxygen consuming microorganisms. It is difficult to estimate the possible consumption of oxygen that might occur in this way since this will depend on the amount of organism remains that reach the bottom and whether these might be scavenged by other organisms (*e.g.* crabs). It is, however, unlikely the sheet pile fauna remains will sink to the bottom in a single pulse, but rather gradually since construction of the counterfort wall will proceed progressively. This will minimise the risk of significant oxygen depression.

Construction activities will thus mobilise sediment into the water column, and this will in turn **probably** release oxygen depleting substances into the water column. However, the area of sediment and associated porewater that will be disturbed by construction activities at any time will be so small in the context of the port water volume that that it is **highly unlikely** the oxygen depleting substances that might be released will reduce the oxygen concentration in the water column to any significant degree. Any reduction in the dissolved oxygen concentration that does occur will be **temporary** as the concentration will return to the baseline when construction activities cease disturbing the sediment at the end of each day, or even within a day. The dissolved oxygen concentration in the water column in the Port of Port Elizabeth is usually high. Biological communities in the port are nevertheless probably habituated to and tolerant of fluctuations in the dissolved oxygen concentration in the water column and motile fauna will be able to avoid areas where the dissolved oxygen concentration is temporarily depressed. However, as stated above it is highly unlikely the oxygen concentration will be depressed to any significant degree below the baseline. The intensity is thus anticipated to be **minor**, and the spatial extent of oxygen depletion to be **site specific**. This impact is fully **reversible** as the dissolved oxygen will quickly return to the baseline once the mobilisation of sediment ceases. The significance rating for this impact without mitigation is thus **VERY LOW**.

Impact assessment without mitigation					
Impact	Deterioration in water quality due to the release of oxygen depleting substances from sediment by construction activities				
Status	Positive		Negative		
	The release of oxygen depleting substances will negatively impact on water quality that may in turn negatively affect biological communities.				
Nature	Direct	Indirect	Reversible	Irreversible	
	The release of oxygen depleting substances from sediment will directly impact on water quality. The oxygen depletion may indirectly impact on biological communities and affect ecological processes. The impact is fully reversible as the dissolved oxygen will quickly return to the baseline once the mobilisation of sediment ceases.				
Extent	Site specific	Local	Regional	National	International
	The impact is site specific because oxygen depletion is unlikely to affect an area of more than a few tens of meters (at the very most) from the point of disturbance.				
Duration	Temporary	Short-Term	Medium-Term	Long-Term	Permanent
	Oxygen depletion could occur intermittently throughout the in-water construction period, but the depletion at any time is likely to last a short period and is thus considered temporary.				
Intensity	Minor	Low	Moderate	High	Severe
	The intensity is minor because a very small depression in the dissolved oxygen concentration is anticipated and biological communities in the estuary are undoubtedly tolerant of small fluctuations in the dissolved oxygen concentration.				
Probability	Highly Unlikely	Unlikely	Possible	Probable	Definite
	It is probable the dissolved oxygen concentration will be depleted by sediment mobilisation, but it is highly unlikely this will have a significant impact on the dissolved oxygen concentration in the water column.				
Confidence	Low	Medium	High		
	The confidence that oxygen depleting substances will be released into the water column is high. The confidence that oxygen concentrations will not decrease so significantly in the water column that this will result in a major ecological impact is also high.				
Significance	Very Low	Low	Medium	High	Fatally flawed

Mitigation

No mitigation is required considering the **VERY LOW** significance rating for this impact. Indeed, little can be done to directly mitigate this impact other than not proceeding with the project at all (the 'Do Nothing' option). The significance of this impact will thus not change with mitigation and remains **VERY LOW**.

Impact assessment with mitigation							
Impact	Deterioration in water quality due to the release of oxygen depleting substances from sediment by construction activities						
Mitigation	None required due to the very low significance rating.						
Nature	Direct	Indirect		Reversible		Irreversible	
Extent	Site specific	Local	Regional	National	International		
Duration	Temporary	Short-Term	Medium-Term	Long-Term	Permanent		
Intensity	Minor	Low	Moderate	High	Severe		
Probability	Highly Unlikely	Unlikely	Possible	Probable	Definite		
Confidence	Low		Medium		High		
Significance	Very Low	Low	Medium	High	Fatally flawed		

Potential for cumulative effects

Certain port operations, such as vessel propeller wash and potentially maintenance dredging, could disturb sediment and mobilise oxygen depleting substances into the water column and in this way could magnify the impact of oxygen depletion because of sediment mobilised by construction activities for the proposed project. However, this is not considered significant since the depletion in dissolved oxygen due to construction activities for the proposed project is anticipated to be minimal.

Required monitoring

No monitoring is required considering the **VERY LOW** significance rating for this impact. If construction coincides with water quality surveys for the Long-Term Ecological Monitoring Programme for the Port of Port Elizabeth, the dissolved oxygen concentration in the water column could be measured at stations positioned along a gradient from very near to distant from construction activities to validate the impact significance rating.

9. Deterioration in water quality due to the release of nutrients from sediment by construction activities

The proposed rehabilitation of the Old Tug Jetty quay area in Phase 1 and the construction of a deck-on-pile extension of the quay area in Phase 2 will disturb the port bottom and mobilise sediment into the water column. These activities include the placing of filter fabric, placing of stone bed layer, placing of counterfort units, piling, and placing of scour protection rock. The mobilisation of sediment can lead to the release of nutrients dissolved in sediment porewater into the water column (Wainright and Hopkinson, 1997; Gibson *et al*., 2015). The mobilisation of particulate organic matter from the sediment may also result in an increase in nutrient concentrations when the matter is remineralised. A possible additional source of oxygen depletion is the decomposing remains of biological communities that currently colonise the sheet pile wall at the Old Tug Jetty, which will die as construction proceeds. A potential additional source of nutrient release with the proposed project is the decomposing remains of fauna that currently colonise the Old Tug Jetty sheet pile wall, which will die when construction proceeds. The most substantial risk will occur when the remains of these fauna sink to the bottom in relatively large amounts, which could lead to a nutrient pulse when they are degraded by oxygen consuming microorganisms or are scavenged by other fauna. It is difficult to estimate the possible nutrient release that might occur in this way since this will depend on the amount of organisms affected at any time. It is, however, unlikely fauna on the entire sheet pile wall will die in a single pulse but rather gradually as construction of the counterfort wall will proceed progressively. This will minimise the risk of nutrient release in a pulse.

An increase in nutrient concentrations can have a direct impact on water quality and in that way an indirect impact on biological communities. The release of small amounts of nutrients can positively impact on primary productivity by increasing nutrient availability to micro- and macroalgae (Lohrenz *et al*., 2004). A marked increase in nutrient concentrations, in contrast, can stimulate the excessive growth of micro- and macroalgae, leading to eutrophication that in turn can lead to a host of ecological problems (including depleting the dissolved oxygen concentration in the water column and sediment). There is no information on the concentrations of nutrients in sediment porewater in the Port of Port Elizabeth, but nutrient concentrations in the water column are usually low. The microalgal biomass in the port is also usually low (see Section 5.1.5). Nevertheless, microalgal blooms have been recorded periodically in the port, indicating that under certain circumstances the port environment is susceptible to eutrophication. The recent construction of the leading jetties for the vessel maintenance slipway, which involved the installation of a large number of piles, had no apparent marked effect on nutrient concentrations in the water column in the port as deduced from measurements made for the Long-Term Ecological Monitoring Programme for the Port of Port Elizabeth.

Construction activities for the proposed project will thus disturb sediment, and this will release nutrients into the water column. Any increase in nutrient concentrations that does occur will be **temporary** since the concentration will return to the baseline when construction activities cease at the end of each day, but may occur intermittently throughout the construction period. Any nutrients that are released will probably be rapidly diluted in the surrounding water column and any increase is thus likely to be **site specific**. Although the nutrients will add to the nutrient concentrations in the water column in the port, the area of sediment and associated porewater that will be disturbed by construction activities at any time will be so small in the context of the port water volume that it is **highly unlikely** the released nutrients will excessively stimulate the growth of microalgae over and above the growth attributed to existing nutrient concentrations. The intensity will thus be **minor**. This impact is fully **reversible** since nutrient concentrations will return to the baseline when the disturbance of sediment ceases. The significance rating for this impact without mitigation is thus **VERY LOW**.

Impact assessment without mitigation					
Impact	Deterioration in water quality due to the mobilisation of bottom sediment leading to the release of nutrients				
Status	Positive	Negative			
	The release of nutrients may negatively impact on water quality that may in turn negatively affect biological communities.				
Nature	Direct	Indirect	Reversible	Irreversible	
	The release of nutrients will directly impact on water quality. The impact on water quality may indirectly stimulate the growth of microalgae and lead to a host of potential ecological impacts. The impact is fully reversible because sediment disturbance and the release of nutrients will cease when construction ceases, and nutrient concentrations will return to the background.				
Extent	Site specific	Local	Regional	National	International
	The impact is site specific because released nutrients will be diluted and dispersed by currents but will not affect nutrient concentrations in the wider port environment nor in the adjacent marine environment.				
Duration	Temporary	Short-Term	Medium-Term	Long-Term	Permanent
	Nutrient release could occur throughout the construction period, but the impact at any time will be temporary.				
Intensity	Minor	Low	Moderate	High	Severe
	The intensity is minor because the total concentration of nutrients anticipated to be released from sediment at any time by construction activities is very low in the context of the wider port.				
Probability	Highly Unlikely	Unlikely	Possible	Probable	Definite
	It is probable nutrients will be released from sediment into the water column. However, it is highly unlikely the released nutrients will stimulate the growth of macro- and microalgae much above the growth attributed to existing nutrient concentrations in the port.				
Confidence	Low	Medium	High		
	The confidence that nutrients will be released into the water column is high. The confidence that nutrient concentrations will not increase so significantly in the water column that this will result in a major impact is also high, despite the fact there is no information on nutrient				

	concentrations in sediment in the project area. This is because the area of sediment that will be disturbed at any time by construction activities will be very small.				
Significance	Very Low	Low	Medium	High	Fatally flawed

Mitigation

No mitigation is required considering the **VERY LOW** significance rating for this impact. Indeed, little can be done to mitigate this impact other than not proceeding with the project at all (the 'Do Nothing' option). The significance rating for this impact with mitigation will thus remain **VERY LOW**.

Impact assessment with mitigation					
Impact	Deterioration in water quality due to the mobilisation of bottom sediment leading to the release of nutrients				
Mitigation	No mitigation is required due to the very low significance rating.				
Nature	Direct	Indirect	Reversible	Irreversible	
Extent	Site specific	Local	Regional	National	International
Duration	Temporary	Short-Term	Medium-Term	Long-Term	Permanent
Intensity	Minor	Low	Moderate	High	Severe
Probability	Highly Unlikely	Unlikely	Possible	Probable	Definite
Confidence	Low	Medium	High		
Significance	Very Low	Low	Medium	High	Fatally flawed

Potential for cumulative effects

Certain port operations, such as vessel propeller wash and potentially maintenance dredging, could disturb sediment and mobilise nutrients into the water column and in this way could magnify the impact of nutrients released because of sediment mobilised by construction activities for the proposed project. However, this is not considered significant since the total concentration of nutrients that is anticipated to be released by construction activities for the proposed project is very small.

Required monitoring

No monitoring is necessary due to the **VERY LOW** significance rating for this impact. If construction coincides with water quality surveys for the Long-Term Ecological Monitoring Programme for the Port of Port Elizabeth, the findings of these surveys may provide information to validate the impact significance rating.

10. Deterioration in water and sediment quality due to the mobilisation of toxic chemicals from sediment by construction activities

The proposed rehabilitation of the Old Tug Jetty quay area in Phase 1 and the construction of a deck-on-pile extension of the quay area in Phase 2 will disturb the port bottom and mobilise sediment into the water column. These activities include the placing of filter fabric, placing of stone bed layer, placing of counterfort units, piling, and placing of scour protection rock. The mobilisation of sediment can lead to the release of toxic chemicals in the sediment into the water column. Toxic chemicals dissolved in porewater in sediment can be released directly into the water column. However, most toxic chemicals in sediment are immobilised by their complexation with sulphides, hydrous metal oxides of iron and manganese, and/or or adsorption onto sediment grains and particulate organic matter. The complexes are generally stable and largely insoluble in the usually low oxygen or anoxic conditions commonly found a few centimetres beneath the sediment surface, limiting their potential to pose a toxic risk to biological communities (Goossens and Zwolsman, 1996; Eggleton and Thomas, 2004). The main mechanism by which toxic chemicals are released from sediment during mobilisation is by the oxidation of these complexes. When sediment is mobilised or otherwise disturbed, oxygen permeates the sediment and destabilises the complexes, and may result in the partitioning of the bound chemicals into the dissolved phase (Eggleton and Thomas, 2004). The rate of metal desorption from complexes during sediment mobilisation is strongly influenced by properties of the sediment, including its grain size and the presence of sulphides, particulate organic matter, and hydrous metal oxides of iron and manganese (Goossens and Zwolsman, 1996; Eggleton and Thomas, 2004; Atkinson *et al*., 2007; Cantwell *et al*., 2008). Some chemical-particle complexes (*e.g.* between high molecular weight polycyclic aromatic hydrocarbons and particulate organic matter) are quite stable even in oxygenated conditions and these chemicals may not desorb from the suspended particulate matter, or the desorption process may be slower than the time it takes for the remobilised particulate organic matter to again settle from the water column onto the bottom.

The behaviour of toxic chemicals after repartitioning or suspension with sediment is complex, governed by the properties of the chemicals and various biogeochemical modifying factors such as the salinity, pH, and dissolved oxygen concentration of the water column (Eggleton and Thomas, 2004). The toxic chemicals may be dispersed in the water column by currents in the dissolved form or bound to suspended particulate matter by currents, but most chemicals are usually rapidly scavenged from the water column and deposited on sediment by flocculation, coagulation, and settlement. Reduced iron and manganese, for example, when oxidised during suspension rapidly scavenge metals and other compounds from the water column. As the compounds settle on the bottom, they are again reduced under anoxic conditions. Thus, while mobilisation may repartition chemicals into the dissolved phase, the increase in concentration usually persists for only a short period. The scavenged chemicals, or chemical-particle complexes mobilised into the water column may settle in a different area to that where the sediment was mobilised, causing the contamination of previously uncontaminated sediment, or adding to the contaminant load in already contaminated sediment. However, as stated above chemicals repartitioned into the dissolved phase are usually rapidly scavenged from the water column, which usually limits the extent of their dispersion.

The repartitioning of chemicals into the dissolved phase makes them more bioavailable than when adsorbed onto or buried in sediment. This is important because toxic chemicals can only exert a toxic effect if they are in a bioavailable form and organisms are actually exposed to the chemicals. An increase in toxic chemical concentrations impacts on water and sediment quality and may impact in turn indirectly impact on biological communities depending on each chemicals concentration and the tolerances of organisms to the chemical. Adverse impacts might occur by fauna and flora accumulating toxic chemicals in their tissue, leading to sub-lethal impacts such as reduced growth rates or an increase in their susceptibility to other stressors, and in extreme cases mortality (*e.g.* Sved and Roberts, 1995; Gregg *et al*., 1997; Cruz-Rodríguez and Chu, 2002; Geffard *et al*., 2007; Tolhurst *et al*., 2007; Lotufo *et al*., 2010). The loss of biological communities through mortality may affect other biota by depleting food resources. Toxic chemicals can enter food webs through their bioaccumulation by fauna and flora, with sub-lethal impacts (Lotufo *et al*., 2010). Some toxic chemicals increase in concentration through successive trophic levels of food webs in a process known as biomagnification and in this way can pose a toxic risk to higher level consumers (*e.g.* sharks, dolphins) and humans that consume contaminated fish and shellfish.

The sediment alongside and near the Old Tug Jetty quay area is metal contaminated, but not to an especially high magnitude. There is no information on the concentrations of other chemicals in sediment in this area, but there is information on polycyclic aromatic hydrocarbons, organochlorine pesticides, polychlorinated biphenyls, and butyltins in sediment near the quay area. It is impossible to determine if these chemicals are present in sediment alongside the Old Tug Jetty quay area without actually analysing the sediment, but this is probably the case considering the trend for the sediment nearby and elsewhere in the port. It is difficult to quantify the amount of toxic chemicals that might be released into the water column when the sediment is mobilised by construction activities based on chemical concentrations in the sediment alone because chemicals differ in their mobility and bioavailability depending on their chemical and mineralogical form and conditions in the water column (Baeyens *et al*., 2003; Nicolau *et al*., 2006; Nouri *et al*., 2011). Chemical concentrations measured in sediment are thus a poor predictor of their potential release from sediment – the fraction that is released by the mobilisation of sediment is usually far lower than concentration measured in sediment. One approach to estimating the release of chemicals is the testing of sediment elutriates, which involves mixing known volumes of water and sediment, agitating the mixture to mimic the sediment mobilisation by dredging, and then analysing chemical concentrations in the water (elutriate). However, even this information will not provide and indication if the chemicals will exert a toxic effect unless the elutriate is tested for toxicity. Elutriate testing was not performed for this study (it is rarely performed in South Africa). However, the sediment sampled at four stations alongside and near the Old Tug Jetty quay area in July 2022 was tested for toxicity to sea urchin embryo-larvae under a sediment-water interface testing regime. A sediment-water interface toxicity test simulates the release of toxic chemicals from bedded sediment into the water column. The sediment sampled at three stations was not toxic to sea urchin embryo-larvae, while sediment sampled that at the fourth station it was slightly toxic. It is probable, therefore, that the disturbance of sediment by construction activities will release toxic chemicals from sediment in some parts of the construction footprint into the water column. Following a precautionary principle the sediment across the construction footprint is assumed to be slightly toxic.

Toxic chemicals will thus probably be released by construction activities into the water column at concentrations that may **possibly** cause slight toxic effects to biological communities. However, construction activities are likely to disturb such low volumes of sediment at any time and the toxic chemicals released into the water column will probably be rapidly scavenged from the water column or diluted and dispersed soon after release. The intensity for this impact is thus **low** and the spatial extent is **site specific**. This impact is possible throughout the construction period but any increase in toxic chemical concentrations will be **temporary**. The impact is fully **reversible** as the release of toxic chemicals will cease when construction ceases and the chemicals will be dispersed and diluted over time. The significance rating for this impact without mitigation is thus **VERY LOW**.

Impact assessment without mitigation					
Impact	Deterioration in water and sediment quality due to the release of toxic chemicals from sediment by construction activities				
Status	Positive		Negative		
	The release of toxic chemicals may negatively impact on water and sediment quality that may in turn negatively affect biological communities.				
Nature	Direct	Indirect	Reversible	Irreversible	
	The release of toxic chemicals will directly impact on water and sediment quality. The impact on water and sediment quality may indirectly affect fauna and flora. The impact is reversible because sediment disturbance and the release of toxic chemicals will cease when construction ceases.				
Extent	Site specific	Local	Regional	National	International
	The impact is site specific because released toxic chemicals will be diluted and dispersed by currents but will very unlikely affect biological communities much beyond the construction area.				
Duration	Temporary	Short-Term	Medium-Term	Long-Term	Permanent
	Toxic chemical release could occur throughout the construction period, but at any time the concentrations will remain in the water for a short period and is thus temporary.				
Intensity	Minor	Low	Moderate	High	Severe
	The intensity is low because a low concentration of toxic chemicals is anticipated to be released at any time by construction activities and this might cause mild toxic effects.				
Probability	Highly Unlikely	Unlikely	Possible	Probable	Definite
	It is possible toxic chemicals will be released at concentrations that will cause toxic effects to biological communities.				
Confidence	Low	Medium	High		
	The confidence that toxic chemicals will not be released into the water column in high concentrations is high. The confidence that toxic chemicals that are released into the water column will cause slight toxic effects in biological communities is also high, based on the results of toxicity testing.				
Significance	Very Low	Low	Medium	High	Fatally flawed

Mitigation

No mitigation is required considering the **VERY LOW** significance rating for this impact. Indeed, little can be done to directly mitigate this impact other than not proceeding with the project at all (the 'Do Nothing' option). The significance rating for this impact will not change with mitigation and thus remains **VERY LOW**.

Impact assessment with mitigation					
Impact	Deterioration in water and sediment quality due to the release of toxic chemicals from sediment by construction activities				
Mitigation	None required due to low significance rating.				
Nature	Direct	Indirect	Reversible	Irreversible	
Extent	Site specific	Local	Regional	National	International
Duration	Temporary	Short-Term	Medium-Term	Long-Term	Permanent
Intensity	Minor	Low	Moderate	High	Severe
Probability	Highly Unlikely	Unlikely	Possible	Probable	Definite
Confidence	Low	Medium	High		
Significance	Very Low	Low	Medium	High	Fatally flawed

Potential for cumulative effects

The proposed project will coincide with the berthing and de-berthing of vessels in the Port of Port Elizabeth. The proposed project may coincide with maintenance dredging in the Port of Port Elizabeth. There is a possibility that toxic chemicals released from sediment mobilised by vessel propeller wash and maintenance dredging will enhance the impact of toxic chemical release associated with the proposed project, and *vice versa*. However, the cumulative impact will probably not be highly significant considering the very small amount of sediment that is anticipated to be mobilised by construction activities and that sediment across most of the Port of Port Elizabeth is not severely contaminated by chemicals. Furthermore, the toxicity testing of sediment sampled in the port in August 2022 showed that the sediment at most stations not including those in the proposed project area was not toxic, but when so that toxicity was slight or marginal. To mitigate this potential cumulative effect, construction for the proposed project and maintenance dredging in the Port of Port Elizabeth should be scheduled so they do not overlap.

Required monitoring

No monitoring is required considering the **VERY LOW** significance rating for this impact. If construction coincides with surveys for the Long-Term Ecological Monitoring Programme for the Port of Port Elizabeth the findings of these surveys may provide information on whether construction has resulted in an increase in metal and polycyclic aromatic hydrocarbon concentrations in the water column and in sediment in the port, but it will be difficult to ascribe any changes that might be evident to construction in a once off survey based on the current sampling design for the monitoring programme. This is because there are numerous existing and possible sources of these chemicals in and to the port.

11. Deterioration in water quality due to dredging related increases in suspended sediment concentrations and turbidity

Sediment alongside and near the Old Tug Jetty quay area will need to be dredged for Phase 1 of the proposed project to allow the removal of existing scour protection rock near the sheet pile wall, to allow the placement of a stone bed and filter fabric layer, and to allow the positioning of the counterfort wall units. Sediment will also need to be dredged for Phase 2 of the proposed project to provide the necessary water depth for larger vessels and to allow the placing of scour protection rock beneath and near the deck-on-pile structure. There is no information yet on the volume of sediment that will need to be dredged during Phase 1 and Phase 2, nor on the dredging method. This information will be finalised after a geotechnical survey has been completed and the engineering design for each phase has been finalised.

Dredging presents numerous predictable and unavoidable environmental impacts. One impact is the mobilisation and release of sediment into the water column, resulting in an increase in the suspended sediment concentration and turbidity in the water column at and near the dredging operations. Depending on the method of dredging the mobilisation of sediment occurs at the dredging head for hydraulic dredging or by the bucket or grab impacting on the bottom during mechanical dredging. Sediment can also be mobilised by dredger propeller wash and the deployment of anchoring systems. The release of sediment occurs through overspill from the bucket or grab during mechanical dredging and overspill from hoppers or barges. The volume of sediment mobilised and released into the water column depends on the nature of the sediment that is dredged (*i.e.* its particle size, mineralogy, bulk density), the depth of the water column at the dredging site, prevailing currents and other forms of turbulence, the type of equipment used for dredging (*e.g.* mechanical versus hydraulic), and skill of dredge operator (*e.g.* speed of dredging, rate at which dredge bucket is lifted).

The highest suspended sediment concentrations can be expected very near the dredging operation (these can be up to several hundred to several thousand milligrams per litre depending on the dredging method), with the highest concentrations usually found in the middle and bottom parts of the water column. Fine-grained sediment (mud) is mobilised and released more easily by dredging and remains in suspension longer than coarse grained sand and is dispersed from the dredging site by currents. The extent of the dispersion depends on the particle size of the sediment, which affects its fall rate, and the strength of currents. Very coarse particles of sand have a high fall velocity in seawater at a temperature of 35°C (in the order of 0.12 $m.s^{-1}$ for coarse-grained sand; Soulsby, 1997) and will settle rapidly on the bottom. Fine-grained particles have a far lower fall velocity (in the order of 0.0003 - 0.0004 $m.s^{-1}$ for silts and clays; Soulsby, 1997) and will disperse over a wider area depending on prevailing currents, but could remain in the water column for hours to possibly days and can thus be dispersed over a wide area depending on prevailing currents. The fine-grained sediment will eventually deposit in areas where and when the current is weakest (*e.g.* slack tide). Some of the fine-grained material could be re-mobilised by currents and be dispersed further on subsequent tides or when the current increases in strength for some other reason. It is important to note that while a turbid plume may be visible a considerable distance down current of dredging operations the actual amount of fine-grained material in suspension that causes the plume to be visible is usually very low (Hitchcock and Drucker, 1996).

An increase in the suspended sediment concentration and turbidity in the water column due to dredging can have the same potential environmental consequences as those that might occur when sediment is mobilised by construction activities (see Impact 6), although the impacts is usually more intense.

The sediment in the dredging footprints for the proposed project is comprised largely of mud. The dredging of sediment will thus increase the suspended sediment concentration and turbidity above the baseline in the water column at and near the dredging site. This is an unavoidable impact of dredging. The water column in the dredging footprint is shallow. The increased suspended sediment concentration and turbidity is anticipated to be highly localised near the dredging operation as currents in the area are anticipated to be weak on average and are thus unlikely to disperse large volumes of suspended sediment over large areas. The suspended sediment is unlikely to be dispersed from the port entrance to any significant degree. The finer-grained material will be dispersed over a wider area depending on prevailing currents but this is likely to increase the suspended sediment concentration only slightly above the baseline. The impact on water quality is thus considered **local**. The increase will be **temporary** since dredging will not proceed 24 hrs a day and dredging will be completed cumulatively within a relatively short period. The suspended sediment concentrations near the dredging operation will probably be high. Biological communities at and near the dredging footprints, including benthic communities and communities that have colonised hard structures such as jetty piles, are probably habituated to the impact of suspended sediment but will be impacted as the suspended sediment concentration near the dredging operation will probably considerably exceed the baseline. The intensity is thus considered **moderate**. The impact is fully **reversible** since biological communities and ecological processes impacted by the elevated suspended sediment concentrations and associated turbidity will recover and re-establish after dredging ceases. The significance rating for this impact without mitigation is thus **MEDIUM**.

Impact assessment without mitigation					
Impact	Deterioration in water quality due to a dredging related increase in suspended sediment concentrations and turbidity				
Status	Positive		Negative		
	The impact is negative since dredging will adversely impact on water quality.				
Nature	Direct	Indirect	Reversible	Irreversible	
	The impact is direct because the dredging will have a direct impact on water quality at and near the dredging site. The impact is also indirect because the impact on water quality will adversely impact on fauna and flora at and near the dredging site. The impact is reversible because the suspended sediment will settle from the water column and the suspended sediment concentration and associated turbidity will return to the background for the area.				
Extent	Site specific	Local	Regional	National	International
	Some sediment that is mobilised and released by dredging will disperse over a wider area than near the dredging site and will thus be local in extent.				
Duration	Temporary	Short-Term	Medium-Term	Long-Term	Permanent
	The impact is temporary because dredging will occur for a relatively short period.				
Intensity	Minor	Low	Moderate	High	Severe
	The intensity is moderate since although biological communities at and near the dredging footprint are likely habituated to elevated suspended sediment concentrations and turbidity, the increase in the suspended solids concentration near the dredging operation will probably considerably exceed the baseline.				
Probability	Highly Unlikely	Unlikely	Possible	Probable	Definite
	Dredging will result in an increase in the suspended sediment concentration and turbidity in the water column at and near the dredging footprint.				
Confidence	Low	Medium	High		
	The confidence that dredging will result in an increase in the suspended sediment concentration and associated turbidity of the water column and that this will adversely impact on water quality and fauna and flora at and near the dredging site is high. The confidence that this will unlikely have a major impact on the ecological productivity in the Port of Port Elizabeth is medium because it is unknown how fauna near the dredging footprint might respond to repeated, albeit intermittent increases in suspended sediment concentrations.				
Significance	Very Low	Low	Medium	High	Fatally flawed

Mitigation

An increase in the suspended sediment concentration and associated turbidity in the water column is an unavoidable impact of dredging. The most effective mitigation is the use of silt curtains. However, deploying silt curtains might not be practical due to the constraints posed by existing deck-on-pile structures near the Old Tug Jetty quay area, and may pose a navigation hazard to vessels that will operate nearby during dredging. The mitigation outlined below can reduce the intensity of this impact. If mitigation is implemented the significance rating for this impact is **LOW**, due to a change in intensity.

Impact assessment with mitigation	
Impact	Deterioration in water quality due to a dredging related increase in suspended sediment concentrations and turbidity
Mitigation	• Use dredging methods that limit the mobilisation and release of fine-grained sediment from dredging equipment. Mechanical dredging with a backhoe usually releases a higher concentration of sediment into the water column than hydraulic dredging. • Dredge in winter when most fauna and flora will not be breeding, the significance being that larval and juvenile stages of marine fauna and the propagules of marine flora are more susceptible to the effects of suspended sediment than are adult stages. • Hopper overspill should be directed down rather than laterally into the water column, to minimise to the extent possible the dispersion of suspended sediment. • Dredging should be completed within the shortest timeframe possible to reduce the

	period over which fauna and flora might be exposed to increased suspended sediment concentrations and associated turbidity. • The dredging footprint should be restricted to the smallest area and depth possible (*i.e.* do not over dredge), thereby minimising the amount of sediment mobilised and released into the water column.				
Nature	Direct	Indirect	Reversible	Irreversible	
Extent	Site specific	Local	Regional	National	International
Duration	Temporary	Short-Term	Medium-Term	Long-Term	Permanent
Intensity	Minor	Low	Moderate	High	Severe
Probability	Highly Unlikely	Unlikely	Possible	Probable	Definite
Confidence	Low	Medium	High		
Significance	Very Low	Low	Medium	High	Fatally flawed

Potential for cumulative effects

The proposed project will coincide with the berthing and de-berthing of vessels in the port. The proposed project may coincide with maintenance dredging in the port. There is a possibility that sediment mobilised by vessel propeller wash and maintenance dredging will magnify the impact of increased suspended sediment concentrations and turbidity due to dredging for the proposed project, and *vice versa*, because vessel movements and dredging will occur very near the proposed project area. However, the cumulative impact will probably not be highly significant considering the small amount of sediment that is anticipated to be mobilised into the water column by construction activities. To mitigate this potential cumulative effect construction for the proposed project and maintenance dredging in the port should be scheduled so they do not overlap, although this is not a necessity considering the significance rating for the impact without mitigation.

Required monitoring

The construction Site Manager, appointed independent Environmental Control Officer, and/or the local Transnet National Ports Authority environmental specialist must verify through observations from the quay wall that dredging is not resulting in such intense and large plumes of suspended sediment in the port that these are clearly visible from the water surface and are causing a marked increase in suspended sediment concentrations over a large area. If this is the case, the dredging method/s should be reviewed to identify areas for improvement to ensure sediment is not excessively mobilised into the water column.

If dredging for the proposed project coincides with water quality surveys for the Long-Term Ecological Monitoring Programme for the Port of Port Elizabeth then the turbidity of the water column could be measured at stations positioned along a gradient from very near to distant from the dredging site to provide a measure of the validity of the impact significance rating.

12. Ecological impacts due to the deposition of sediment outside the dredging footprint

Sediment alongside and near the Old Tug Jetty quay area will need to be dredged for Phase 1 of the proposed project to allow the removal of existing scour protection rock near the sheet pile wall, to allow the placement of a stone bed and filter fabric layer, and to allow the positioning of the counterfort wall units. Sediment will also need to be dredged for Phase 2 of the proposed project to provide the necessary water depth for larger vessels and to allow the placing of scour protection rock beneath and near the deck-on-pile structure. There is no information yet on the volume of sediment that will need to be dredged during Phase 1 and Phase 2, nor on the dredging method. This information will be finalised after a geotechnical survey has been completed and the engineering design for each phase has been finalised.

Dredging presents numerous predictable environmental impacts. One impact is the mobilisation and release of sediment into the water column. The volume of sediment that is mobilised and released into the water column depends on the nature of the sediment that is dredged (*i.e.* its grain size), the depth of the water column at the dredging site, prevailing currents and other forms of turbulence, the method of dredging (*e.g.* mechanical versus hydraulic), and the skill of dredge operator (*e.g.* speed of dredging, rate at which dredge bucket is lifted). The highest suspended sediment concentrations are near the dredger (these can be up to several hundred milligrams per litre or more), in the middle and lower parts of the water column. Coarse heavy particles of sand will fall (back) to the bottom quickly (within seconds) near the point of disturbance or introduction. Fine-grained particles, such as silt and clay, have a low fall velocity and will remain in suspension for longer (hours to possibly days for very fine-grained material) and will be dispersed over a wider area depending on prevailing currents. The fine-grained sediment will eventually deposit in areas where and when the current is weakest (*e.g.* slack tide). Some of the fine-grained material could be re-mobilised by currents and be dispersed further on subsequent tides or when the current increases in strength for some other reason.

Sediment that is mobilised and released into the water column by dredging will thus settle on the seabed outside the dredging footprint. The area over which sediment mobilised and released by dredging for the Old Tug Jetty rehabilitation will settle in the Port of Port Elizabeth has not been modelled. The sediment in the dredging footprint is a mix of sand and mud, but the mud content is considerably higher than the sand content. It is unlikely a significant volume of the sediment will be dispersed over a large area beyond the dredging footprint since currents in the project area are anticipated to be weak on average. It is thus anticipated that most of the sediment mobilised and released into the water column by dredging will settle on the bottom near the dredging footprint and this impact will thus be most intense near the dredging footprint. Although plumes of sediment mobilised or released into the water column by vessel propeller wash, dredging, and construction can be seen extending over quite a large area in satellite images of the Port of Port Elizabeth (see Figures 22 and 23), the visible plume some distance from these operations is probably represented by very fine-grained material that comprises only a small volume of the sediment that was mobilised and released by these disturbances. A small amount of sediment will thus be deposited further from the dredging footprint.

Sediment that is mobilised and released into the water and subsequently deposited on the bottom will have the same potential environmental consequences as those that might occur when sediment that is mobilised by construction activities is deposited on the bottom (see Impact 7).

Dredging for the Old Tug Jetty sheet pile wall rehabilitation in Phase 1 and for the construction of the deck-on-pile structure in Phase 2 of the proposed project will thus mobilise and release sediment into the water column and the sediment will settle on the bottom outside the dredging footprints, where it will **probably** bury or smother benthic biological communities. Although very fine-grained sediment mobilised or released into the water column may be dispersed by currents over a fairly wide area, currents in the affected area are probably weak on average and most of the sediment is expected to settle on the bottom relatively near the dredging footprints. The most significant impact is thus expected near the dredging footprints the extent of this impact is thus considered **site-specific**. Depending on the dredging method, sediment deposition could be fairly significant near the dredging footprints. However, the deposition will be intermittent as dredging will not proceed throughout the day and the more mobile benthic invertebrate infauna and epifauna will be able to migrate through the sediment. However, some components of the biological communities near the dredging footprints may suffer mortality and it will take some time for the affected benthic biological communities to recover to the same species diversity, abundance, and biomass as that which existed before dredging. This is expected to be occur within a short period after the disturbance and the duration is thus considered **short-term**. There appear to be no benthic invertebrate infauna or epifauna in that part of the port most likely to be impacted that are of special ecological, commercial, or social significance, and impacts on other components of the biological community in the port that may be indirectly affected, such as through a loss of food resources, are likely to be insignificant. Benthic biological communities near the dredging footprints are most likely already disturbed by vessel propeller wash and maintenance dredging and are thus probably habituated to the impacts of sediment deposition, although probably not to the same degree that can be expected from a dredging operation nearby. Benthic biological communities near the dredging footprints will thus experience some degree of impoverishment due to sediment deposition, but it is **unlikely** this will lead to a substantial loss in ecological productivity. The intensity is thus considered **low**. The impact is fully **reversible** as its potential to occur will cease when dredging ceases, and fauna will colonise and migrate through, or otherwise deal with the deposited sediment over time. The significance rating for this impact is thus **LOW**.

Impact assessment without mitigation					
Impact	Ecological impacts due to the deposition of sediment outside the dredging footprint				
Status	Positive		Negative		
	The deposition of sediment on the bottom in quantities above the baseline will negatively impact benthic biological communities by burial and smothering, amongst other impacts.				
Nature	Direct	Indirect	Reversible	Irreversible	
	Sediment deposited on the bottom will directly impact benthic biological communities and indirectly impact fauna that use the affected area for food or other resources. The impact is reversible because it will only persist for the construction period, and fauna will colonise or migrate through the deposited sediment.				
Extent	Site specific	Local	Regional	National	International
	Most of the mobilised or released sediment will probably settle near the point of dredging. The extent is thus site specific.				
Duration	Temporary	Short-Term	Medium-Term	Long-Term	Permanent
	The dredging period will be short, but the impact may extend for a longer period of benthic biological communities are severely impacted. This impact is thus considered short-term.				
Intensity	Minor	Low	Moderate	High	Severe
	The intensity is anticipated to be low because the deposition of sediment is unlikely to substantially exceed the baseline deposition rate apart from very near the dredging footprints, because benthic biological communities in the project area are undoubtedly habituated to the deposition of suspended sediment on the bottom, and because the benthic biological communities that will be directly impacted are not of special ecological, commercial, or social significance. Impacts on other components of the biological community in the port that may be indirectly affected, such as through a loss of food resources, are likely to be insignificant.				
Probability	Highly Unlikely	Unlikely	Possible	Probable	Definite
	Dredging will mobilise and release sediment into the water column and this will settle on the bottom and will bury and smother benthic biological communities, but it is unlikely this will have a significant ecological impact.				
Confidence	Low		Medium	High	
	The confidence that sediment will be mobilised and released into the water column and that this will settle on the bottom and bury or smother benthic biological communities is high. This is an unavoidable impact of dredging. The confidence that the intensity of this impact will be low and not moderate is medium in the absence of information on the dredging method.				
Significance	Very Low	Low	Medium	High	Fatally flawed

Mitigation

Recommended mitigation for this impact is thus outlined below. The most effective mitigation for this impact is the installation of silt curtains around the dredging operation. However, it is uncertain if silt curtains will be used, although considering the **LOW** significance rating for this impact this level of mitigation is probably not warranted. Other mitigation will probably have a minor influence on the significance rating, which thus remains **LOW** with mitigation.

Impact assessment with mitigation	
Impact	Ecological impacts due to the deposition of sediment outside the dredging footprint
Mitigation	• Dredging should ideally be performed in winter when ecological productivity is lowest and dependencies by other biota on biological communities in and near the dredging footprints is lowest.

	• Dredging should be completed within the shortest timeframe possible so that recolonisation of the exposed can proceed. • The dredging footprint should be restricted to the smallest area and depth possible (*i.e.* do not over dredge) to minimise the area disturbed and the duration of dredging.				
Nature	Direct	Indirect	Reversible	Irreversible	
Extent	Site specific	Local	Regional	National	International
Duration	Temporary	Short-Term	Medium-Term	Long-Term	Permanent
Intensity	Minor	Low	Moderate	High	Severe
Probability	Highly Unlikely	Unlikely	Possible	Probable	Definite
Confidence	Low	Medium	High		
Significance	Very Low	Low	Medium	High	Fatally flawed

Potential for cumulative effects

The proposed project will coincide with the berthing and de-berthing of vessels in the port and may coincide with maintenance dredging. Sediment mobilised by vessel propeller wash and maintenance dredging that settles in the area near the dredging footprints may magnify the impact of sediment deposition associated with dredging for the proposed project, and *vice versa*. However, the cumulative impact is unlikely to be significant considering the small volume of sediment that is anticipated to be mobilised and released by dredging and because most of this sediment is expected to settle near the dredging footprints. The scheduling of dredging for the proposed project and maintenance dredging so they do not overlap will avoid this cumulative impact, but is not a necessity.

Required monitoring

No dedicated environmental monitoring is necessary considering the **LOW** significance rating for this impact. However, if dredging for the proposed project coincides with water quality surveys for the Long-Term Ecological Monitoring Programme for the Port of Port Elizabeth, the turbidity of the water column could be measured at stations positioned along a gradient from very near to distant from construction activities to provide a measure of the validity of the impact significance rating. The Long-Term Ecological Monitoring Programme for the Port of Port Elizabeth does not measure suspended sediment (solids) concentrations in the water column, but this could be implemented in such a survey at minimal additional cost as a further measure to validate the impact significance rating. Furthermore, if construction coincides with sediment quality surveys for the Long-Term Ecological Monitoring Programme for the Port of Port Elizabeth, the analysis of benthic invertebrate communities in sediment sampled at sites near the proposed project construction footprint may provide a further and perhaps more appropriate measure of the validity of the impact significance rating.

13. Deterioration in water quality due to the release of oxygen depleting substances from sediment by dredging

Sediment alongside and near the Old Tug Jetty quay area will need to be dredged for Phase 1 of the proposed project to allow the removal of existing scour protection rock near the sheet pile wall, to allow the placement of a stone bed and filter fabric layer, and to allow the positioning of the counterfort wall units. Sediment will also need to be dredged for Phase 2 of the proposed project to provide the necessary water depth for larger vessels and to allow the placing of scour protection rock beneath and near the deck-on-pile structure. There is no information yet on the volume of sediment that will need to be dredged during Phase 1 and Phase 2, nor on the dredging method. This information will be finalised after a geotechnical survey has been completed and the engineering design for each phase has been finalised.

The dredging of sediment will lead to the mobilisation and release of sediment into the water column and in this way will release oxygen depleting substances into the water column, with the same potential environmental consequences as those that might occur when sediment is mobilised by construction activities (see Impact 8). Water quality monitoring has shown that there is usually only a small and an often difficult to detect depletion of the dissolved oxygen concentration in the water column near dredging operations, but when a depletion is evident the oxygen concentration usually returns to the baseline within a short period (in the order of <30 minutes) after dredging ceases (*e.g.* USACE, 1976; USACE, 1998; Houston *et al*., 1989; Pledger *et al*., 2021).

Dredging will thus mobilise and release sediment into the water column and this will release oxygen depleting substances into the water column. Water quality monitoring near dredging operations has shown that dredging usually has a minimal, localised effect on the dissolved oxygen concentration in the water column. The dissolved oxygen concentration in the water column in the port is usually high. Any depression in the dissolved oxygen concentration that does occur during dredging for Phase 1 and Phase 2 will be temporary as the concentration will return to the baseline when dredging ceases at the end of each day, but may occur daily for a fairly long period and is thus considered **short-term**. Any depression in the dissolved oxygen concentration is likely to be restricted to the area near dredging operations and the spatial extent of this impact is thus **site specific**. Biological communities in the Port of Port Elizabeth are undoubtedly habituated to and tolerant of small fluctuations in the dissolved oxygen concentration in the water column and mobile fauna will be able to avoid areas where the dissolved oxygen concentration is temporarily depressed. The benthic biological community near the dredging footprints is also not especially diverse. There is thus **unlikely** to be a significant impact on ecological processes in the port. The intensity is thus considered **low**. This impact is fully **reversible** as the dissolved oxygen concentration will return the baseline soon after dredging ceases. The significance rating for this impact without mitigation is thus **LOW**.

Impact assessment without mitigation					
Impact	Deterioration in water quality due to the release of oxygen demanding substances from sediment by dredging				
Status	Positive		Negative		
	The release of oxygen depleting substances will negatively impact on water quality that may in turn negatively affect biological communities.				
Nature	Direct	Indirect	Reversible	Irreversible	
	The release of oxygen depleting substances will directly impact on water quality. The oxygen depletion may indirectly impact on biological communities and affect ecological processes. The impact is reversible because sediment mobilisation and the associated release of oxygen depleting substances will cease when construction ceases.				
Extent	Site specific	Local	Regional	National	International
	A depletion in dissolved oxygen concentration is likely to be restricted to a small area near the dredging footprints and the impact is thus site specific.				
Duration	Temporary	Short-Term	Medium-Term	Long-Term	Permanent
	The dissolved oxygen concentration will return to the baseline at the end of each dredging day but could daily throughout the dredging period and is thus considered short-term.				
Intensity	Minor	Low	Moderate	High	Severe
	The depletion in dissolved oxygen concentration is expected to be minimal and biological communities in the port are undoubtedly tolerant of small fluctuations in the dissolved oxygen concentration. The intensity is thus considered low.				
Probability	Highly Unlikely	Unlikely	Possible	Probable	Definite
	The dissolved oxygen concentration in the water column will be depleted by the release of oxygen demanding substances when sediment is mobilised and released by dredging but this is unlikely to lead to a significant decrease in the dissolved oxygen concentration.				
Confidence	Low	Medium	High		
	The confidence that oxygen depleting substances will be released into the water column by dredging is high. The confidence that oxygen concentrations will not decrease so significantly in the water column that this will significantly impact ecological processes in the port is also high.				
Significance	Very Low	Low	Medium	High	Fatally flawed

Mitigation

Recommended mitigation for this impact is outlined below. If the mitigation is implemented the effect will be to reduce the intensity from low to minor and the significance rating for this impact with mitigation is thus

VERY LOW.

Impact assessment with mitigation					
Impact	Deterioration in water quality due to the release of oxygen demanding substances from sediment by dredging				
Mitigation	• Dredging should ideally be performed in winter when most components of biological communities will not be reproducing, the significance being the larval and juvenile stages of marine fauna and the propagules of marine flora are more susceptible to the effects of lower dissolved oxygen concentrations than the adult stages. • Dredging should be completed within the shortest timeframe possible to limit the period over which biological communities might be exposed to lowered dissolved oxygen concentrations. • The dredging footprint should be restricted to the smallest area and depth possible (*i.e.* do not over dredge), to minimise the amount and time over which oxygen depleting substances are mobilised and released from sediment. • If possible, there should be no return flow from dredger hoppers or dredging barges.				
Nature	Direct	Indirect	Reversible	Irreversible	
Extent	Site specific	Local	Regional	National	International
Duration	Temporary	Short-Term	Medium-Term	Long-Term	Permanent
Intensity	Minor	Low	Moderate	High	Severe
Probability	Highly Unlikely	Unlikely	Possible	Probable	Definite
Confidence	Low	Medium	High		
Significance	Very Low	Low	Medium	High	Fatally flawed

Potential for cumulative effects

Certain port operations, such as vessel propeller wash and potentially maintenance dredging, could disturb sediment and mobilise oxygen depleting substances into the water column and in this way could magnify the impact of oxygen depletion because of sediment mobilised by dredging for the proposed project. However, this is not considered significant since the depletion in dissolved oxygen due to dredging for the proposed project is anticipated to be minimal.

Required monitoring

No monitoring is required considering the **VERY LOW** significance rating for this impact. If dredging coincides with water quality surveys for the Long-Term Ecological Monitoring Programme for the Port of Port Elizabeth, the dissolved oxygen concentration in the water column could be measured at stations positioned along a gradient from very near to distant from dredging activities to validate the impact significance rating.

14. Deterioration in water quality due to the release of nutrients from sediment by dredging

Sediment alongside and near the Old Tug Jetty quay area will need to be dredged for Phase 1 of the proposed project to allow the removal of existing scour protection rock near the sheet pile wall, to allow the placement of a stone bed and filter fabric layer, and to allow the positioning of the counterfort wall units. Sediment will also need to be dredged for Phase 2 of the proposed project to provide the necessary water depth for larger vessels and to allow the placing of scour protection rock beneath and near the deck-on-pile structure. There is no information yet on the volume of sediment that will need to be dredged during Phase 1 and Phase 2, nor on the dredging method. This information will be finalised after a geotechnical survey has been completed and the engineering design for each phase has been finalised.

The dredging of sediment will lead to the mobilisation and release of sediment into the water column and in this way will release nutrients into the water column, with the same potential environmental consequences as those that might occur when sediment is mobilised by construction activities (see Impact 9).

Dredging will thus mobilise and release sediment and this way will release nutrients into the water column. Dredging can mobilise and release a considerable volume of sediment into the water column depending on the dredging method. However, the volume of porewater disturbed in the dredging footprints will be very small in the context of the port water volume. It is thus **unlikely** a sufficient volume of nutrients will be released to excessively stimulate the growth of microalgae over and above the growth attributed to existing nutrient concentrations. The impact is thus likely to be **site specific** in extent, **short-term** in duration, and **minor** in intensity. This impact is fully **reversible** since nutrient concentrations will return to the baseline when the disturbance of sediment ceases. The significance rating for this impact without mitigation is thus **VERY LOW**.

Impact assessment without mitigation					
Impact	Deterioration in water quality due to the release of nutrients from sediment by dredging				
Status	Positive		Negative		
	The release of nutrients may negatively impact on water quality that may in turn negatively affect biological communities.				
Nature	Direct	Indirect	Reversible	Irreversible	
	The release of nutrients will directly impact on water quality. The impact on water quality may indirectly stimulate the growth of microalgae and lead to a host of potential ecological impacts. The impact is reversible because sediment disturbance and the release of nutrients will cease when construction ceases, and nutrient concentrations will return to the background.				
Extent	Site specific	Local	Regional	National	International
	The impact is site specific because released nutrients will be diluted and dispersed by currents but will highly unlikely affect nutrient concentrations in the greater port environment or in the adjacent marine environment.				
Duration	Temporary	Short-Term	Medium-Term	Long-Term	Permanent
	Nutrient release will occur throughout the dredging period and the duration is thus short-term.				
Intensity	Minor	Low	Moderate	High	Severe
	The intensity is minor because the concentration of nutrients anticipated to be released at any time by dredging is low.				
Probability	Highly Unlikely	Unlikely	Possible	Probable	Definite
	It is unlikely the released nutrients will stimulate the growth of macro- and microalgae much above the growth attributed to existing nutrient concentrations in the port.				
Confidence	Low	Medium	High		
	The confidence that nutrients will be released into the water column is high. The confidence that nutrient concentrations will not increase so significantly in the water column that this will significantly affect ecological processes is medium because details on the volume of sediment that needs to be dredged and the method of dredging is not available, and because there is no information on nutrient concentrations in sediment in the dredging footprints.				
Significance	Very Low	Low	Medium	High	Fatally flawed

Mitigation

No mitigation is required considering the **VERY LOW** significance rating for this impact. However, it is good practice to implement mitigation to further reduce the potential for and implications of environmental impacts. Recommended mitigation for this impact is thus outlined below. The significance rating for this impact will not change with mitigation and thus remains **VERY LOW**.

Impact assessment with mitigation					
Impact	Deterioration in water quality due to the release of nutrients from sediment by dredging				
Mitigation	• Dredging should ideally be performed in winter when the growth of flora is limited by temperature. • The dredging footprint should be restricted to the smallest area and depth possible (*i.e.* do not over dredge), thereby minimising the amount of nutrients released from sediment.				
Nature	Direct	Indirect	Reversible	Irreversible	
Extent	Site specific	Local	Regional	National	International
Duration	Temporary	Short-Term	Medium-Term	Long-Term	Permanent

Intensity	Minor	Low	Moderate	High	Severe
Probability	Highly Unlikely	Unlikely	Possible	Probable	Definite
Confidence	Low		Medium		High
Significance	Very Low	Low	Medium	High	Fatally flawed

Potential for cumulative effects

Certain port operations, such as vessel propeller wash and potentially maintenance dredging, could disturb sediment and mobilise nutrients into the water column and in this way could magnify the impact of nutrients released because of sediment mobilised by dredging for the proposed project. However, this is not considered significant since the total concentration of nutrients that is anticipated to be released by dredging for the proposed project is very small.

Required monitoring

No monitoring is necessary due to the **VERY LOW** significance of this impact after mitigation. If construction coincides with water quality surveys for the Long-Term Ecological Monitoring Programme for the Port of East London, the findings of these surveys may provide information to validate the impact significance rating.

15. Deterioration in water quality due to the release of toxic chemicals from sediment by dredging

Sediment alongside and near the Old Tug Jetty quay area will need to be dredged for Phase 1 of the proposed project to allow the removal of existing scour protection rock near the sheet pile wall, to allow the placement of a stone bed and filter fabric layer, and to allow the positioning of the counterfort wall units. Sediment will also need to be dredged for Phase 2 of the proposed project to provide the necessary water depth for larger vessels and to allow the placing of scour protection rock beneath and near the deck-on-pile structure. There is no information yet on the volume of sediment that will need to be dredged during Phase 1 and Phase 2, nor on the dredging method. This information will be finalised after a geotechnical survey has been completed and the engineering design for each phase has been finalised.

Dredging can promote the release of toxic chemicals from sediment (Sturve *et al*., 2005; Bocchetti *et al*., 2010; Yeager et al., 2010; Layglon *et al*., 2020), with the same potential environmental consequences as those that might occur when sediment is mobilised by construction activities (see Impact 10).

The contaminant and toxicity status of sediment sampled alongside and near the Old Tug Jetty quay area in August 2022 was discuss under Impact 10 and will thus not be repeated here.

Dredging will **probably** release toxic chemicals into the water column at concentrations that will cause a minor toxic effect to sensitive components of the local biological communities. The intensity for this impact is thus considered **low**, and since the released toxic chemicals will be removed from the water column and/or diluted and dispersed by currents the toxic effects are only likely near the dredging footprints the impact is anticipated to be **site specific**. Toxic chemicals could be released from sediment throughout the dredging period and the duration is thus **short-term**. The impact is fully **reversible** as its potential to occur will cease when dredged ceases and any toxic chemicals that are mobilised and released into the water column will be dispersed and diluted and scavenged from the water column. The significance rating for this impact without mitigation is thus **LOW**.

Impact assessment without mitigation		
Impact	Deterioration in water quality due to the release of toxic chemicals from sediment by dredging	
Status	Positive	Negative
	The release of toxic chemicals may negatively impact on water and sediment quality that may in turn negatively affect biological communities.	

Nature	Direct	Indirect		Reversible	Irreversible
	The release of toxic chemicals will directly impact on water and sediment quality. The impact on water and sediment quality may indirectly affect biological communities. The impact is reversible because sediment disturbance and the release of toxic chemicals will cease when construction ceases, and any toxic chemicals that are mobilised and released into the water column will be dispersed and diluted and scavenged from the water column.				
Extent	Site specific	Local	Regional	National	International
	The impact is site specific because the released toxic chemicals will be removed from the water column and diluted and dispersed by currents and are thus only likely to pose a toxic risk near the dredging footprints.				
Duration	Temporary	Short-Term	Medium-Term	Long-Term	Permanent
	Toxic chemical release could occur throughout the dredging periods and the duration is thus short-term.				
Intensity	Minor	Low	Moderate	High	Severe
	The intensity is low because a low magnitude toxic effect was only evident in one of four sediment samples collected near the Old Tug Jetty quay area and is anticipated to possibly affect only sensitive components of the local biological communities.				
Probability	Highly Unlikely	Unlikely	Possible	Probable	Definite
	It is probable toxic chemicals will be released at concentrations that will cause toxic effects to sensitive components of the biological communities at and very near the dredging footprints.				
Confidence	Low		Medium		High
	The confidence that toxic chemicals will probably be released into the water column by dredging is high. The confidence that the toxic chemicals will cause minor toxicity is medium due to the lack of information on chemical concentrations and toxicity for deeper sediment in the dredging footprints.				
Significance	Very Low	Low	Medium	High	Fatally flawed

Mitigation

The release of toxic chemicals from sediment is an unavoidable impact of the dredging of contaminated sediment and little can be done to directly mitigate this impact other than not dredging at all (the 'Do Nothing' option). The only way that mitigation can reduce the significance of this impact is to lower the intensity. One way to achieve this is to use a silt curtain to limit the dispersion of toxic chemicals adsorbed onto suspended sediment from the dredging site. Other mitigation is outlined below, but these may not be implemented or possible. The significance rating for this impact with mitigation thus remains **LOW**.

Impact assessment with mitigation					
Impact	Deterioration in water quality due to the release of toxic chemicals from sediment by dredging				
Mitigation	• Use dredging methods that limit the loss of fine-grained sediment from dredging equipment, the significance being that many types of toxic chemicals preferentially adsorb onto fine-grained material in the sediment (*e.g.* mud grains, particulate organic matter) and this material has the potential to be transported by currents over the widest area and hence to transfer adsorbed contaminants beyond the dredging footprints. • Use a silt curtain to limit the dispersion of fine-grained material onto which contaminants may be adsorbed from the dredging area. • Dredging should ideally be performed in winter when most fauna and flora will not be breeding, the significance being the larval and juvenile stages of marine fauna and the propagules of marine flora are more susceptible to the effects of toxic chemicals than the adult stages. • Dredging should be completed within the shortest timeframe possible to reduce the period over which biological communities might be exposed to toxic chemicals mobilised from sediment. • The dredging footprint should be restricted to the smallest area and depth possible (*i.e.* do not over dredge), thereby minimising the amount of toxic chemicals mobilised from sediment.				
Nature	Direct	Indirect		Reversible	Irreversible
Extent	Site specific	Local	Regional	National	International
Duration	Temporary	Short-Term	Medium-Term	Long-Term	Permanent
Intensity	Minor	Low	Moderate	High	Severe

Probability	Highly Unlikely	Unlikely	Possible	Probable	Definite
Confidence	Low		Medium		High
Significance	Very Low	Low	Medium	High	Fatally flawed

Potential for cumulative effects

The proposed project will coincide with the berthing and de-berthing of vessels in the Port of Port Elizabeth. The proposed project may coincide with maintenance dredging in the Port of Port Elizabeth. There is a possibility that the release of toxic chemicals from sediment mobilised by vessel propeller wash and maintenance dredging will enhance the impact of toxic chemical release associated with the proposed project, and *vice versa*. However, the cumulative impact will probably not be highly significant considering the very small amount of sediment that is anticipated to be mobilised by construction activities and that sediment across most of the Port of Port Elizabeth is not severely contaminated by chemicals. To mitigate this potential cumulative effect, dredging for the proposed project and maintenance dredging in the Port of Port Elizabeth should be scheduled so they do not overlap.

Required monitoring

No monitoring is necessary considering the **LOW** significance of this impact. If construction coincides with surveys for the Long-Term Ecological Monitoring Programme for the Port of Port Elizabeth, the findings of these surveys may provide information on whether the metal and polycyclic aromatic hydrocarbon contamination status of the water column and sediment in the port has changed markedly, but it will be difficult to ascribe any changes evident in a once off survey and based on the current sampling design for the monitoring programme to dredging activities with a high level confidence.

16. Ecological impacts due to the removal, injury, and disturbance of biological communities in dredging footprints

Sediment alongside and near the Old Tug Jetty quay area will need to be dredged for Phase 1 of the proposed project to allow the removal of existing scour protection rock near the sheet pile wall, to allow the placement of a stone bed and filter fabric layer, and to allow the positioning of the counterfort wall units. Sediment will also need to be dredged for Phase 2 of the proposed project to provide the necessary water depth for larger vessels and to allow the placing of scour protection rock beneath and near the deck-on-pile structure. There is no information yet on the volume of sediment that will need to be dredged during Phase 1 and Phase 2, nor on the dredging method. This information will be finalised after a geotechnical survey has been completed and the engineering design for each phase has been finalised.

The removal, disturbance, and injury of biological communities in and on sediment in the dredging footprint is an unavoidable impact of the dredging of sediment. Benthic macro- and microflora, invertebrate infauna (*e.g.* burrowing prawns and annelid worms), slow moving or sessile (immobile) invertebrate epifauna (*e.g.* gastropods), slow moving fish, and the eggs of fish and invertebrates that develop on sediment are especially susceptible. Dredging usually results in a marked decrease in the species diversity, abundance, and biomass of benthic invertebrate and, if present also macroflora communities in the dredging footprint (*e.g.* Newell *et al*., 1998). Zooplankton, phytoplankton, pelagic invertebrates, and fish may also be entrained into the dredger by suction if the dredging method is hydraulic, and they are injured or (usually) killed in the process (Reine and Clarke, 1998; Wyss *et al*., 1999; Drabble, 2012). The disturbance of sediment by dredging can result in the mobilisation and entrainment of benthic and epibenthic invertebrates into the water column and this may attract fish that feed on the invertebrates to the dredging site. Although this might outwardly appear to be a slight benefit for the fish, the benefit may be short-lived as they run the risk of being entrained into the dredging works. The loss of benthic macro- and microflora and benthic invertebrate infauna and epifauna in the dredging footprint essentially amounts to (temporary) habitat loss or displacement for fish and larger motile invertebrates that feed on the biota, and in this way may affect their abundance and survivorship in addition to other ecosystem processes.

As stated above, the removal, disturbance, and injury of biological communities in dredging footprints is an unavoidable impact of the dredging of sediment. However, benthic invertebrate infauna and epifauna do recolonise newly exposed sediment after dredging. Based on the findings of published studies some benthic invertebrate fauna will probably recolonise or otherwise use the newly exposed sediment within hours to days, but the recovery of benthic biological communities to a comparable species composition, abundance, and biomass to that which existed before dredging will take longer (potentially years in some habitats) (Ellis, 1996; Newell *et al*., 1998). The recovery of biological communities on muddy substrata after dredging disturbance is generally faster than for communities on sandy substrata, and slowest for for communities on gravelly substrata. Initial recolonisation of benthic invertebrate fauna will occur through invasion (or active immigration) by motile fauna (*e.g.* amphipods, crabs; Morton, 1977; van Moorsel 1993, 1994; Hall, 1994) from less disturbed or undisturbed areas nearby and by larval settlement (Skilleter, 1998). Short-lived species and/or species with a high reproduction rate (so-called opportunists, like amphipods and various worms) will likely recover more rapidly than slower growing, longer-lived species (*e.g.* gastropods, large worms).

Dredging will lead to a permanent increase in the water column depth alongside and near the Old Tug Jetty quay area, as the new depth will be maintained by periodic maintenance dredging during the operational phase. The increase in the depth is anticipated to be minimal (in the order of 1-2 m) but might nevertheless reduce in the amount of light reaching the bottom. There are no macroalgae on the bottom and the possibly changed light regime will thus have a limited impact on primary productivity in the port. The changed light regime might impact some invertebrates and fish that feed by sight, but this is unlikely to be significant considering the anticipated small change in depth. It is also unlikely the increase in water column depth will lead to a difference in the types of benthic invertebrate infauna and infauna that will colonise the exposed sediment compared to the existing communities.

Dredging will thus **definitely** remove, injure, and disturb biological communities in the dredging footprints. The removal, injury and disturbance of biological communities will be limited to the dredging footprints and their immediate surroundings and is thus **site specific**, although their loss may affect ecological processes over a wider area of the port. Biota will recolonise sediment in the dredging footprints and the impact is thus fully **reversible**. It will, however, take time for the communities to recover to a comparable species composition, abundance, and biomass to that which existed before dredging, including because scour protection rock will be placed on the sediment at some period after dredging is completed for Phase 1 and it will take time for scour protection rock to be inundated by sediment. The duration of this impact is thus considered **medium-term**. The benthic habitat in the dredging footprints is not particularly unique and the benthic invertebrate community nearby, and thus also presumably in the dredging footprints is not especially species diverse nor abundant when compared to communities elsewhere in the port. There are no apparent benthic or epibenthic invertebrates in sediment near, and hence presumably also in the dredging footprints that are of special ecological, commercial, or social significance. The benthic habitat in the dredging footprints is replicated elsewhere in the port and is thus unlikely to represent critical habitat. Thus, while biological communities in the dredging footprints will be severely impacted by removal, injury, and disturbance, the associated temporary loss of access to this habitat by other fauna and the temporary loss in ecological productivity is unlikely to have a significant impact on ecosystem processes in the port. The intensity is thus considered **low**. The significance rating for this impact without mitigation is thus **MEDIUM**.

Impact assessment without mitigation		
Impact	Ecological impacts due to the removal, injury, and disturbance of biological communities in dredging footprints	
Status	Positive	Negative
	Dredging will result in the removal, injury, and disturbance of biological communities in the dredging footprints and a loss in ecological productivity.	

Nature	Direct	Indirect	Reversible	Irreversible	
	Dredging will directly impact on biological communities in the dredging footprint. The impact to biological communities in the dredging footprint will indirectly impact on the ecological productivity of the port. The impact is reversible because biota will recolonise and use the dredged area after dredging and construction has ceased.				
Extent	Site specific	Local	Regional	National	International
	The loss, injury and disturbance of biological communities will be limited to the dredging footprints and their immediate surroundings is thus considered site specific.				
Duration	Temporary	Short-Term	Medium-Term	Long-Term	Permanent
	The impact is medium-term because although biota will recolonise the dredged area after dredging ceases it will take time for the communities to recover to a comparable species composition, abundance, and biomass to that existing before dredging.				
Intensity	Minor	Low	Moderate	High	Severe
	Biological communities in dredging footprints will be severely impacted, but this will have a low intensity effect on the ecology of the port.				
Probability	Highly Unlikely	Unlikely	Possible	Probable	Definite
	The removal, injury, and disturbance of biological communities in the dredging footprints is definite.				
Confidence	Low	Medium	High		
	The confidence that biological communities in the dredging footprints will be lost or disturbed and that this will have an impact on ecological productivity in the port is high. The confidence that the newly exposed sediment will be recolonised by biota and that the area will provide functionally similar ecological productivity and ecosystem services to the pre-dredging sediment is also high. The confidence that the temporary loss of biological communities in the dredging footprints will have a minor impact on ecological productivity in the port is medium in the absence of information on the productivity of the affected habitat and biological communities.				
Significance	Very Low	Low	Medium	High	Fatally flawed

Mitigation

The removal, injury, and disturbance of biological communities in dredging footprints is an unavoidable impact of the dredging of sediment and little can be done to mitigate this impact other than not dredging at all (the 'Do Nothing' option). If the mitigation outlined below is implemented it would change the intensity from medium to low. However, in the absence of more detailed information on the dredging method the significance rating for this impact with mitigation remains **MEDIUM**.

Impact assessment with mitigation					
Impact	Ecological impacts due to the removal, injury, and disturbance of biological communities in dredging footprints				
Mitigation	• Dredging should ideally be performed in winter when ecological productivity is lowest and dependencies by other biota on biological communities in and near the dredging footprints is lowest. • Dredging should be completed within the shortest timeframe possible so that recolonisation of the exposed can proceed. • The dredging footprint should be restricted to the smallest area and depth possible (*i.e.* do not over dredge) to minimise the area disturbed and the duration of dredging.				
Nature	Direct	Indirect	Reversible	Irreversible	
Extent	Site specific	Local	Regional	National	International
Duration	Temporary	Short-Term	Medium-Term	Long-Term	Permanent
Intensity	Minor	Low	Moderate	High	Severe
Probability	Highly Unlikely	Unlikely	Possible	Probable	Definite
Confidence	Low	Medium	High		
Significance	Very Low	Low	Medium	High	Fatally flawed

Potential for cumulative effects

The proposed project will coincide with the berthing and de-berthing of vessels in the port. The proposed project may coincide with maintenance dredging in the Port of Port Elizabeth. There is a probability that the disturbance of fauna and flora communities by vessel propeller wash and maintenance dredging will enhance the impact of the disruption of ecosystem processes associated with the proposed project, and *vice versa*. However, the cumulative impact will probably not be highly significant considering the small area of sediment that needs to be dredged or otherwise disturbed for the proposed project, and that benthic biological communities elsewhere in the port are regularly disturbed by vessel propeller wash. To mitigate this potential cumulative effect, dredging for the proposed project and maintenance dredging in the Port of Port Elizabeth should be scheduled so they do not overlap.

Required monitoring

No monitoring is required since there is sufficient information in the scientific literature to show that benthic biological communities disturbed by dredging do recover.

17. Deterioration in water quality due to an increase in suspended sediment concentrations during dredged sediment disposal

The sediment dredged in Phases 1 and 2 of the proposed project will be disposed at a registered dredged spoil disposal site in Algoa Bay. Dredged sediment is usually disposed from a dredge vessel or barge through two half doors or valves at the bottom of the hull. The dredged sediment in a hopper or barge represents a dense slurry that, when disposed, behaves as a dense fluid when released into the less dense seawater surrounding it. Surveys have shown that most of the sediment disposed in this way reaches the bottom as a fluid mass. However, some of the sediment is stripped into suspension from the descending mass by friction and entrainment of surrounding water. Dredge vessels often dispose of sediment while moving and at the end of a disposal event will pass water through the hopper to remove sediment trapped at door hinges and so on, which promotes the suspension of sediment. Sediment is also mobilised into suspension when the fluid sediment mass impacts the seabed and surges as a density current laterally under its momentum. The sediment left in suspension by the descent and impact on the seabed will disperse under the impact of currents. Estimates of the volume of sediment stripped from the fluid mass during descent range from about 1-4% (Truitt, 1986). Some portion of this 1-4% mass of suspended sediments stripped from the main mass of material likely deposits in the immediate vicinity of the disposal and thus remains inside most disposal sites, although the size of this portion will vary considerably with site and sediment characteristics. The very fine fraction of sediment on the deposited mass is also eroded and mobilised into suspension by currents at the time of deposition, and then gradually over a longer timeframe after disposal (Palanques *et al*., 2022).

An increase in suspended sediment concentrations and turbidity generated by the open water disposal of dredged sediment is usually restricted to the lower part (15-20%) of the water column and declines by orders of magnitude toward the surface (Truitt, 1988). The increase in suspended sediment concentrations and turbidity near the bottom may be intense depending on the nature and volume of the sediment disposed and characteristics of the disposal site (Palanques *et al*., 2022). However, the suspended sediment concentration and turbidity decreases rapidly after a disposal event and usually approaches the background within tens of minutes to a few hours (USACE, 1976; LTMS, 1998; van Parijs *et al*., 2002; Anchor, 2003; Roman-Sierra et al., 2011; USACE, 2015; Palanques *et al*., 2022), although in large volume dredging projects the disposal events may be so frequent the suspended sediment concentration does not approach the background until the dredging programme ceases (Palanques *et al*., 2022).

The mobilisation of deposited sediment by currents following a disposal event may continue for some time, leading to frequent, low intensity increases in the suspended sediment concentration and turbidity (Palanques *et al*., 2022).

A satellite image in Google Earth that captured a dredger disposing sediment dredged in the Port of Port Elizabeth at the dredged spoil disposal site in Algoa Bay provides an example of the impact of sediment disposal on the suspended sediment concentration in the water column. In this case a suspended sediment plume is evident at the water surface, which probably reflects the fact the dredger was moving while disposing sediment. The dredger in the satellite image might be far larger than the vessel/barge that will be used to dispose dredged sediment for the proposed project. The extent of the impact on suspended sediment concentrations in the water column may thus be smaller for the proposed project.

An increase in the suspended sediment concentration and turbidity in the water column due to dredged sediment disposal can have the same potential environmental consequences as those that might occur when sediment is mobilised by construction activities (see Impact 6).

There is no information on benthic and pelagic biological communities at and very near the dredged spoil disposal site in Algoa Bay. There are no benthic macroalgae in the area but the water column can be expected to provide habitat for a range of microalgal, invertebrate, and fish species. Masikane (2011) investigated the structure and composition of benthic invertebrate communities at a 10 m water column depth at six stations in Algoa Bay, one of which was situated off the Papenkuils River inshore of the dredged spoil disposal site. Masikane (2011) performed two surveys at the stations, one in 2008 and another in 2009. The sediment at the Papenkuils River station was found to comprise a higher fine-grained fraction and to have a higher total organic content than other stations. In both surveys the benthic invertebrate community at the Papenkuils River station was dominated by polychaetes, followed either by amphipods or bivalves. Decapoda were also an important component of the community. In contrast, the benthic invertebrate community at other stations was dominated by amphipods. Masikane (2011) concluded that the primary factor influencing the difference in the benthic invertebrate community structure and composition at the Papenkuils River station compared to other stations was the discharge of effluent from the river. Many species of polychaete worms are known to tolerate and in some cases flourish in areas influenced by effluent discharge and may account for the dominance of the benthic invertebrate community by polychaetes.

It is reasonable to assume that benthic biological communities at and near the dredged spoil disposal site in Algoa Bay have been shaped by the repeated disposal of dredged sediment from the Port of Port Elizabeth, and that the communities are to a large degree probably habituated to and tolerant of dredged sediment disposal. Evidence from satellite imagery provided in Google Earth also provides evidence the communities at and near the dredged spoil disposal site are also periodically exposed to elevated suspended sediment concentrations and turbidity associated with high flow discharge events from the Papenkuils River and Swartkops River estuary.

Schumann *et al*. (2005) recorded an average current velocity at 12 m depth about 1 km off the Papenkuils River mouth of ~0.04 $m.s^{-1}$ and an apparent maximum velocity of ~0.15 $m.s^{-1}$. Calm conditions (<0.01 $m.s^{-1}$) occurred about 9.5% of the time. The currents were found to largely flow parallel to the coast, with the dominant flow to the north. It should, however, be noted that current measurements were made for a short period of 46 days and probably do not reflect the trend for currents through the year. However, the weak current speeds are consistent with the higher mud fraction present in sediment in the sheltered western part of Algoa Bay, including at the dredged spoil disposal site.

The disposal of dredged sediment will increase the suspended sediment concentration and turbidity above the baseline in the water column at and near the open water dredged spoil disposal site in Algoa Bay. This is an unavoidable impact of dredged sediment disposal at open water dredged spoil disposal sites. The findings of studies elsewhere in the world show that the increase in the suspended sediment concentrations and turbidity above the baseline after open water dredged sediment disposal is usually restricted to a small area (few hundred meters) and returns to the baseline soon after each disposal event, although some fine-grained material may be dispersed over a wide area depending on prevailing conditions. It is reasonable to assume this will also be the case at the dredged spoil disposal site in Algoa Bay based on the slow current speeds recorded the site. The impact on water quality though an increase in the suspended sediment concentration and turbidity is thus anticipated to be **site specific** and the duration **temporary**. The impact is anticipated to be of a **minor** intensity since biological communities at and near the dredged spoil disposal site are probably habituated to and thus tolerant of the impacts of elevated suspended sediment concentrations and turbidity through the repeated disposal of dredged sediment at the dredged spoil disposal site. The biological communities are also periodically exposed to elevated suspended sediment concentrations and turbidity associated with discharges from the Papenkuils River and Swartkops River estuary. The impact is fully **reversible** since increases in the suspended sediment concentration and turbidity will cease after dredged sediment disposal ceases and affected biological communities will recover. The significance rating for this impact is thus **VERY LOW**.

Impact assessment without mitigation					
Impact	Deterioration in water quality due to an increase in suspended sediment concentrations during dredged sediment disposal				
Status	Positive		Negative		
	The impact is negative since the disposal of dredged sediment will adversely impact on water quality on and near the dredged spoil disposal site.				
Nature	Direct	Indirect	Reversible	Irreversible	
	The impact is direct because the disposal of sediment will have a direct impact on water quality on and near the dredged spoil disposal site. The impact is also indirect because the impact to water quality will adversely impact on fauna and flora on and near the dredged spoil disposal site, and potentially over a wider area in Algoa Bay. The impact is reversible because the suspended sediment will settle from the water column and the suspended sediment concentration and associated turbidity will return to the background for the area.				
Extent	Site specific	Local	Regional	National	International
	The disposal of sediment will have a direct site-specific impact on water quality, but the impact to fauna and flora could disrupt ecological processes in the wider Algoa Bay.				
Duration	Temporary	Short-Term	Medium-Term	Long-Term	Permanent
	The impact is temporary because it is highly likely the suspended sediment concentration and associated turbidity of the water column will quickly return to the background.				
Intensity	Minor	Low	Moderate	High	Severe
	The intensity is minor because biological communities at and near the dredged spoil disposal site are likely to be habituated to and thus tolerant of the impacts of periodically elevated suspended sediment concentrations and turbidity through repeated dredged sediment disposal and periodic discharges from nearby rivers and estuaries.				
Probability	Highly Unlikely	Unlikely	Possible	Probable	Definite
	The disposal of dredged sediment will result in an increase in the suspended solids concentration and turbidity above the baseline. This is an unavoidable impact of dredged sediment disposal at open water dredged spoil disposal sites.				
Confidence	Low		Medium	High	
	The confidence that the disposal of dredged sediment will lead to an increase in the suspended sediment concentration and turbidity in the water column and that this will have a minor impact on biological communities at and near the dredged spoil disposal site is high.				
Significance	Very Low	Low	Medium	High	Fatally flawed

Mitigation

No mitigation is required considering the **VERY LOW** significance rating for this impact. The mobilisation of suspended sediment into the water column is an unavoidable impact of open water dredged sediment disposal and little can be done to mitigate this impact. Mitigation that can be implemented to further reduce the significance of this impact is nevertheless outlined below. The significance rating for this impact will remain **VERY LOW** with mitigation

Impact assessment with mitigation	
Impact	Deterioration in water quality due to an increase in suspended sediment concentrations during dredged sediment disposal
Mitigation	• Dredged sediment should ideally be disposed in late winter to early spring when most fauna and flora will not be breeding, the significance being that larval and juvenile stages of marine fauna and propagules of marine fauna are more susceptible to the effects of suspended sediment than adult stages. • Dredging should be completed within the shortest timeframe possible to reduce the

	period over which fauna and flora might be exposed to elevated suspended sediment and turbidity due to the disposal of dredged sediment. • The dredging footprint should be restricted to the smallest area and depth possible (*i.e.* do not over dredge), thereby minimising the amount of sediment that needs to be disposed at the dredged spoil disposal site.				
Nature	Direct	Indirect	Reversible	Irreversible	
Extent	Site specific	Local	Regional	National	International
Duration	Temporary	Short-Term	Medium-Term	Long-Term	Permanent
Intensity	Minor	Low	Moderate	High	Severe
Probability	Highly Unlikely	Unlikely	Possible	Probable	Definite
Confidence	Low	Medium	High		
Significance	Very Low	Low	Medium	High	Fatally flawed

Potential for cumulative effects

Dredging for the proposed project might coincide with maintenance dredging in the Port of Port Elizabeth. There is a possibility that water quality impairment caused by an increase in the suspended sediment concentration and turbidity above the baseline due to the disposal of sediment dredged for the proposed project could be enhanced by the concurrent disposal of maintenance dredged sediment at the dredged spoil disposal site. To mitigate this potential cumulative effect dredging for the proposed project and maintenance dredging in the Port of Port Elizabeth could be scheduled so they do not overlap, but this is not a necessity considering the very low significance rating for this impact. The period between the last disposal event for sediment dredged for the proposed project and the start of dredged sediment disposal for the next maintenance dredging cycle, or *vice versa*, should be as long as possible to allow time for the erosion of sediment from the spoil disposal site and for suspended sediment concentrations and turbidity to return to the baseline, and to provide biological communities to recover to some degree. The same sectors of the dredged spoil disposal site where dredged sediment is disposed for the proposed project and for maintenance dredging should also be different.

Required monitoring

No monitoring is required considering the **VERY LOW** significance rating for this impact.

18. Deterioration in water quality due to the release of oxygen depleting substances from sediment during disposal

The sediment dredged in Phases 1 and 2 of the proposed project will be disposed at a registered dredged spoil disposal site in Algoa Bay. Dredged sediment is usually disposed from a dredge vessel or barge through two half doors or valves at the bottom of the hull. The dredged sediment in a hopper or barge represents a dense slurry that, when disposed, behaves as a dense fluid when released into the less dense seawater surrounding it. Surveys have shown that most of the sediment disposed in this way reaches the bottom as a fluid mass. However, some of the sediment is stripped into suspension from the descending mass by friction and entrainment of surrounding water. In this way oxygen depleting substances may be released into the water column, with the same potential impacts as those that might occur when sediment is mobilised by construction activities (see Impact 8). Monitoring near open water dredged sediment disposal operations has shown that the dissolved oxygen depletion in the water column near open water dredged sediment disposal operations has shown that the dissolved oxygen concentration in the disposal plume can at times fall to 0 $mg.l^{-1}$, but in most cases the depletion is usually minimal, localised, and usually difficult to detect from the baseline away from the disposal plume (Slotta *et al*., 1973; Westley *et al*., 1973; USACE, 1976; USACE, 1998).

Dredged sediment disposal will thus mobilise and release sediment into the water column and in this way will release oxygen depleting substances into the water column. As stated above, monitoring has shown that the effect of dredged sediment disposal on the dissolved oxygen concentration in the water column is usually minimal, localised, and in most cases it is difficult to detect a difference to the baseline a short distance from a dredged sediment disposal operation. The dissolved oxygen concentration in the water column at the dredged spoil disposal site is unknown. Masikane (2011) provides a mean dissolved oxygen concentration for the (integrated) water column at a site at the 10 m contour off the Papenkuils River mouth (*i.e.* inshore of the dredged spoil disposal site) of 6.84 $mg.l^{-1}$ in a survey in 2008 and 6.53 $mg.l^{-1}$ in a survey in 2009. The bottom water concentration was lower than the integrated concentration for the water column, at 5.28 $mg.l^{-1}$ in 2008 and 5.62 $mg.l^{-1}$ in 2009. These concentrations exceed that which is usually considered adequate to sustain most forms of aquatic life (5 $mg.l^{-1}$). It is thus **probable** the dissolved oxygen concentration in the water column will be depleted when dredged sediment is disposed. Any reduction in the dissolved oxygen concentration that does occur will, however, be **temporary** as the concentration will return to the baseline shortly after dredged sediment disposal ceases since currents will replenish the concentration. The depletion is unlikely to have a significant impact on ecological processes as the dissolved oxygen concentration in the water column at and near the dredged spoil disposal site is probably fairly high. The impact is thus considered **site specific** in spatial extent and **minor** in intensity. The impact is fully **reversible** as the dissolved oxygen concentration will return to the baseline shortly after each disposal event. The significance rating for this impact without mitigation is thus **VERY LOW**.

Impact assessment without mitigation					
Impact	Deterioration in water quality due to the release of oxygen depleting substances from sediment during disposal				
Status	Positive		Negative		
	The release of oxygen depleting substances from disposed sediment will negatively impact on water quality that may in turn may negatively affect biological communities.				
Nature	Direct	Indirect	Reversible	Irreversible	
	The release of oxygen depleting substances will directly impact on water quality. The oxygen depletion may indirectly impact on biological communities and affect ecological processes. The impact is reversible because the dissolved oxygen concentration will return to the baseline when dredged sediment disposal ceases.				
Extent	Site specific	Local	Regional	National	International
	The impact is site specific because oxygen depletion is unlikely to affect an area of more than a few tens of meters from the point of dredged sediment disposal.				
Duration	Temporary	Short-Term	Medium-Term	Long-Term	Permanent
	Oxygen depletion is anticipated to be temporary as the oxygen concentration in the water column will be replenished by currents after each disposal event.				
Intensity	Minor	Low	Moderate	High	Severe
	The intensity is minor because the depletion in the oxygen concentration is anticipated to be minimal.				
Probability	Highly Unlikely	Unlikely	Possible	Probable	Definite
	It is probable the dissolved oxygen concentration in the water column will be depleted during sediment disposal.				
Confidence	Low	Medium	High		
	The confidence that oxygen depleting substances will be released into the water column during dredged sediment disposal is high. The confidence that oxygen concentration will not decrease so significantly in the water column that this will result have a significant impact on ecological processes is also high.				
Significance	Very Low	Low	Medium	High	Fatally flawed

Mitigation

No mitigation is required considering the **VERY LOW** significance rating for this impact. However, it is good practice to implement mitigation to further reduce the potential for and implications of environmental impacts. The significance rating for this impact with mitigation will remain **VERY LOW**.

Impact assessment with mitigation	
Impact	Deterioration in water quality due to the release of oxygen depleting substances from sediment during disposal
Mitigation	• Dredging, and hence dredged sediment disposal, should ideally be performed in winter when most fauna and flora will not be breeding, the significance being the larval and juvenile stages of marine fauna and the propagules of marine flora are more susceptible

	to the effects of low dissolved oxygen concentrations than the adult stages.				
Nature	Direct	Indirect	Reversible	Irreversible	
Extent	Site specific	Local	Regional	National	International
Duration	Temporary	Short-Term	Medium-Term	Long-Term	Permanent
Intensity	Minor	Low	Moderate	High	Severe
Probability	Highly Unlikely	Unlikely	Possible	Probable	Definite
Confidence	Low	Medium	High		
Significance	Very Low	Low	Medium	High	Fatally flawed

Potential for cumulative effects

Dredging for the proposed project might coincide with maintenance dredging in the Port of Port Elizabeth. There is a possibility that the disposal of sediment dredged for the proposed project and that maintenance dredged could be disposed at the same time and that this could enhance oxygen depletion in the water column. Although the enhancement is likely to be minimal, to mitigate this potential cumulative effect, dredging for the proposed project and maintenance dredging in the Port of Port Elizabeth should be scheduled so they do not overlap.

Required monitoring

No monitoring is required considering the **VERY LOW** significance rating for this impact.

19. Deterioration in water quality due to the release of nutrients from sediment during disposal

The sediment dredged in Phases 1 and 2 of the proposed project will be disposed at a registered dredged spoil disposal site in Algoa Bay. Dredged sediment is usually disposed from a dredge vessel or barge through two half doors or valves at the bottom of the hull. The dredged sediment in a hopper or barge represents a dense slurry that, when disposed, behaves as a dense fluid when released into the less dense seawater surrounding it. Surveys have shown that most of the sediment disposed in this way reaches the bottom as a fluid mass. However, some of the sediment is stripped into suspension from the descending mass by friction and entrainment of surrounding water. In this way nutrients in the sediment may be released into the water column (Varkitzi *et al*., 2022), with the same potential environmental consequences as those that might occur when sediment is mobilised by construction activities (see Impact 9). Nutrient concentrations in Algoa Bay are generally low but are higher at and near wastewater discharges from the Papenkuils River estuary and Fishwater Flats marine outfall (van Zyl, 2017).

Dredged sediment disposal will thus mobilise and release sediment into the water column and in this way will release nutrients into the water column. The nutrients will be diluted and dispersed by currents after release. The increase in nutrient concentrations above the baseline is thus likely to be **site specific** in spatial extent and **temporary** in duration. It is **highly unlikely** the released nutrients will stimulate the growth of macro- and microalgae much above the growth attributed to existing nutrient concentrations in Algoa Bay, which are generally low. The intensity is thus anticipated to be **minor**. This impact is fully **reversible** since nutrient concentrations will return to the baseline after each disposal event. The significance rating for this impact without mitigation is thus **VERY LOW**.

Impact assessment without mitigation				
Impact	Deterioration in water quality due to the release of nutrients from sediment during disposal			
Status	Positive	Negative		
	The release of nutrients may negatively impact on water quality that may in turn negatively affect biological communities.			
Nature	Direct	Indirect	Reversible	Irreversible
	The release of nutrients will directly impact on water quality. The released nutrients may indirectly stimulate the growth of microalgae and lead to a host of potential ecological			

	impacts. The impact is reversible because the release of nutrients into the water column will cease when dredged sediment disposal ceases.				
Extent	Site specific	Local	Regional	National	International
	The impact is site specific because the released nutrients will be rapidly diluted and dispersed by currents.				
Duration	Temporary	Short-Term	Medium-Term	Long-Term	Permanent
	Nutrient release will occur throughout the dredging period, but the increase in nutrient concentrations will only be temporary at each disposal event.				
Intensity	Minor	Low	Moderate	High	Severe
	The intensity is minor because a low concentration of nutrients is anticipated to be released into the water column.				
Probability	Highly Unlikely	Unlikely	Possible	Probable	Definite
	It is highly unlikely the released nutrients will stimulate the growth of macro- and microalgae much above the growth attributed to existing nutrient concentrations in Algoa Bay.				
Confidence	Low		Medium		High
	The confidence that nutrients will highly likely be released into the water column during dredged sediment disposal is high. The confidence that nutrient concentrations will not increase so significantly in the water column that this will result in a major impact is medium because there is no information on nutrient concentrations in sediment in the dredging footprints.				
Significance	Very Low	Low	Medium	High	Fatally flawed

Mitigation

No mitigation is required considering the **VERY LOW** significance rating for this impact. However, it is good practice to implement mitigation to further reduce the potential for and implications of environmental impacts. Recommended mitigation for this impact is thus outlined below. The significance rating for this impact will not change with mitigation and thus remains **VERY LOW**.

Impact assessment with mitigation					
Impact	Deterioration in water quality due to the release of nutrients from sediment during disposal				
Mitigation	• Dredging should ideally be performed in winter when the growth of flora is limited by temperature.				
Nature	Direct	Indirect	Reversible	Irreversible	
Extent	Site specific	Local	Regional	National	International
Duration	Temporary	Short-Term	Medium-Term	Long-Term	Permanent
Intensity	Minor	Low	Moderate	High	Severe
Probability	Highly Unlikely	Unlikely	Possible	Probable	Definite
Confidence	Low		Medium		High
Significance	Very Low	Low	Medium	High	Fatally flawed

Potential for cumulative effects

Dredging for the proposed project might coincide with maintenance dredging in the Port of Port Elizabeth. There is a possibility that the disposal of sediment dredged for the proposed project and that maintenance dredged could be disposed at the same time and that this could enhance oxygen depletion in the water column. Although the enhancement is likely to be minimal, to mitigate this potential cumulative effect, dredging for the proposed project and maintenance dredging in the Port of Port Elizabeth should be scheduled so they do not overlap.

Required monitoring

No monitoring is necessary due to the **VERY LOW** significance rating for this impact.

20. Ecological impacts due to the transfer of toxic chemicals in dredged sediment to the dredged spoil disposal site

The sediment dredged in Phases 1 and 2 of the proposed project will be disposed at a registered dredged spoil disposal site in Algoa Bay. The transfer of toxic chemicals in contaminated sediment to open water dredged spoil disposal sites should such disposal be allowed is an unavoidable impact of dredged sediment disposal (Stronkhorst *et al*., 2003; De Witte *et al*., 2016; Donázar-Aramendía *et al*., 2020; Tao *et al*., 2021). Components of the biological community that survive or avoid the physical effects of dredged sediment disposal (*e.g.* burial, smothering) and those that colonise the deposited sediment on the dredged spoil disposal site can be exposed to toxic chemicals in the sediment. The toxic chemicals may pose an acute or chronic toxic risk to biological communities, which might also bioaccumulate the chemicals and in this way the chemicals enter food webs in the relevant area (Donázar-Aramendía *et al*., 2020). Disposed sediment is gradually eroded by currents from dredged spoil disposal sites and in this way deeper sediment that is contaminated by toxic chemicals is exposed, potentially prolonging the exposure of biological communities to toxic chemicals. Toxic chemicals adsorbed onto sediment eroded and dispersed from a dredged spoil disposal site by currents will be deposited in the surrounding area, transferring the contaminants to these areas and increasing the spatial extent over which biological communities might be exposed to toxic chemicals. However, the concentrations in this deposited sediment will be lower than that disposed due to dilution with the surrounding sediment.

The sediment alongside and near the Old Tug Jetty quay area is metal contaminated. There is no information on the concentrations of other chemicals in sediment alongside the quay area but there is information on polycyclic aromatic hydrocarbon, organochlorine pesticide, polychlorinated biphenyl, and butyltin concentrations in sediment near part of the quay area. It is impossible to determine if these chemicals are present in sediment that will be dredged alongside the Old Tug Jetty quay area, but this is probable considering the trend for the sediment nearby and elsewhere in the port. Following the precautionary principle, therefore, the sediment across the dredging footprints is assumed to be mildly contaminated by a suite of toxic chemicals. The sediment is not severely contaminated by metals. Metal concentrations in the sediment are lower than concentrations specified by the Level I and Level II of the sediment quality guidelines (Action List) that the Department of Forestry, Fisheries and the Environment uses to regulate the open water disposal of sediment dredged in South African ports. The South African Action List does not provide guidelines for organic chemicals. The concentrations of organic chemicals in sediment near the Old Tug Jetty quay area do not exceed the Effects Range Low of the sediment quality guidelines derived by Long *et al*. (1995) for use in North American coastal waters. The Long *et al.* (1995) sediment quality are widely used to assess the risks posed by chemicals in sediment and have a similar narrative intent as the South African National Action List. The sediment is thus also considered suitable for open water disposal based on the concentrations of other toxic chemicals. The sediment sampled at four stations alongside and near the Old Tug Jetty quay area in July 2022 was tested for toxicity to sea urchin embryo-larvae under a sediment-water interface testing regime. The sediment at three of the stations was not toxic to sea urchin embryo-larvae, while that at the fourth station was slightly toxic. Following the precautionary principle the sediment across the dredging footprints is assumed to be slightly toxic.

The sediment at the dredged spoil disposal site was not significantly contaminated by metals when surveyed in 2017 (Figures 43 and 44).

Toxic chemicals in sediment dredged alongside and near the Old Tug Jetty quay area will thus be transferred to dredged spoil disposal site in Algoa Bay. During disposal, the contaminants will concentrate initially on the dredged disposal site but over time will be eroded and dispersed along with sediment, and in this way they will be diluted and dispersed over a wider area in Algoa Bay. It is unlikely toxic chemicals in the sediment will pose a significant acute toxic risk to all but the most sensitive components of biological communities at and near the dredged spoil disposal site considering the results of the toxicity testing of sediment sampled in the Port of Port Elizabeth in July 2022, including alongside the Old Tug Jetty quay area, but a chronic impact is **possible**. The intensity for this impact is thus considered **low**. The impact is considered **site specific** in extent since toxic chemicals in sediment eroded and dispersed from the dredged spoil disposal site will be deposited over a wider area and in this way will be diluted and are thus unlikely to present an acute toxic risk. The dredged spoil disposal site is not in a particularly dispersive environment and it might thus take some time for toxic chemicals to be eroded and dispersed from the site. The gradual erosion of contaminated sediment will increase the period over which biological communities might be exposed to toxic chemicals in the sediment. The impact is thus considered **short-term** in duration. The impact is fully **reversible** since sediment will be dispersed from the disposal site with time, diluting the concentrations of toxic chemicals. The significance rating for this impact without mitigation is thus **LOW**.

Impact assessment without mitigation					
Impact	Ecological impacts due to the transfer of toxic chemicals in dredged sediment to the dredged spoil disposal site				
Status	Positive		Negative		
	Toxic chemicals in dredged sediment will negatively impact on sediment quality at and near the dredged spoil disposal site that may in turn negatively affect biological communities.				
Nature	Direct	Indirect	Reversible	Irreversible	
	Toxic chemicals in disposed sediment will directly impact on sediment quality on the and near the dredged spoil disposal site. The toxic chemicals in disposed sediment may impact biological communities on and near the dredged spoil disposal site. The impact is reversible because the disposed sediment and associated toxic chemicals will be eroded and dispersed from the dredged spoil disposal site over time.				
Extent	Site specific	Local	Regional	National	International
	The impact is site specific in extent because although toxic chemicals in sediment eroded and dispersed from the dredged spoil disposal site will be deposited over a wider area, they will be dispersed and diluted in the process are thus unlikely to present a toxic risk.				
Duration	Temporary	Short-Term	Medium-Term	Long-Term	Permanent
	The impact is short-term because the dredged spoil disposal site is not in a dispersive environment, and it may take some time for currents to erode and disperse contaminated sediment from the site. The gradual erosion of contaminated sediment will also increase the period over which biological communities might be exposed to toxic chemicals in the sediment.				
Intensity	Minor	Low	Moderate	High	Severe
	The intensity is low since toxic chemicals transferred to the dredged spoil disposal site are unlikely to pose a significant toxic risk to biological communities, but might pose a chronic toxicity risk.				
Probability	Highly Unlikely	Unlikely	Possible	Probable	Definite
	The transfer of toxic chemicals in dredged sediment to the dredged spoil disposal site will occur, and it is possible the chemicals may pose a toxic risk to biological communities.				
Confidence	Low	Medium	High		
	The confidence that toxic chemicals in dredged sediment will be transferred to the dredged spoil disposal site is high. This is an unavoidable consequence of the open water disposal of contaminated sediment. The confidence that toxic chemicals in the sediment will possibly pose a chronic toxic risk to biological communities is medium (they are considered unlikely to do so but the absence of information on toxic chemicals other than metals this raises some uncertainty).				
Significance	Very Low	Low	Medium	High	Fatally flawed

Mitigation

There is nothing that can be done to directly mitigate this impact other than not dredging at all (the 'Do Nothing' option) or disposing of dredged sediment at a landfill site on land. However, the latter option is unlikely to be followed and comes with its own environmental impacts that could outweigh those associated with open water disposal. Mitigation that can be considered is outlined below but it is uncertain if this mitigation will be possible and in the case of thin layer placement comes with its own environmental implications. The significance rating for this impact thus remains **LOW** with mitigation.

Impact assessment with mitigation	
Impact	Ecological impacts due to the transfer of toxic chemicals in dredged sediment to the dredged spoil disposal site
Mitigation	• Dredged sediment should be disposed in as thin a layer on the dredged spoil disposal site as is possible as this will facilitate the dispersion of contaminated sediment from the spoil

	disposal site over as large an area possible, and in this way dilute the toxic chemical concentrations. Thin layer placement will also oxygenate sediment, facilitating the oxidation (breakdown) of toxic chemicals such as hydrogen sulphide. However, this will lead to elevated suspended sediment concentrations and turbidity over a far wider area compared to the disposal of sediment in a confined area of the dredged spoil disposal site. • Dredging, and hence the disposal of dredged sediment, should ideally be done in winter when most fauna and flora will not be breeding, the significance being that larval and juvenile stages of marine fauna and propagules of marine flora are more susceptible to the effects of toxic chemicals than adult stages.				
Nature	Direct	Indirect	Reversible	Irreversible	
Extent	Site specific	Local	Regional	National	International
Duration	Temporary	Short-Term	Medium-Term	Long-Term	Permanent
Intensity	Minor	Low	Moderate	High	Severe
Probability	Highly Unlikely	Unlikely	Possible	Probable	Definite
Confidence	Low	Medium	High		
Significance	Very Low	Low	Medium	High	Fatally flawed

Potential for cumulative effects

Dredging for the proposed project may coincide with maintenance dredging in the Port of Port Elizabeth. There is thus a possibility that toxic chemicals in sediment maintenance dredged elsewhere in the port and transferred to the dredged spoil disposal site could magnify the impact of toxic chemicals transferred in sediment dredged for the proposed project. However, the cumulative impact will probably not be significant considering sediment across the Port of Port Elizabeth is not severely contaminated by chemicals apart from manganese, and that the toxicity testing of sediment sampled in the port in 2022 showed slight toxicity for sediment in parts of the port, but in most parts the sediment was not toxic. To mitigate this potential cumulative effect, dredging for the proposed project and maintenance dredging in the Port of Port Elizabeth should be scheduled so they do not overlap. The period between the last disposal event for sediment dredged for the proposed project and the start of dredged sediment disposal for the next maintenance dredging cycle should be as long as possible as this will provide time for contaminated sediment to be dispersed from the disposal site.

There is also a possibility that the impact of toxic chemicals transferred in sediment to the dredged spoil disposal site could be magnified by the accumulation on the site of toxic chemicals introduced from other sources into Algoa Bay, including via surface (stormwater) runoff from urban areas and the discharge of wastewater via the Papenkuils River. However, any toxic chemicals introduced into Algoa Bay from other sources are unlikely to accumulate to any significant degree on the dredged spoil disposal site since the site is about 1.6 km from the nearest shoreline. Toxic chemicals that are introduced from shoreline sources into Algoa Bay are thus likely to undergo substantial dilution, transformation, and deposition by the time currents might cause them to pass over the dredged spoil disposal site. Furthermore, the sediment on the dredged spoil disposal site is comprised predominantly of sand, which has a low propensity for accumulating toxic chemicals.

Required monitoring

No monitoring is necessary since the amount of toxic chemicals that might be transferred to the dredged spoil disposal site is low.

21. Ecological impacts due to physical effects of sediment disposal at the dredged spoil disposal site

The sediment dredged in Phases 1 and 2 for the proposed project will be disposed at a registered dredged spoil disposal site in Algoa Bay. Dredged sediment is usually disposed from a dredge vessel or barge through two half doors or valves at the bottom of the hull. The dredged sediment in a hopper or barge represents a dense slurry that, when disposed, behaves as a dense fluid when released into the less dense seawater surrounding it. Surveys have shown that most of the sediment disposed in this way reaches the bottom as a fluid mass. A predictable and unavoidable impact of dredged sediment disposal at open water dredged spoil disposal sites is the burial, smothering, and crushing of biological communities, including benthic invertebrate infauna and poorly mobile epifauna, bottom-dwelling fish, and the eggs of invertebrates and fish that are deposited and develop until hatching on the bottom (Miller *et al*., 2002). Similar impacts can also occur near a dredged spoil disposal site when sediment is transported off the site by currents (Essink, 1999; Miller *et al*., 2002; Stronkhorst *et al*., 2003; Bolam *et al*., 2011; Boon and Dalfsen, 2022). Most benthic invertebrate infauna live in the top 10 cm of sediment and rely on a connection (*e.g.* burrows) to the sediment-water interface for ventilation (respiration) and feeding. The 'excessive' deposition of fine-grained sediment (mud) on sandy sediment can lead to the clogging of the spaces between sand grains, displacing the fauna that live between the sand grains or retarding the exchange of oxygen with the overlying water, leading to the suffocation of benthic invertebrate fauna. Frequent repositioning to maintain a relative distance to the sediment-water interface, or the need by burrowing organisms to increase maintenance to prevent the infilling of burrows, requires that organisms shift their energy allotment from other functions, such as growth or reproduction. If the deposited sediment has a different grain size to the sediment existing before deposition it may alter the physical properties of the sediment, which can impact on bottom-dwelling fauna that prefer to live in or on sediment of a fairly specific grain size because of their need to maintain an open burrow or because of their mode of feeding, for example (Holland *et al*., 2005; Smit *et al.*, 2006; Smit *et al.*, 2008; Boon and Dalfsen, 2022). The deposition of muddy sediment on sandy sediment is generally more problematic than the reverse (Diaz and Boesch, 1977; Boon and Dalfsen, 2022). Many benthic invertebrate infauna and epifauna can migrate upwards through placed sediment and may be relatively unimpacted by sediment deposition within reasonable limits (Maurer *et al.* 1979, 1981a, 1981b, 1982, 1986; Fredette and French, 2004; Wilber *et al*., 2007). Maurer *et al.* (1979), for example, found that some benthic invertebrates can migrate through as much as 30 cm of deposited sediment, although other invertebrates are less tolerant of burial and smothering and may be significantly affected by even a thin layer of placed sediment (Schaffner, 1993; Wilber and Clarke, 2007; Hendrick *et al*., 2016). The consequence of sediment disposal impacts is an altered species composition, abundance, and biomass of biological communities on and near dredged spoil disposal sites (Miller *et al*., 2002; Bolam and Rees, 2003; Stronkhorst *et al*., 2003; Bolam *et al*., 2011; Donázar-Aramendía *et al*., 2018; Donázar-Aramendía, 2020; Bolam *et al*., 2021; Tao *et al*., 2021; Boon and Dalfsen, 2022), with attendant impacts to other ecosystem processes (*e.g.* fish that rely on invertebrates in the affected area as a food resource will be deprived of this resource and essentially suffer habitat displacement).It should, however, be noted that it is not always possible to determine if the changes in biological communities at dredged spoil disposal sites is a consequence of the physical effects of sediment disposal or other features of the disposed sediment that might also affect biological communities, such as the presence of toxic chemicals in the sediment.

Benthic biological communities impacted by the disposal of dredged sediment do recover after this disturbance. Some benthic invertebrate infauna and epifauna will recolonise newly deposited sediment within hours to days, but recovery to a comparable species composition, abundance, and biomass to that existing before disposal takes longer (potentially years) (Ellis, 1996; Newell, 1998; Gilkinson *et al*., 2005; Stronkhorst *et al*., 2003). Initial recolonisation likely occurs by invasion (or active immigration) by motile fauna (*e.g.* amphipods, crabs; Morton, 1977; van Moorsel 1993, 1994; Hall, 1994; Ellis, 2000) from less or undisturbed areas nearby and by larval settlement (Skilleter, 1998; Ellis, 1996, 2000). Short-lived species and/or species with a high reproduction rate (so-called opportunists; includes amphipods, various worms) recover more rapidly than slower growing, longer-lived species (*e.g.* gastropods, large worms). If the deposited sediment is substantially different to that at the site prior to sediment disposal, the benthic invertebrates that colonise the site may differ to the those that were present prior to disposal (Tao *et al*., 2021).

The dredged spoil disposal site can be classified as being in a moderately dispersive environment as evident from the texture of the sediment sampled at and near the disposal site in 2017. Thus, the sediment sampled at and near the dredged spoil disposal site at that time was comprised predominantly of very fine-grained and medium-grained sand (Figure 43 and Table 3). The mud content of the sediment was low, ranging from 1.11-1.43%. In comparison, the sediment sampled near the Old Tug Jetty quay area consists primarily of mud (61.90-93.48%). The texture of the sediment in the dredging footprints is thus somewhat different to that on the dredged spoil disposal site if the measurements made in 2017 are still relevant, which seems probable.

There is no information on benthic and pelagic biological communities at and near the dredged spoil disposal site in Algoa Bay. There are no benthic macroalgae in the area but the water column can be expected to provide habitat for a range of microalgal, invertebrate, and fish species, while other fauna such as birds and dolphins may use the area for foraging. Masikane (2011) investigated the structure and composition of benthic invertebrate communities at a 10 m water column depth at six stations in Algoa Bay, one of which was situated off the Papenkuils River inshore of the dredged spoil disposal site. Masikane (2011) performed two surveys, in 2008 and 2009. The sediment at the Papenkuils River station was found to comprise a higher fine-grained fraction and to have a higher total organic content than other stations. In both surveys the benthic invertebrate community at the Papenkuils River station was dominated by polychaetes, followed either by amphipods or bivalves. Decapoda were also an important component of the community. In contrast, the benthic invertebrate community at other stations was dominated by amphipods. Masikane (2011) concluded that the primary factor influencing the difference in the benthic invertebrate community structure and composition at the Papenkuils River station compared to other stations was the discharge of effluent from the river. Many species of polychaete worms are known to tolerate and in some cases flourish in areas influenced by effluent discharge and may account for the dominance of the benthic invertebrate community by polychaetes. It is uncertain if the benthic invertebrate community at and near the dredged spoil disposal site when undisturbed by dredged sediment disposal would resemble that at the Papenkuils River station investigated by Masikane (2011), but this seems possible. The key feature is that the communities in the area are dominated by small, fast growing, short-lived species that are likely to rapidly re-colonise disturbed areas (providing there is no significant contamination).

The disposal of dredged sediment will thus lead to the burial, smothering, and crushing of benthic biological communities at and possibly also very near the dredged spoil disposal site in Algoa Bay. This is an unavoidable impact of dredged sediment disposal at open water dredged spoil disposal sites. Most of the sediment disposed from dredgers or barges with hull opening doors reaches the bottom as a fluid mass. Fine-grained sediment will be suspended in the water column during disposal events and will disperse and settle in the area surrounding the dredged spoil disposal site depending on prevailing currents, but the volume of sediment that will be deposited on the seabed outside the disposal site is anticipated to comprise a minor proportion of that disposed. The impact is thus considered **site specific**. It is reasonable to assume biological communities at and near the dredged spoil disposal site in Algoa Bay have been shaped by the repeated disposal of dredged sediment from the Port of Port Elizabeth and that the communities are to a large degree habituated to and tolerant of dredged sediment disposal to the extent possible. It is nevertheless probable that in areas on the dredged spoil disposal site where the deposition of sediment is heaviest the benthic biological community, or at least a significant proportion thereof, will be buried, smothered, and crushed to a degree this will lead to the injury and mortality of components of the community. However, areas of heavy sediment deposition are likely to comprise a very small part of the dredged spoil disposal site and an even smaller part of available similar habitat in Algoa Bay considering the small volume of sediment that will be dredged for the proposed project. In areas of the dredged spoil disposal site where the deposition is less pronounced, benthic biological communities will be disturbed but it is unlikely there will be a complete loss of benthic ecology. The intensity is thus anticipated to be **low**. The benthic biological community on the dredged disposal site will recover, probably starting within days of a disposal event. However, it will take time for the communities to return to a species composition, abundance, and biomass like that which existed before disposal provided there is no further disposal in a specific area. The surficial sediment near the Old Tug Jetty quay area has a granulometry that is muddier compared to that on the dredged spoil disposal site. The dredged sediment may thus alter the physical properties of sediment on and near the dredged spoil disposal site and in this way might retard recovery. The impact is thus considered **short-term**. The impact is fully **reversible** since of the disposal of dredged sediment ceases benthic biological communities will return to a species composition, abundance, and biomass like that which existed before disposal. The significance rating for this impact without mitigation is thus **LOW**.

Impact assessment without mitigation					
Impact	Ecological impacts due to physical effects of sediment disposal at the dredged spoil disposal site				
Status	Positive		Negative		
	The disposal of dredged sediment will negatively impact on benthic biological communities at and possibly near the dredged spoil disposal site.				
Nature	Direct	Indirect	Reversible	Irreversible	
	The disposal of dredged sediment will directly impact biological communities at and possibly near the dredged spoil disposal site by burial, smothering, and crushing. The loss and disturbance of biological communities at the dredged spoil disposal site will indirectly affect other components of the Algoa Bay ecosystem. The impact is reversible because benthic biological communities at the dredged spoil disposal site will recover to a species composition, abundance, and biomass like communities on unimpacted sediment nearby if dredged sediment disposal ceases.				
Extent	Site specific	Local	Regional	National	International
	Most of the dredged sediment disposed will deposit on the seabed in the dredged spoil disposal site.				
Duration	Temporary	Short-Term	Medium-Term	Long-Term	Permanent
	Benthic biological communities adversely affected by dredged sediment disposal will recover depending on future disposal events, but it will take time for the communities to return to a species composition, abundance, and biomass like that before disposal. However, recolonisation is expected to proceed within days to months and the duration is thus considered short-term.				
Intensity	Minor	Low	Moderate	High	Severe
	The intensity is low since benthic biological communities at and near the dredged spoil disposal site are probably habituated to and shaped by dredged sediment disposal through repeated burial and smothering associated with maintenance dredged sediment disposal. Although there will be a loss of biological communities and thus benthic ecology in areas where the sediment deposition is heaviest, these are likely to be restricted in spatial extent.				
Probability	Highly Unlikely	Unlikely	Possible	Probable	Definite
	The disposal of dredged sediment will affect biological communities at and possibly near the dredged spoil disposal site.				
Confidence	Low	Medium	High		
	The confidence that the disposal of dredged sediment will adversely impact on biological communities at and possibly near the dredged spoil disposal site is high (such impacts are well documented in the scientific literature). The confidence that dredged sediment disposal will impact on the ecological productivity of Algoa Bay and that this impact will be of a low rather than minor intensity is medium.				
Significance	Very Low	Low	Medium	High	Fatally flawed

Mitigation

Recommended mitigation for this impact is outlined below. If dredged sediment is placed in a thin layer on the dredged spoil disposal site, the main effect will be to change the duration of this impact from short-term to temporary and the intensity from low to minor. However, it is uncertain if thin layer placement will be feasible as this will depend on the dredging vessel, which is not yet finalised. It is also uncertain if the timing of dredging and hence dredged sediment disposal will be such that this coincides with winter or early spring, and if not whether a decision will be made to ensure dredging is performed at these times. The significance rating for this impact with mitigation thus remains **LOW**.

Impact assessment with mitigation					
Impact	Ecological impacts due to physical effects of sediment disposal at the dredged spoil disposal site				
Mitigation	• Dredged sediment should be spread in as thin a layer as is practicable on the dredged spoil disposal site (*i.e.* thin layer placement). This will aid in the migration of benthic invertebrate fauna through the deposited sediment. • Dredged sediment should ideally be disposed in late winter to early spring when most fauna and flora will not be breeding. This will aid in the recolonisation of the site in late spring to summer by the larvae and settling stages of benthic invertebrate fauna. • The dredging footprint should be restricted to the smallest area and depth possible (*i.e.* do not over dredge), in this way minimising the volume of sediment that needs to be disposed at the dredged spoil disposal site.				
Nature	Direct	Indirect	Reversible	Irreversible	
Extent	Site specific	Local	Regional	National	International
Duration	Temporary	Short-Term	Medium-Term	Long-Term	Permanent
Intensity	Minor	Low	Moderate	High	Severe
Probability	Highly Unlikely	Unlikely	Possible	Probable	Definite
Confidence	Low	Medium	High		
Significance	Very Low	Low	Medium	High	Fatally flawed

Potential for cumulative effects

Dredging for the proposed project might coincide with maintenance dredging in the Port of Port Elizabeth. There is a possibility that the burial, smothering, and crushing of biological communities caused by the deposition of sediment dredged for the proposed project at the dredged spoil disposal site could be enhanced by the concurrent disposal of maintenance dredged sediment. To mitigate this potential cumulative effect, dredging for the proposed project and maintenance dredging in the Port of Port Elizabeth should be scheduled so they do not overlap. The period between the last disposal event for sediment dredged for the proposed project and the start of dredged sediment disposal for the next maintenance dredging cycle, or *vice versa*, should be as long as possible to provide time for biological communities to recover to some degree, assuming that the same sectors of the dredged spoil disposal site will not be used for dredged sediment disposal.

Required monitoring

None.

22. Impacts associated with the disposal of sediment leading to an elevated seabed at the dredged spoil disposal site

The sediment dredged in Phases 1 and 2 for the proposed project will be disposed at a registered dredged spoil disposal site in Algoa Bay. The disposal of dredged sediment has the potential to raise the seabed at the dredged spoil disposal site. If the seabed is elevated substantially above the current elevation this may pose a navigation hazard to large vessels that occasionally anchor near the disposal site. An elevated seabed also has the potential to refract and amplify waves to a degree this causes shoreline erosion.

The disposal of dredged sediment will raise the seabed at the dredged spoil disposal site in Algoa Bay. However, the volume of sediment that needs to be disposed is so small the elevation is likely to be insignificant and is **highly unlikely** to refract and amplify waves or to present a navigational risk, especially when it is considered that the disposal of larger volumes of maintenance dredged sediment at the site have had no such apparent impacts. The elevation will be site specific, but the implications would occur over a wider area and is thus **local**. Considering the small volume of sediment that needs to be disposed the intensity is **minor**. The impact will be **short-term** and **reversible** as sediment will be eroded by currents from the dredged spoil disposal site, but this will take time. The significance rating for this impact is thus **VERY LOW**.

Impact assessment without mitigation					
Impact	Impacts associated with the disposal of sediment leading to an elevated seabed at the dredged spoil disposal site in Algoa Bay				
Status	Positive		Negative		
	The impact is negative because an elevation in the seabed can pose a navigation risk and lead to the refraction and amplification of waves to a degree this causes shoreline erosion.				
Nature	Direct	Indirect	Reversible	Irreversible	
	The impact is direct because sediment disposal will lead directly to an elevation in the seabed. The impact is reversible because disposed sediment will be eroded from the dredged spoil disposal site over time.				
Extent	Site specific	Local	Regional	National	International
	Although sediment will only be disposed on the dredged spoil disposal site and the seabed elevation will thus be restricted to the site, the amplification and refraction of waves can lead to impacts at the shoreline distance from the site.				
Duration	Temporary	Short-Term	Medium-Term	Long-Term	Permanent
	The impact is short-term because the disposed sediment will be eroded by currents from the dredged spoil disposal site, but this will take time.				
Intensity	Minor	Low	Moderate	High	Severe
	The intensity is minor as the elevation in the seabed is likely to insignificant.				
Probability	Highly Unlikely	Unlikely	Possible	Probable	Definite
	The disposal of dredged sediment will raise the elevation of the seabed at the dredged spoil disposal site in Algoa Bay. However, the volume of sediment that needs to be disposed is so small this is highly unlikely to have an impact on vessel navigation or waves.				
Confidence	Low	Medium	High		
	The confidence that the elevation in the seabed will not have a significant impact is high.				
Significance	Very Low	Low	Medium	High	Fatally flawed

Mitigation

No mitigation is required considering the **VERY LOW** significance rating for this impact. However, it is good practice to implement mitigation to further reduce the potential for and implications of environmental impacts. Recommended mitigation for this impact is thus outlined below. To minimise the possible impact of increased sedimentation on the dredged spoil disposal site the dredged sediment should be spread in as thin a layer as is practicable on the disposal site (*i.e.* thin layer placement). Thin layer placement limits sediment mounding that could lead to wave amplification and refraction that could in turn lead to shoreline erosion, and limits navigation risks by ensuring the seabed is not unduly elevated (USACE, 2015). However, it is uncertain if thin layer placement will be feasible as this will depend on the dredging vessel, which is not yet finalised. The significance rating for this impact thus remains **VERY LOW** with mitigation.

Impact assessment with mitigation					
Impact	Impacts associated with the disposal of sediment leading to an elevated seabed at the dredged spoil disposal site				
Mitigation	• The dredged sediment should be spread in as thin a layer as is practicable on the spoil disposal site (*i.e.* thin layer placement), to avoid impacts that might arise due to a significantly elevated seabed. • Large vessels should not use the area near the dredged spoil disposal site for anchoring.				
Nature	Direct	Indirect	Reversible	Irreversible	
Extent	Site specific	Local	Regional	National	International
Duration	Temporary	Short-Term	Medium-Term	Long-Term	Permanent
Intensity	Minor	Low	Moderate	High	Severe
Probability	Highly Unlikely	Unlikely	Possible	Probable	Definite
Confidence	Low	Medium	High		
Significance	Very Low	Low	Medium	High	Fatally flawed

Potential for cumulative effects

Dredging for the proposed project might coincide with maintenance dredging in the Port of Port Elizabeth.

There is a possibility that disposal of dredged sediment for these projects could significantly impact the seabed elevation if the dredged spoil is disposed in the same sectors of the dredged spoil disposal site. To mitigate this potential cumulative effect, dredging for the proposed project and maintenance dredging in the Port of Port Elizabeth should be scheduled so they do not overlap and the sectors of the dredged spoil disposal site where dredged sediment is disposed should be different.

Required monitoring

No monitoring is required considering the **VERY LOW** significance rating for this impact. Nevertheless, it would be informative if the bathymetry of the dredged spoil disposal site in Algoa Bay was surveyed before dredged sediment disposal for the proposed project, to identify areas where dredged sediment can be disposed without significantly altering the elevation of the seabed. A follow-up survey after dredged material disposal has ceased would also be informative but is not a necessity.

23. Ecological impacts due to the temporary loss of sheet pile wall biological communities

In Phase 1 of the proposed project a counterfort wall will be constructed in front of the existing sheet pile wall at the Old Tug Jetty. The area between the new counterfort wall and existing sheet pile wall will be backfilled with solid material. The biological communities that have colonised the intertidal and subtidal parts of the existing quay wall, including barnacles, sponges, ascidians, and associated communities of animals that live amongst these larger fauna will be destroyed by construction of the counterfort wall. The subtidal parts of fenders, access ladders, and so on, have also been colonised by encrusting fauna and these will also be destroyed when this quay furniture is removed to allow construction of the counterfort wall.

The loss of the sheet pile biological communities will impact on the ecological productivity of the port and possibly also in the neighbouring marine environment. It is not easy to estimate the loss in ecological productivity in the port since the productivity of the biological communities in the port has not been quantified. The biological communities on the sheet pile wall are neither species diverse nor high in biomass, as concluded from a visual survey of the communities in the upper part of the intertidal at various points along the sheet pile wall and based on a comparison to communities in the same part of the intertidal elsewhere in the port. The reason is uncertain but could be related to the fact the sheet pile wall is composed of metal, which may exclude colonisation by some types of fauna (the material from which artificial structures are composed is known to influence the composition of encrusting biological communities). The loss of biological communities, and hence the temporary loss in ecological productivity will not be immediate since the counterfort wall will be constructed progressively. Fauna will probably colonise newly laid parts of the counterfort wall as construction proceeds, but these will probably be impacted by other construction activities and may not be very productive during the construction period.

The loss of the sheet pile fauna and associated productivity will be temporary since fauna will colonise the new counterfort wall. The colonisation will probably be quite rapid, but it will take some time (possibly years) for a 'mature' biological community to develop.

The destruction of the sheet pile wall biological communities and associated loss in ecological productivity is an unavoidable consequence of the proposed project. The associated loss in ecological productivity is anticipated to be **medium-term** in duration since although biota will colonise the new counterfort wall it may potentially take years for the community to reach a similar species composition, abundance, and biomass to that which presently exists on the quay wall. The impact is anticipated to be of a **low** intensity since although biological communities and ecological productivity will be lost and modified this will be temporary, and because the biological communities on the sheet pile wall are neither species diverse nor high in biomass and their temporary loss is thus **unlikely** to have a major impact on ecosystem processes in the port. The impact will be **local** since the loss in ecological productivity will impact on the wider port environment and possibly also the adjacent marine environment, if only temporarily and to a minor degree. The impact is fully **reversible** since biological communities will colonise the new counterfort wall and these will probably resemble those presently on the quay wall in terms of species composition, abundance, and biomass, and hence also productivity. The significance rating for this impact without mitigation is thus **LOW**.

Impact assessment without mitigation					
Impact	Ecological impacts due to the temporary loss of sheet pile wall biological communities				
Status	Positive		Negative		
	The impact is negative because biological communities will be lost and this will impact on ecological productivity, albeit temporarily.				
Nature	Direct	Indirect	Reversible	Irreversible	
	The impact is direct because biological communities on the sheet pile wall will be lost. The impact is also indirect because the loss of biological communities will affect the ecological productivity of the port. The impact is fully reversible because biological communities will develop on the new counterfort wall.				
Extent	Site specific	Local	Regional	National	International
	The impact is local because the loss of the sheet pile wall biological communities will impact on the ecological productivity of the wider port and possibly also the adjacent marine ecosystem.				
Duration	Temporary	Short-Term	Medium-Term	Long-Term	Permanent
	The impact is medium-term since biological communities will develop on the new counterfort wall, but it may take several years for mature communities to develop.				
Intensity	Minor	Low	Moderate	High	Severe
	The loss in ecological productivity will be low as the biological communities on the sheet pile wall are not especially species diverse nor abundant, and its temporary loss is unlikely to have a major impact on the ecology of the port.				
Probability	Highly Unlikely	Unlikely	Possible	Probable	Definite
	It is unlikely the loss of the biological communities and associated ecological productivity will have a major impact on the ecology of the port.				
Confidence	Low	Medium	High		
	The confidence that the loss of biological communities on the sheet pile wall will affect the ecological productivity in the port is high. The confidence that biological communities will develop on the new counterfort wall in time and that this impact will thus be medium-term is also high.				
Significance	Very Low	Low	Medium	High	Fatally flawed

Mitigation

Nothing can be done to directly mitigate this impact other than not proceeding with the project at all (the 'Do Nothing' option). The significance rating for this impact will thus not change with mitigation and remains **LOW**. There is an opportunity to improve the habitat value of the new quay wall for encrusting biological communities through various strategies, including roughening its surface. Whether such strategies are possible from an engineering and especially financial perspective is uncertain and were thus not considered in the impact significance assessment with mitigation.

Impact assessment with mitigation					
Impact	Ecological impacts due to the temporary loss of sheet pile wall biological communities				
Mitigation	None required due to very low significance rating. No mitigation is in fact possible.				
Nature	Direct	Indirect	Reversible	Irreversible	
Extent	Site specific	Local	Regional	National	International
Duration	Temporary	Short-Term	Medium-Term	Long-Term	Permanent
Intensity	Minor	Low	Moderate	High	Severe
Probability	Highly Unlikely	Unlikely	Possible	Probable	Definite
Confidence	Low	Medium	High		
Significance	Very Low	Low	Medium	High	Fatally flawed

Potential for cumulative effects

None.

Required monitoring

None.

24. Ecological impacts due to underwater noise

Construction activities for the proposed project will lead to the generation of underwater noise. The noise may arise from the engines of construction support vessels, dredging vessels, heavy machinery, and in Phase 2 by pile insertion for the deck-on-pile structure. The most significant source of underwater noise will be associated with piling. A yet to be determined number of tubular piles of 600 mm diameter will be driven into place. The piling period is unknown at this time and will be finalised when the engineering design is finalised. There are two ways in which steel piles can be inserted. The first is vibratory piling, which uses a vibratory hammer. The second is percussive (or hammer) piling, which uses a heavy weight (hammer) to ram piles into the substrate. Percussive piling generates a much higher level of noise than vibratory piling, which can be well above the ambient and can travel over considerable distances underwater.

There is little information on the effect of anthropogenic noise on estuarine and marine invertebrates, but that which is available suggests that some benthic invertebrates do respond behaviourally to anthropogenic noise (Solan *et al*., 2016; Wang *et al*., 2022). Various invertebrates use mechanoreception to locate food and prey (*e.g.* Klages *et al*., 2002) and are probably sensitive to noise. Solé *et al*. (2022) exposed European common cuttlefish (*Sepia officinalis*) adults, larvae, and eggs to playback drilling and percussive pile driving sounds in the laboratory. After exposure, damage was observed in the statocyst sensory epithelia (hair cell extrusion) in adults compared to controls, and no anti-predator reaction was observed. The exposed larvae showed a decreased survival rate with an increasing received sound level when they were exposed to maximum pile-driving and drilling sound levels, but lower sound levels were not found to elicit severe damage. A decrease in the hatching success of eggs was observed with increasing received sound levels.

The potential effects of underwater noise on fish include a range of non-auditory tissue damage to mortality, auditory tissue damage that may permanently reduce hearing ability, a temporary reduction in hearing sensitivity, and behavioural effects such as startle (diving or tighter shoaling) or avoidance responses (Popper and Hastings, 2009; Mueller-Blenkle *et al*., 2010). Fish near (few meters) active percussive piling operations can be killed by underwater noise, while those within about 15 m can suffer serious non-lethal injury. Behavioural effects occur over large distances of up to ~150 m, but potentially further. Although many fish will avoid an area of piling due to the impact of noise, small weak swimming fish and larvae carried by currents may or will be unable to avoid the area.

The potential effects of underwater noise on birds include causing diving them to move away from the area, in which case the consequence is essentially the same as habitat loss, albeit temporary. Underwater noise may also cause diving birds to temporarily interrupt their normal activity leading to, for example, reduced feeding rates, or increased energy expenditure through movement away from sources of disturbance. There is some evidence to suggest that underwater noise from ships has contributed to a marked decline on the population of African Penguins (*Spheniscus demersus*) in Algoa Bay (Pichegru *et al*., 2022).

Marine mammals use acoustics for communication, navigation, and foraging, and are particularly sensitive to underwater noise (Clark *et al*., 2009; Leunissen *et al*., 2019). Underwater noise emissions can result in disruption of foraging behaviour, displacement, masking of communications, disturbance, and injury (Carstensen *et al*., 2006; Tougaard *et al*., 2009; Thompson *et al*., 2010; Brandt *et al*., 2011; Paiva *et al*., 2015; Leunissen *et al*., 2019). Stress-related responses from increased ambient and local noise levels can include rapid swimming away from ship(s), changes in surfacing, breathing, and diving patterns, changes in group composition, changes in migration routes, and changes in vocalisations (Richardson *et al*., 1995; Weilgart, 2007). The noise emitted by percussive piling can have serious, permanent impacts on the hearing of cetaceans at distances of up to ~250 m from the point of origin, while their behaviour may be affected at distances of 2.5 km pr more from the point of origin.

Construction activities, particularly piling, will thus generate underwater noise that will **probably** impact on fauna. Dolphins are known to periodically enter the port, presumably to feed. Dolphins and whales are also known to utilise the marine environment near the port - this is in fact one of the preferred habitats for southern right whales (*Eubalaena australis*), Indian Ocean humpback dolphins (*Sousa plumbea*), and Indo-Pacific bottlenose dolphins (*Tursiops aduncus*) in Algoa Bay (Melly *et al*., 2018). Underwater noise generated by piling in Phase 2 may propagate beyond the port, but it likely to be substantially reduced by the presence of surrounding infrastructure. Dredgers will travel to the dredged spoil disposal site in Algoa Bay, but they are unlikely to significantly increase the amount of noise above existing levels. The spatial extent of this impact is thus **regional**. The impact on the most sensitive of fauna may be **high** in intensity in the case of piling. The impact will be **short-term** and is **reversible** as the generation of underwater noise will cease when construction ceases. The significance rating for this impact without mitigation is thus **MEDIUM**.

Impact assessment without mitigation					
Impact	Ecological impacts due to underwater noise				
Status	Positive		Negative		
	The impact is negative because underwater noise poses a risk to fauna.				
Nature	Direct	Indirect	Reversible	Irreversible	
	The impact is direct because underwater noise will impact directly on fauna. It is also indirect because the direct impact on fauna will have implications for ecosystem processes not directly linked to the noise disturbance. The impact is reversible because the underwater noise will cease when construction ceases, and fauna displaced by noise will return to the affected area.				
Extent	Site specific	Local	Regional	National	International
	The impact area for piling can be relatively large (several km) for marine mammal species and may thus extend into Algoa Bay. Potential impacts from underwater noise during backfilling, dredging, disposal of dredged sediment, and noise from vessels is anticipated to be restricted to the area near the activity or vessel. However, dredge vessels which will travel into Algoa Bay. The impact is thus regional.				
Duration	Temporary	Short-Term	Medium-Term	Long-Term	Permanent
	Underwater noise will be generated through much of the construction period, but the most intense sound will be generated during the piling operation in Phase 2. The piling operation is expected to be completed in a fairly short period and will be preceded by a short period of dredging works. The duration is thus considered short-term.				
Intensity	Minor	Low	Moderate	High	Severe
	The intensity of this impact may be high if not mitigated. Fauna in the area near the port are probably somewhat habituated to noise due to vessel traffic in the area.				
Probability	Highly Unlikely	Unlikely	Possible	Probable	Definite
	Underwater noise will probably affect fauna.				
Confidence	Low	Medium	High		
	The confidence that underwater noise will affect fauna is high. The confidence that this effect will be severe is low in the absence of noise modelling.				
Significance	Very Low	Low	Medium	High	Fatally flawed

Mitigation

Recommended mitigation for this impact is outlined below. Several details for the proposed project are yet to be finalised. The recommended mitigation should thus be expanded on in the Environmental Management Programme Report formulated for the project when these details are finalised. If the mitigation is implemented the intensity can be reduced to moderate, but the significance rating with mitigation will remain **MEDIUM**.

Impact assessment with mitigation	
Impact	Ecological impacts due to underwater noise
Mitigation	• In so far as conditions permit, vibratory piling should be used in preference to percussive

<table>
<tr><td></td><td colspan="20">piling.
• Piling should ideally be limited to a time outside the breeding period for fauna likely to be most adversely impacted by underwater noise, since noise exposure might force fauna to forage or breed in sub-optimal areas or to avoid the area entirely. The ideal period is autumn/winter. It is, however, acknowledged that this might not be practical for the project and that the piling period may extend over several months.
• A pre-piling survey for the presence of marine mammals (in this case likely to be restricted to dolphins) of the area near the piling activity should be performed for 15 minutes. If dolphins should be observed, piling must not commence until at least 15 minutes after dolphins were last observed. It is especially important to ensure that dolphins left the area in the direction of the estuary mouth, to avoid them being trapped in the upper part of the estuary by an underwater noise barrier.
• A 'soft-start'/'ramp-up' regime should be followed at the commencement of piling on each day to allow those fauna that can an opportunity to move away from the area before the sound pressure increases to a level that they might be injured. This procedure should also be followed if there is a temporary halt in piling on any given day.
• If dolphins are observed near the piling operation when in full power, there is no need to cease piling as the dolphins can be assumed to have entered the area 'voluntarily' and to not be overly disturbed by the underwater noise.
• Driving tubular steel piles into the substrate one at a time will reduce the magnitude of underwater noise exposure. However, this will prolong the period over which high intensity underwater noise is generated by piling. No recommendation is thus made on whether piles should be driven individually or concurrently, although it is probable this will ne individually.
• If dead fish are observed near the piling operation the ramp up regime should be lengthened.</td></tr>
<tr><td>Nature</td><td colspan="5">Direct</td><td colspan="5">Indirect</td><td colspan="5">Reversible</td><td colspan="5">Irreversible</td></tr>
<tr><td>Extent</td><td colspan="4">Site specific</td><td colspan="4">Local</td><td colspan="4">Regional</td><td colspan="4">National</td><td colspan="4">International</td></tr>
<tr><td>Duration</td><td colspan="4">Temporary</td><td colspan="4">Short-Term</td><td colspan="4">Medium-Term</td><td colspan="4">Long-Term</td><td colspan="4">Permanent</td></tr>
<tr><td>Intensity</td><td colspan="4">Minor</td><td colspan="4">Low</td><td colspan="4">Moderate</td><td colspan="4">High</td><td colspan="4">Severe</td></tr>
<tr><td>Probability</td><td colspan="4">Highly Unlikely</td><td colspan="4">Unlikely</td><td colspan="4">Possible</td><td colspan="4">Probable</td><td colspan="4">Definite</td></tr>
<tr><td>Confidence</td><td colspan="7">Low</td><td colspan="6">Medium</td><td colspan="7">High</td></tr>
<tr><td>Significance</td><td colspan="4">Very Low</td><td colspan="4">Low</td><td colspan="4">Medium</td><td colspan="4">High</td><td colspan="4">Fatally flawed</td></tr>
</table>

Potential for cumulative effects

Underwater noise generated by construction will add to the underwater noise generated by other port operations, such as the movement of tugs, large vessels, and dredging vessels.

Required monitoring

Since the proposed project will take place in the Port of Port Elizabeth and this is not a common forage area for dolphins it is not considered necessary to have a trained and certified marine mammal observer onsite to aid in identifying if dolphins are present in the area. Precautions must nevertheless be taken by the contractor to ensure that dolphins and other marine mammals are not harmed by underwater noise, particularly that generated by piling in Phase 2 of the proposed project. Prior to the commencement of piling on any given day a nominated representative of the contractor that has received some training in identifying marine mammals should undertake a visual survey (using binoculars) of the port area near the Old Tug Jetty quay area for the presence of dolphins, for a period of ~20 minutes. If dolphins are observed piling must not proceed until the dolphins have left the area. If dolphins are observed to enter the area while piling is underway the piling does not need to cease if it has been continuous. The piling pre-survey procedure and soft start must also be followed if there is a pause of more than 30 minutes in piling at any time.

25. Ecological impacts due to above water noise disturbance

Construction activities for the proposed project will lead to the generation of above water noise. In phase 1 of the proposed project, the noise will arise from the operation of generators and other machinery, vehicles, and construction support and dredging vessels amongst a host of other noise generating activities usually associated with construction sites. In Phase 2, piling will present an additional source of noise. The above water noise will principally affect aquatic birds, which may as a result avoid the area near construction activities for the period that high noise levels are generated. The consequence is essentially the same as habitat loss (albeit temporary). A field survey provided little evidence that birds use the immediate area near the Old Tug Jetty quay area, probably because of the high levels of human and vessel activity in the area. Birds that do frequent the area are undoubtedly habituated to and tolerant of noise associated with ongoing port activities but are not (at least regularly) exposed to sounds as intense as those that are generated by percussive piling. Even in the case of percussive piling some degree of habituation for some bird species will probably be an outcome (Hill *et al.*, 1997). High levels of noise will not last all day as construction will be limited to daylight hours, meaning birds will be able to roost near the proposed project area at night. However, the noise will go on for some time and may cause sensitive birds to leave the area until construction ceases.

Construction activities, particularly piling in Phase 2 for the deck-on-pile structure, will generate above water noise that will **probably** impact on birds in the area. Birds that feed in, roost, or otherwise frequent the proposed project area are undoubtedly habituated to the prevailing above water noise associated with port operations. The intensity of noise generated by percussive piling will, however, exceed that generated by prevailing port operations and may present a substantial disturbance for the most sensitive birds. Some birds will probably become habituated to the above water noise, but others might leave the immediate area. Few birds use the proposed project area due to ongoing human and vessel activities. Noise will be generated throughout the construction period, but piling, which will generate the largest amount of noise, will be restricted to daylight hours over a relatively short period. The impact intensity is thus considered **low**, the duration as **short-term**, and the extent as **site specific**. This impact is fully **reversible** as birds will use the area once the noise recedes after construction. The significance rating for this impact without mitigation is thus **LOW**.

Impact assessment without mitigation					
Impact	Ecological impacts due to above water noise				
Status	Positive		Negative		
	The impact is negative because above water noise will negatively affect various fauna.				
Nature	Direct	Indirect	Reversible	Irreversible	
	The impact is direct because underwater noise will impact directly on fauna and flora. It is also indirect because the direct impact on fauna will have implications for ecosystem processes not directly linked to the noise disturbance. The impact is reversible because the underwater noise will cease when construction ceases.				
Extent	Site specific	Local	Regional	National	International
	The impact is site specific because above water noise will probably not significantly disturb fauna more than a few hundred meters from the site of the noise.				
Duration	Temporary	Short-Term	Medium-Term	Long-Term	Permanent
	The impact is short-term because high intensity above water noise will last for a relatively short period.				
Intensity	Minor	Low	Moderate	High	Severe
	The intensity of this impact is considered low since few birds appear to use the area near the proposed project area and those that do use the wider port area are undoubtedly habituated to noise associated with ongoing port activities.				
Probability	Highly Unlikely	Unlikely	Possible	Probable	Definite
	Above water noise will probably have an adverse effect on some fauna.				
Confidence	Low		Medium	High	
	The confidence that underwater noise will have an adverse effect on fauna is high. The confidence that this effect will have a substantial impact is medium in the absence of noise modelling.				
Significance	Very Low	Low	Medium	High	Fatally flawed

Mitigation

Recommended mitigation for this impact is outlined below. Several details for the proposed project are yet to be finalised. The recommended mitigation should thus be expanded on in the Environmental Management Programme Report formulated for the project when these details are finalised. However, even if the mitigation is implemented it is unlikely to reduce the significance of this impact, which thus remains **LOW** with mitigation.

Impact assessment with mitigation					
Impact	Ecological impacts due to above water noise				
Mitigation	• In so far as conditions allow, vibratory piling must be used in preference to percussive piling. • Piling should ideally be limited to a time outside the breeding period for fauna likely to be most adversely impacted by underwater noise, since noise exposure might force the fauna to forage or breed in sub-optimal areas or to avoid the area entirely. The ideal period is autumn/winter. It is, however, acknowledged that this might not be practical for the project and that the piling period will extend over many months. • A 'soft-start'/'ramp-up' regime should be followed at the commencement of piling on each day to allow any dolphins that might not have been observed and fish to move away from the area before the sound pressure increases. This procedure should also be followed if there is a temporary halt in piling on any given day. • Driving tubular steel piles into the substrate one at a time will reduce the magnitude of underwater noise exposure. However, this will prolong the period over which high intensity underwater noise is generated by piling. No recommendation is thus made on whether piles should be driven individually or concurrently, although it is probable this will be individually.				
Nature	Direct	Indirect	Reversible	Irreversible	
Extent	Site specific	Local	Regional	National	International
Duration	Temporary	Short-Term	Medium-Term	Long-Term	Permanent
Intensity	Minor	Low	Moderate	High	Severe
Probability	Highly Unlikely	Unlikely	Possible	Probable	Definite
Confidence	Low	Medium	High		
Significance	Very Low	Low	Medium	High	Fatally flawed

Potential for cumulative effects

Above water noise generated by construction activities for the proposed project will add to the above water noise generated by other (normal) port activities, such as the movement of tugs, large vessels, and dredging vessels. This may magnify the degree of disturbance to birds that feed in the port.

Required monitoring

None.

6.2.2. Operational phase impacts

26. Impact of altered quay wall geometry on hydrodynamics

Phase 1 of the proposed project calls for the installation of a counterfort wall in front of the existing Old Tug Jetty sheet pile wall. The counterfort wall will result in the permanent loss of open water and sediment habitat since at its maximum extent it will project ~6 m further into the port than the existing sheet pile wall. The total surface area of counterfort wall extension is estimated at 1003 m^2. Phase 2 of the proposed project calls for the construction of a deck-on-pile structure extension to part of the counterfort wall. The construction will require the installation of a yet to be determined number of piles to support the deck. Changes to the geometry of quay walls and other infrastructure in ports and the installation of piles can lead to changes in the strength and direction of currents and in this way can negatively impact on ecological processes by altering sediment erosion and deposition patterns and the flushing and turnover of the water column (and in the worst case scenario lead to the development of (periodically) stagnant conditions in the water column), and can concentrate the settlement of toxic contaminants on the bottom in specific areas. Altered current strengths can affect the migration of fauna, such as larval or very small fish and invertebrates. No modelling has been performed to determine how the altered geometry of the Old Tug Jetty quay wall and the installation of piles for the deck-on-pile structure will impact on hydrodynamic processes in the Port of Port Elizabeth. The change caused by the quay wall extension will probably be insignificant considering the small increase in its projection into the port and because the new quay wall will be aligned to the existing quay wall. The existing deck-on-pile structures near and joined to the Old Tug Jetty quay area have affected sediment accumulation in the area. This is evident in the shallower water beneath these structures, as evident from the bathymetric survey of the area (see Figure 9). It is probable the accumulation is a result of the difficulty of dredging sediment beneath the deck-on-pile structures.

A **permanent** change in port hydrodynamics will thus occur and will be **irreversible**. However, it is **unlikely** the altered hydrodynamics will have a significant impact on ecological processes and the intensity is thus **minor**. The impact will likely only affect a small area near the rehabilitated and new structures and is thus **site specific**. The significance rating for this impact is thus **VERY LOW**.

Impact assessment without mitigation					
Impact	Impact of altered quay wall geometry on hydrodynamics				
Status	Positive		Negative		
	The alteration in hydrodynamics is considered neutral.				
Nature	Direct	Indirect	Reversible	Irreversible	
	The impact is direct because it will lead to a direct change in hydrodynamics. The impact is irreversible.				
Extent	Site specific	Local	Regional	National	International
	The impact is site specific because only the area near the new quay wall is likely to be affected.				
Duration	Temporary	Short-Term	Medium-Term	Long-Term	Permanent
	The change in hydrodynamics will be permanent.				
Intensity	Minor	Low	Moderate	High	Severe
	The change in hydrodynamics is considered to have a minor intensity.				
Probability	Highly Unlikely	Unlikely	Possible	Probable	Definite
	A change in hydrodynamics will occur. However, it is highly unlikely the change will significantly impact ecological processes.				
Confidence	Low	Medium	High		
	The confidence that there will be a change in hydrodynamics is high. The confidence that the change in hydrodynamics will not have a significant ecological impact is medium because the precise nature of the change is uncertain.				
Significance	Very Low	Low	Medium	High	Fatally flawed

Mitigation

There is nothing that can be done to directly mitigate this impact other than not proceeding with the project (the 'Do Nothing' option). The impact significance rating thus remains **VERY LOW** with mitigation.

Impact assessment with mitigation					
Impact	Impact of altered quay wall geometry on hydrodynamics				
Mitigation	None				
Nature	Direct	Indirect	Reversible	Irreversible	
Extent	Site specific	Local	Regional	National	International
Duration	Temporary	Short-Term	Medium-Term	Long-Term	Permanent
Intensity	Minor	Low	Moderate	High	Severe
Probability	Highly Unlikely	Unlikely	Possible	Probable	Definite
Confidence	Low	Medium	High		
Significance	Very Low	Low	Medium	High	Fatally flawed

Potential for cumulative effects

None identified.

Required monitoring

Periodic bathymetric surveys of the area will show if there is increased sediment erosion or deposition as a result of the new quay wall and deck-on-pile structure.

27. Ecological impact due to permanent habitat loss

Phase 1 of the proposed project will involve for the installation of a counterfort wall in front of the existing Old Tug Jetty sheet pile wall. The counterfort wall will result in the permanent loss of open water and sediment since at its maximum extent it will project ~6 m further into the port than the existing sheet pile wall. The total surface area of counterfort wall extension is estimated at 1003 m^2. Phase 2 of the proposed project will involve the construction of a deck-on-pile structure extension to part of the counterfort wall. The construction will require the installation of a yet to be determined number of piles to support the deck. The area encompassed by the piles will result in the permanent loss of open water and sediment. The surface area of sediment that will be lost comprises <?% of sediment surface area in the port. The volume of open water that will be lost comprises a similarly small proportion of the open water available in the port.

The permanent loss of open water and sediment will diminish the available habitat for pelagic and benthic biological communities. The permanent loss of open water and sediment habitat will impact on the ecological productivity of the port and may have a minor impact on the ecological productivity of the adjacent marine environment as these environments are connected. It is impossible to estimate the loss in ecological productivity as there is no information on the productivity of water column and benthic habitat in the proposed project footprint. The area and volume of open water and sediment habitat that will be permanently lost is, as stated above, small in relation to the overall open water and sediment habitat in the Port of Port Elizabeth and comparable habitat is available elsewhere in the port. The open water and sediment habitat that will be lost are already disturbed and are thus not in a pristine state. The loss of habitat will not result in habitat fragmentation since the extended quay will follow the line of the existing quay wall/shoreline.

The proposed project will thus result in the **permanent** loss of open water and sediment habitat. The loss is essentially **irreversible** since the quay wall extension will be designed for a 50-year service life. The volume and area of open water and sediment that will be lost is small in relation to the overall water volume and sediment in the port but will affect ecological processes beyond the development footprint and the spatial extent is thus **local**. The loss of open water and sediment will diminish the available habitat for biological communities but is **unlikely** to have population level effects nor a major effect on ecological processes in the port. Nevertheless, habitat will be permanently lost and the intensity is thus **moderate**. The significance rating for this impact without mitigation is thus **LOW**.

<table>
<tr><th colspan="6">Impact assessment without mitigation</th></tr>
<tr><td>Impact</td><td colspan="5">Ecological impact due to the permanent habitat loss</td></tr>
<tr><td>Status</td><td colspan="2">Positive</td><td colspan="3">Negative</td></tr>
<tr><td></td><td colspan="5">The loss of open water and sediment habitat will negatively impact on biological communities and ecological processes.</td></tr>
<tr><td>Nature</td><td>Direct</td><td>Indirect</td><td colspan="2">Reversible</td><td>Irreversible</td></tr>
<tr><td></td><td colspan="5">The proposed project will lead to the direct loss of open water and sediment habitat. The loss of open water and sediment habitat will diminish the available habitat for biological communities, and this will indirectly affect ecological processes. The impact is essentially irreversible since the quay wall extension and deck-on-pile structure will be designed for a 50-year service life.</td></tr>
<tr><td>Extent</td><td>Site specific</td><td>Local</td><td>Regional</td><td>National</td><td>International</td></tr>
<tr><td></td><td colspan="5">The impact is local because the loss of open water and sediment habitat will affect ecological processes in the greater port area and possibly also the adjacent marine environment.</td></tr>
</table>

Duration	Temporary	Short-Term	Medium-Term	Long-Term	Permanent
	The loss of open water and sediment habitat will be permanent since the quay wall extension and deck-on-pile structure will be designed for a 50-year service life.				
Intensity	Minor	Low	Moderate	High	Severe
	The open water and sediment habitat that will be lost is already disturbed and is not so unique that its loss is highly significant from a critical habitat perspective. The volume and area of water and sediment habitat that will be lost is small in relation to the available habitat in the port. Nevertheless, habitat will be permanently lost and the intensity is thus moderate.				
Probability	Highly Unlikely	Unlikely	Possible	Probable	Definite
	The loss of open water and sediment habitat will affect biological communities and ecological processes in the port. However, it is unlikely the habitat loss will have a significant impact on biological communities and ecological processes in the port.				
Confidence	Low		Medium		High
	The confidence that the loss of open water and sediment habitat will affect ecological processes in the port is high. The confidence that the intensity of the loss is moderate is medium for the reason the productivity of open water and sediment in the proposed construction footprints has not been quantified.				
Significance	Very Low	Low	Medium	High	Fatally flawed

Mitigation

There is nothing that can be done to directly mitigate this impact other than not proceeding with the proposed project (the 'Do Nothing' option). The piles for the deck-on-pile structure will provide a surface area for colonisation by encrusting organisms and will offset some of the loss in ecological productivity through the loss of open water and sediment habitat. However, to what extent the loss will be offset in this is uncertain and the impact significance rating thus remains **LOW**. In many parts of the world solutions are being implemented to improve the ecological value of engineered structures, but none are planned the proposed project. These include highly complex and thus costly engineering designs, such is incorporating artificial rock pools in quay walls, to simple solutions, such as increasing the roughness of quay walls to increase the area available for, or attractiveness to encrusting biological communities. There is thus an opportunity to improve the ecological value of rehabilitated Old Tug Jetty quay wall by considering such strategies in the final engineering design.

Impact assessment with mitigation					
Impact	Ecological impact due to the permanent habitat loss				
Mitigation	None				
Nature	Direct	Indirect	Reversible	Irreversible	
Extent	Site specific	Local	Regional	National	International
Duration	Temporary	Short-Term	Medium-Term	Long-Term	Permanent
Intensity	Minor	Low	Moderate	High	Severe
Probability	Highly Unlikely	Unlikely	Possible	Probable	Definite
Confidence	Low		Medium		High
Significance	Very Low	Low	Medium	High	Fatally flawed

Potential for cumulative effects

Transnet National Ports Authority has no plans for projects in the short-term in the Port of Port Elizabeth that will lead to the further loss of open water and sediment habitat (TNPA, 2019). However, longer-term projects may lead to a further loss of habitat and ecological productivity in the port. However, in the absence of confirmed and concrete longer-term plans it is difficult to estimate the significance of the cumulative loss.

Required monitoring

None.

28. Ecological impact due to habitat modification by the deck-on-pile structure

If there is demand for deeper berth, Phase 2 of the proposed project will involve the construction of a deck-on-pile structure seaward of the counterfort wall. The current conceptual engineering design has the deck-on-pile structure extending 5.8 m from the counterfort wall.

Deck-on-pile structures present several ecological impacts apart from habitat loss due to the presence of piles (as addressed above – see Impact 26). The most obvious is shading of the water environment beneath. Shading by overwater structures has been shown to reduce macrophyte and macroalgal density by inhibiting photosynthesis (Pardal-Souza *et al*., 2017). In this way communities of aquatic vegetation that provide valuable nursery habitat for invertebrates and fish and foraging habitat for invertebrates, fish, and birds, are damaged or completely lost (Sanger *et al*., 2004; Castellan and Kelty, 2005; Pardal-Souza *et al*., 2017). Shading in this context is insignificant for the proposed project as there are no macrophytes in the project area and virtually no macroalgae on piles on jetties alongside the Old Tug Jetty. The absence of macroalgae may be a dual consequence of shading by the existing deck-on-pile structures and by vessels that moor alongside these structures.

Shading by overwater structures also has consequences for fish and invertebrates. Haas *et al*. (2002), Morley *et al*. (2012), and Pardal-Souza *et al*. (2017) found that densities and assemblages of epibenthic organisms were reduced or altered beneath overwater structures compared to areas with no such structures. Many fish are visually oriented and a sudden change in light can reduce their performance in visual tasks, such as spatial orientation, prey capture, schooling, predator avoidance, and migration, and cause them to avoid shaded areas under overwater structures (Bulleri *et al*., 2004; Munsch *et al*., 2017). Abundances of fish can thus be substantially reduced under overwater structures (Able *et al*., 1998; Able and Duffy-Anderson, 2005; Southard *et al*., 2006; Able *et al*., 2013; Munsch *et al*., 2017). Other fish take advantage of overwater structures, especially ambush predators like large teleost fish and sharks (Cermak, 2002; Able *et al*., 2013; Grothues *et al*., 2016; Munsch *et al*., 2017). There is evidence that pylons attract more adult piscivorous species and fewer juveniles than adjacent habitats. By concentrating predators, such structures may pose a threat to other fish. Toft *et al*. (2004) reported significantly greater abundance of several fish species beneath overwater structures compared to open water habitat, while Able *et al*. (1998) and Able and Duffy-Anderson (2005) also found that certain fish preferred this habitat. In this case the fish were not visual predators but rather rely on other senses, such as olfaction, to detect and capture prey. This provides support for a reduced light regime impact of overwater structures favouring species adapted to a low light intensity niche.

The piles on overwater structures provide habitat for encrusting fauna, such as mussels, barnacles, and oysters. When these organisms die, including through predation, their shell remains may be displaced by other fauna from the pile and sink to the bottom, modifying the nature of the substrate (to become donated by shell hash) and a consequent change in benthic invertebrate communities (Able and Duffy-Anderson, 2005). The shell hash will displace native invertebrates unable to live in and on this substrate and favour colonisation by those that can.

Overwater structures thus lead to changes in habitat that have implications for ecosystem processes. A benefit of overwater structures is they do not result in the complete loss of habitat as do bulkhead structures (*e.g.* the proposed counterfort wall) and provide habitat for fauna and perhaps also flora, albeit that the biological assemblages are usually modified compared to the absence of such a structure, as discussed above.

The proposed deck-on-pile structure will thus cause shading and will modify the sediment habitat beneath. These negative impacts will be slightly offset by the positive impact of the piles offering habitat for encrusting biological communities. It is probable the species diversity and biomass of the fauna that colonise the piles will exceed that in the sediment habitat lost by their placement, but this will might not offset the total adverse impact of the structure on ecological processes. The impact of the deck-on-pile structure will be **local** as it will affect ecological processes in the wider port area by modifying ecological productivity, but this is **unlikely** to be a significant effect and the intensity is thus considered **low**. The impact will be **permanent** and

irreversible since the structure will be designed for a 50-year service life. The significance rating for this impact without mitigation is thus **LOW**.

Impact assessment without mitigation					
Impact	Ecological impact due to habitat modification by the deck-on-pile structure				
Status	Positive		Negative		
	The deck-on-pile structure will have a positive impact for encrusting fauna and flora that colonise the piles, but a negative impact for other fauna and flora. It is probable the overall impact will be negative.				
Nature	Direct	Indirect	Reversible	Irreversible	
	The impact is direct because the deck-on-pile structure will directly affect fauna and flora. In this way the structure will indirectly affect other fauna and flora and ecological processes in the wider port area. The impact is essentially irreversible as the structure will be designed and built for a 50-year service life.				
Extent	Site specific	Local	Regional	National	International
	The impact is considered local because it is probable ecological processes in the wider port area will be affected.				
Duration	Temporary	Short-Term	Medium-Term	Long-Term	Permanent
	The impact is permanent as the structure will be designed and built for a 50-year service life.				
Intensity	Minor	Low	Moderate	High	Severe
	The open water and sediment habitat that will be affected is already disturbed and is not so unique that its loss is highly significant from a critical habitat perspective. The intensity is thus considered low.				
Probability	Highly Unlikely	Unlikely	Possible	Probable	Definite
	The deck-on-pile structure will affect ecological processes, but the effect is unlikely to be highly significant.				
Confidence	Low	Medium	High		
	The confidence that the deck-on-pile structure will affect ecological processes is high. The confidence that the intensity of the impact will be low is medium – it may well be lower or higher.				
Significance	Very Low	Low	Medium	High	Fatally flawed

Mitigation

The most obvious solutions to limiting the amount of shading cast by the proposed deck-on-pile structure is to limit its width, limit the number of piles on the structure, and/or allow light to transmit beneath by including grating or glass inserts in the concrete deck. These solutions have been used effectively on such structures elsewhere in the word. However, the inclusion of grating or glass inserts into the concrete deck might not be feasible since the grating or inserts may not have the structural strength to bear the loads exerted by heavy equipment and vehicles that will use the deck-on-pile. Since the engineering design for the deck-on-pile structure has yet to be finalised there is an opportunity to consider the impact of shading in the design. However, the degree to which shading can be mitigated through the engineering design is uncertain, and in light of this uncertainty it is assumed none of these solutions will be implemented. The significance rating for this impact with mitigation thus remains **LOW**.

Impact assessment with mitigation					
Impact	Ecological impact due to habitat modification by the deck-on-pile structure				
Mitigation	• The number of piles used should be limited to the smallest number possible, to decrease the shade cast by pilings. • If possible, inserts should be incorporated into the deck of the deck-on-pile structure to transmit light to the water beneath.				
Nature	Direct	Indirect	Reversible	Irreversible	
Extent	Site specific	Local	Regional	National	International
Duration	Temporary	Short-Term	Medium-Term	Long-Term	Permanent
Intensity	Minor	Low	Moderate	High	Severe
Probability	Highly Unlikely	Unlikely	Possible	Probable	Definite
Confidence	Low	Medium	High		
Significance	Very Low	Low	Medium	High	Fatally flawed

Potential for cumulative effects

The deck-on-pile structure will add to the shading and other impacts of the extensive area already affected by deck-on-pile structures near the Old Tug Jetty quay area, including the jetty leading from the quay area and the leading jetties nearby (see Figure 42).

Required monitoring

None.

6.2.3. Decommissioning phase impacts

As stated previously, there is no intended decommissioning phase for the project as the rehabilitated quay will be designed for a 50-year service life subject to regular and effective maintenance (PRDW, 2017). It is impossible to anticipate what the port and its surroundings may resemble at that time, making it difficult to assess the significance of decommissioning impacts.

7. Conclusions, Recommendations, and Authorisation Opinion

7.1. Environmental impact statement

The rehabilitation of the Old Tug Jetty sheet pile quay wall in the Port of Port Elizabeth is needed to prevent the ongoing deterioration of this infrastructure to a degree that it poses operational, human health, and environmental risks. The proposed rehabilitation of the sheet pile quay wall in Phase 1 and the possible construction of a deck-on-pile structure in Phase 2, should the need arise, will obviously impact on the biophysical environment in the port and at and near the dredged spoil disposal site in Algoa Bay. A total of 25 impacts were identified for the construction phase and three for the operational phase of the proposed project, as summarised in Table 3. Most construction phase impacts are anticipated to be site specific in their spatial extent and of a minor or low intensity since the affected area and associated biological communities is already disturbed by existing port operations. Most of the identified impacts are fully reversible and biological communities in the affected area, and hence also ecological processes, will recover and re-establish after construction ceases to a degree permitted by ongoing port activities and notwithstanding the permanent loss of some open water and sediment habitat.

The recent demolition and reconstruction of the leading jetties for the vessel maintenance operation near the Old Tug Jetty quay area had no apparent significant impact on biological communities and ecological processes in the port. This lends confidence that the proposed rehabilitation of the Old Tug Jetty quay area will also not have a major long-term impact on ecological processes in the port.

Certain aspects of the proposed rehabilitation of the Old Tug Jetty sheet pile quay wall and the deck-on-pile structure are yet to be finalised, including the final engineering design and construction and dredging methods. The identification and assessment of environmental impacts in the current assessment provides an opportunity to mitigate some impacts through the engineering design and construction method. There is similarly an opportunity to include in the engineering design strategies for reducing existing impacts, such as surface runoff storage systems to limit the ingress of contaminants into the estuary.

7.2. Monitoring recommendations

Considering that of the environmental impacts identified were assessed to have a very low or low significance there is no need to implement detailed aquatic environmental monitoring programme for the proposed project. It seems probable the construction period will overlap with surveys for the Long-Term Ecological Monitoring Programme for the Port of Port Elizabeth, which should identify if there are any unforeseen major changes to the aquatic environment in the port associated with the proposed construction activities. There is also no need for a detailed aquatic environmental monitoring programme at and near the dredged spoil disposal site in Algoa Bay for the same reasons, although having information of the status of biological communities at and near this site would be beneficial in the long-term.

7.3. Authorisation opinion

This Marine Ecology Specialist Study has identified and assessed impacts to the biophysical environment in the Port of Port Elizabeth and at and near the dredged spoil disposal site in Algoa Bay that might or will arise due to the proposed rehabilitation of the Old Tug Jetty sheet pile wall in Phase 1 and the construction of a deck-on-pile structure in Phase 2. As stated elsewhere in this report, if the proposed project proceeds it will entail unavoidable impacts to the biophysical environment. Section 31 (n) of the National Environmental Management Act: Environmental Impact Assessment Regulations, GNR. 543 of 2010 (as amended in 2014), requires that the Environmental Assessment Practitioner provide an opinion on whether the proposed project (activity) should or should not be authorised. The purpose of this section is to provide a reasoned opinion in this context for impacts to the biophysical environment that might or will arise because of the proposed project.

Phase 1 of the proposed project will largely involve improvements to existing infrastructure at the Old Tug Jetty quay area. The improvements will result in an increase in the footprint of the existing infrastructure and will thus lead to the permanent loss of a small amount of open water and sediment habitat. The construction of a deck-on-pile structure in Phase 2 will involve the construction of new infrastructure and will thus lead to a further increase in the infrastructure footprint, but this increase will not be matched by an equivalent permanent loss of open water and sediment habitat as the new infrastructure will be of a deck-on-pile type. The project will primarily affect already disturbed environments in the Port of Port Elizabeth and at and near the dredged spoil disposal site in Algoa Bay and will not substantially affect pristine natural resources. Some rare, threatened, or endangered species may periodically enter the port and/or use the area near the dredged spoil disposal site but these areas, as far as could be established, do not constitute critical habitat for rare, threatened, or endangered species. Most of the biophysical environmental impacts identified will directly and indirectly affect a small area at and near the proposed project site in the port or at and near the dredged spoil disposal site in Algoa Bay and are not anticipated to have major nor long-lasting consequences as most impacts are fully reversible. As stated above the proposed project will result in the permanent loss of open water and sediment habitat in the port. The amount of habitat that will be lost is small in relation to available similar habitat in the port and its loss is not anticipated to result on major changes to populations or ecological processes in the port. In those instances where the significance of identified environmental impacts was rated as greater than low the implementation of mitigation and responsible practices during the construction and operational phases should reduce the significance to acceptable levels. None of the impacts is considered unacceptably significant such that they constitute a fatal flaw for the proposed project.

The proposed project will thus have a very low to low negative overall impact on the biophysical environment. The specialist that prepared this specialist report is thus of the opinion that, based on purely biophysical environmental considerations, the proposed project can be approved provided recommended and/or other more effective mitigation that might be identified is implemented and the final engineering design and construction method statement do not identify additional environmental impacts or increase the significance of assessed impacts. In the event of the latter, the significance assessment of some of the identified environmental impacts might need to be revisited.

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9. Glossary of Terms

Abiotic factors	The physical, chemical, and other non-living components of the environment that an organism lives in. These factors include all aspects of climate, geology, and atmosphere that affect ecological systems.
Acute effect	Rapid adverse (lethal) effect caused for example by contaminants or physical processes. The term can be used to define either the exposure or the response to an exposure (effect).
Acute toxicity	The discernible adverse effects induced in an organism within a short period of time of exposure to a chemical. For aquatic animals, this usually refers to continuous exposure to the chemical in water for a period of up to four days.
Acute toxicity test	A method used to determine the concentration of a substance that produces a toxic effect on a specified percentage of test organisms in a short period of time.
Adsorption/adsorb	Bonding of chemicals onto the surfaces of suspended particles by way of physical, chemical, and biological processes.
Adverse effect	Change in the morphology, physiology, growth, development, reproduction, or life span of an organism, system, or (sub)population that results in an impairment of functional capacity, an impairment of the capacity to compensate for additional stress, or an increase in susceptibility to other influences.
Aerobic	Occurring in the presence of oxygen. An aerobic environment is one characterised by the presence of free oxygen (O_2), in contrast to an anaerobic environment which is one devoid of free oxygen.
Aliquot	A sub-sample of the original sample.
Alkaline	Having the properties of a base, a pH greater than 7.
Ambient	Environmental or surrounding conditions.
Ammonia (NH_3)	A chemical combination of nitrogen and hydrogen that occurs extensively in nature. It is a water-soluble gas that behaves as a weak base. It can exert toxic effects on aquatic life. Synonymous with the obsolete term free and saline and ammonia.
Ammonium (NH_4^+)	The protonated form and conjugate acid of ammonia. It predominates under low-pH conditions.
Anaerobic	Occurring in the absence of oxygen. An anaerobic environment is characterised by the absence of free oxygen.
Anaerobic (anoxic) sediment	Aquatic sediments that have a high organic matter content. The organic matter is subject to a bacterial decay process that causes the oxygen level in sediments to sharply decline, producing anaerobic conditions. If this situation continues, hydrogen sulphide can form which combines with iron to give the sediments a black appearance.
Analyte	A substance measured in the laboratory. A chemical for which a sample (such as water, air, or blood) is tested in a laboratory. For example, if the analyte is mercury, the laboratory test will determine the amount of mercury in the sample.
Anoxic (anoxia)	A condition where very little to no oxygen (typically <0.5 $mg.l^{-1}$) is present in a waterbody or in water between the grains of sediment.
Anthropogenic	Made and/or introduced into the environment by human activities, as pertaining to contaminants/pollutants.
Aquatic ecosystem	All the living and non-living material interacting within an aquatic system (*e.g.* pond, lake, river, ocean).
Assemblage	An association of interacting populations in a habitat (*e.g.* an assemblage of benthic invertebrates on the seabed).
Backfill	The word is used in two contexts; to refill an excavated area with uncontaminated soils; and the material used to refill an excavated area.
Bacteria	Single-celled organisms that generally reproduce by fission. Some are pathogenic (disease causing), but most are free-living, with some being saprophytic (feed on dead or decaying organic matter).

Baseline	Information gathered at the beginning of a study which describes the environment prior to development of a project, and against which predicted changes (impacts) are measured.
Baseline	A reference condition against which changes, or trends are judged - usually a set of conditions that exist at a particular point in time.
Bathymetry	Measurement of the depth of water in oceans, rivers, or lakes.
Benthic	Pertaining to the environment inhabited by organisms living on or in the bottom.
Benthos	Living organisms (*e.g.* algae and animals) associated with the bottom.
Bioaccumulate	The process by which chemical substances are taken up by living things and retained.
Bioavailability	A measure of the physiochemical access that a chemical or toxicant has to the biological processes of an organism. The less the bioavailability of a toxicant, the less its toxic effect on an organism.
Bioavailable	A substance in a chemical and physical form that allows it to affect organisms or be accumulated by them.
Bioavailable	A substance in a chemical and physical form that allows it to affect organisms or be accumulated by them.
Biodiversity	The diversity, or variety, of plants, animals and other living things in a particular area or region. It encompasses habitat diversity, species diversity and genetic diversity.
Biogeochemistry	The relationship between geochemistry and the biology of a region.
Biological community	An assemblage of organisms characterised by a distinctive combination of species occupying a common environment and interacting with one another.
Biomass	Total weight of organisms per unit area or volume of water or sediment.
Biota	All living things, including microorganisms, plants and animals.
Biota	The animal and plant life of a particular region.
Bloom (microalgal)	An unusually large number of organisms per unit of water, usually microalgae, made up of one or a few species.
Catchment	The total area draining into a river, reservoir, or other body of water.
Catchment	A catchment is a basin shaped area of land, bounded by natural features such as hills or mountains from which surface and sub surface water flows into streams, rivers and wetlands. Water flows into, and collects in, the lowest areas in the landscape.
Chart Datum	The level of water that charted depths displayed on nautical charts are measured from.
Chlorophyll-*a*	Chlorophyll-*a* is the green pigment found in all plants and in nearly all algae. Chlorophyll-*a* allows plants and algae to use sunlight in the process of photosynthesis for growth. The concentration of chlorophyll-*a* in estuarine, coastal or marine waters is used as an indicator of photosynthetic plankton biomass.
Chronic Toxicity	The response of an organism to long-term exposure to a chemical substance. Among others, the responses that are often measured in chronic toxicity tests include lethality, decreased growth, and impaired reproduction.
Coliform bacteria	A group of bacteria primarily found in human and animal intestines and wastes. These bacteria are widely used as indicator organisms to show the presence of such wastes in water and the possible presence of pathogenic (disease-producing) bacteria. *Escherichia coli* (*E. coli*) is one of the faecal coliform bacteria widely used for this purpose.
Colony forming unit (CFU)	A unit (measurement) of density used to estimate bacteria concentrations in ocean water. The number of bacterial cells that grow to form entire colonies, which can then be quantified visually.
Community	Any group of organisms belonging to several different species that co-occur in the same habitat or area. An association of interacting assemblages in any given water body.
Community composition	All the types of biological taxa present in a community.
Community structure	All the types of taxa present in a community and their relative abundances.
Concentration	The quantifiable amount of a substance in water, food or sediment.

Construction Phase	The stage of project development comprising site preparation as well as all construction activities associated with the development.
Contaminant	Biological (*e.g.* bacterial and viral pathogens) and chemical introductions capable of producing an adverse response (effect) in a biological system, seriously injuring structure and/or function.
Cope	The top edge of a quay or jetty adjacent to a berth.
Counterfort wall	A counterfort retaining wall is a cantilever wall with counterforts, or buttresses, attached to the inside face of the wall to further resist lateral thrust. Some common materials used for retaining walls are treated lumber, concrete block systems, poured concrete, stone, and brick
Critical Habitat	Specific areas within the geographical area occupied by a species at the time of listing that contain physical or biological features essential to conservation of the species and that may require special management considerations or protection.
CSIR	Council for Scientific and Industrial Research
Cumulative effects/impact	Effects on the environment resulting from actions that are individually minor but that add up to a greater total effect as they take place over a period of time.
Detection limit	The smallest concentration or amount of a substance that can be reported as present with a specified degree of certainty by analytical procedures.
Dissolved oxygen	Oxygen that is dissolved in water and therefore freely available for plants (phytoplankton), shellfish, fish, and other animals to use.
Diversity	A measurement of community structure that describes the abundances of different species within a community, taking into account their relative rarity or commonness.
Ecological processes	The metabolic functions of ecosystems - energy flow, elemental cycling, and the production, consumption, and decomposition of organic matter.
Ecology	The study of the interrelationships of organisms with and within their physical surroundings.
Ecosystem	Any system in which living organisms and their immediate physical, chemical and biological environment are interactive and interdependent.
Enterococci	Any streptococcal bacteria normally found in the human intestinal tract. Usually non-pathogenic.
Environmental indicator	A measurable feature or features that provide managerially and scientifically useful evidence of environmental and ecosystem quality or reliable evidence of trends in quality.
Environmental value	Anything a community agrees a body of water should be protected for. This might include an ecosystem, industry, agriculture, recreation, and its spiritual and cultural uses/importance.
Epifauna	Animals that live at or on the sediment surface, being either attached (sessile) or capable of movement.
Epifauna/epibenthic animals	The animals that live on the surface of sediments or on and among rocks and other structures.
Escherichia (*E.*) *coli*	A type of faecal coliform bacteria which is found in large numbers in the faeces of humans and other mammals, and birds. It serves as a reliable indicator of recent faecal contamination of water.
Eutrophication	A condition in an aquatic ecosystem where high nutrient concentrations stimulate blooms of algae (*e.g.* phytoplankton). Algal decomposition may lower dissolved oxygen concentrations. Although eutrophication is a natural process in the aging of lakes and some estuaries, it can be accelerated by both point and non-point sources of nutrients.
Faecal coliform	A type of bacteria found in faecal material of humans and other mammals. It serves as a reliable indicator of recent faecal contamination of water.
Flocculation	The coagulation and agglomeration of colloidal and finely divided suspended matter to form floes.
Food chain	The transfer of food energy from plants through herbivores to carnivores. An example: algae being eaten by zooplankton (grazers; herbivores) which in turn are eaten by small fish (planktivores; predators) which are then eaten by larger

	fish (piscivores; fish eating predators) and eventually by people or other predators (fish-eating birds, mammals).
Food web	The interlocking patterns formed by a series of interconnected food chains.
Geochemical	Principles of physical chemistry and geology affecting minerals and rocks.
Grab	A mechanical device designed to collect bottom sediment samples. The device consists of a pair of hinged jaws and a release mechanism that allows the opened jaws to close and entrap a sediment sample once they touch bottom.
Gravity wall	Retaining wall of heavy cross-section that resists horizontal actions by means of dead weight and friction.
Guideline	A numerical concentration limit or narrative statement recommended to support and maintain a designated water use.
Habitat	A place where the physical and biological elements of ecosystems provide an environment and elements of the food, cover and space resources needed for plant and animal survival.
Heavy metal	An imprecise term with no sound terminological or scientific basis, used loosely to refer to metals that are toxic.
Highest Astronomical Tide	The elevation of the highest predicted astronomical tide expected to occur at a specific tide station over the National Tidal Datum Epoch.
Hydrocarbons	Organic compounds consisting exclusively of the elements carbon and hydrogen and including such substances as paraffin, benzene and fuel oil. Some are obtained by cracking larger molecules (*e.g.* petrol).
Hydrophobic	Having little or no affinity for water, repels or does not absorb water.
Hypoxia	The condition of low dissolved oxygen in aquatic systems (typically with a concentration <2 $mg.l^{-1}$ but >0.5 $mg.l^{-1}$).
Impact	A change in the chemical, physical or biological quality or condition of a waterbody caused by external sources.
Impairment	A detrimental effect on the biological integrity of a water body caused by an impact.
In situ	In the natural habitat as opposed to in a laboratory or controlled situation.
Indicator	Characteristics for the environment, both abiotic and biotic, that can provide quantitative information on condition or state of an ecosystem. They include biological indicators (*e.g.* species composition, species abundance) and physical or chemical indicators (*e.g.* dissolved oxygen concentration, temperature). These often represent the targets, or water quality objectives, that need to be met to actually achieve the desired level of ecosystem protection.
Infauna	Those animals that live within bottom sediment.
Infauna	Animals of any size that within sediment. They move freely through interstitial spaces between sedimentary particles, or they build burrows or tubes.
Inorganic	Any compound lacking carbon.
Invertebrate	An animal without a backbone (*e.g.* a starfish, crab, or worm).
Laydown areas	An area that has been cleared for the temporary storage of equipment and supplies.
Macroalgae	A member of the macroscopic algal life of an area, especially of a body of water; large aquatic algae.
Macrophyte	A member of the macroscopic plant life of an area, especially of a body of water; large aquatic plant.
Mean High Water Spring	*the hihgest level which spring tides reach on average over a period of time*
Mean Low Water Spring	*the lowest level which spring tides reach on average over a period of time*
Median	The median is the middle value in a data set ranked from lowest to highest.
Method detection limit	The minimum concentration of a substance that can be measured and reported with 99% confidence that the concentration is greater than zero.
Micro/Algal bloom	A heavy growth of algae in and on a body of water; usually results from high nitrate and phosphate concentrations entering water bodies from farm

	fertilizers and detergents; phosphates also occur naturally under certain conditions.
Microalgae	Photosynthetic microscopic organisms and are also known as phytoplankton.
Microbiology	The study of micro-organisms.
Microorganism	A living organism invisible or barely visible to the naked eye because of its small size; some, however, produce colonies of macroscopic size.
Monitoring	Periodic or continuous surveillance or testing to determine the level of compliance with statutory requirements and/or pollutant levels in various media or in humans, animals, and other living things.
Normalise	Perform a data calculation in order to express results in terms of a reference parameter or characteristic.
Nutrient enrichment	A term that describes the addition of too much nutrient (nitrogen, phosphorus and carbon), to waterbodies from human actions and the resulting responses that typically leads to changes in plant and animal communities and degradation of water and sediment quality.
Nutrients	Essential chemicals (*e.g.* nitrogen and phosphorus) needed by plants for growth.
Organochlorides	A group of organic (carbon-containing) insecticides that also contain chlorine. These chemicals tend not to break down easily in the environment. DDT, Toxaphene and Endosulfan are all organochlorides.
Pathogen	An agent such as a virus, bacterium or fungus that can cause diseases in humans. Pathogens can be present in municipal, industrial, and non-point-source discharges.
Percentile	A value on a scale of 100 that indicates the percent of a distribution that is equal to or below it.
pH	pH is a measure of acidity or alkalinity of water on a log scale from 1 (extremely acidic) through 7 (neutral) to 14 (extremely alkaline).
Photosynthesis	The conversion of carbon dioxide to carbohydrates in the presence of chlorophyll using light energy.
Physico-chemical	Measurement of both physical properties (*e.g.* temperature, salinity) and chemical determinants (*e.g.* metals and nutrients) to characterise the state of an environment.
Phytoplankton	Microscopic floating plants, mainly algae, that live suspended in bodies of water and that drift about because they cannot move by themselves or because they are too small or too weak to swim effectively against a current.
Pile cap	A reinforced or mass concrete connecting beam cast around the head of a group of piles enabling it to act as a single unit to support the imposed load.
Pollution	The Paris Convention defines pollution as the introduction by man, directly or indirectly, of substances or energy into the marine environment (including estuaries) resulting in such deleterious effects as hazards to human health, harm to living resources and to marine ecosystems, damage to amenities or interference with other legitimate uses of the sea.
Polychlorinated biphenyls (PCBs)	A group of toxic chemicals used for a variety of purposes including electrical applications, carbonless copy paper, adhesives, hydraulic fluids, and caulking compounds. PCBs do not breakdown easily and are listed as cancer-causing agents under Proposition 65
Polycyclic aromatic hydrocarbon	A class of chemical compounds composed of fused six-carbon rings. Polycyclic aromatic hydrocarbons are commonly found in petroleum oils (*e.g.* gasoline and fuel oils) and are emitted from various combustion processes (*e.g.* automobile exhausts, electric companies).
Population	An aggregate of interbreeding individuals of a biological species within a specified location.
Primary production	The first stage in the production of organic matter, mainly because of phytoplankton and algal growth.
Producers	Organisms able to build up their body substance from inorganic materials.
Propeller wash	The disturbed mass of water pushed aft (or fore when in reverse) by the propeller of watercraft.
Quay	A structure built parallel to the bank of a waterway for use as a landing place.

Recruitment	The replenishment or addition of individuals of an animal or plant population through reproduction, dispersion, and migration.
Redox potential	An expression of the oxidising or reducing power of a solution relative to a reference potential.
Reference toxicant	A chemical used to access the constancy of response of a given species of test organisms to that chemical. It is assumed that any change in sensitivity to the reference substance will indicate the existence of some similar change in degree of sensitivity to other chemicals/effluents whose toxicity is to be determined.
Replicate	Taking more than one sample or performing more than one analysis. In chemical analysis and toxicity testing a duplicate.
Salinity	A measurement of the amount of salt in water.
Sediment	Mud, sand, silt, clay, shell debris, and other particles that settle on the bottom of rivers, lakes, estuaries, and oceans.
Sheet pile wall	Sheet pile walls are constructed by driving prefabricated sections into the ground. Soil conditions may allow for the sections to be vibrated into ground instead of it being hammer driven. The full sheet pile wall is formed by connecting the joints of adjacent sheet pile sections in sequential installation.
Species	A category of biological classification ranking immediately below the genus, comprising related organisms potentially capable of interbreeding. A species is identified by a two part name; the name of the genus followed by a Latin or Latinised un-capitalised noun agreeing grammatically with the genus name.
Species richness	The number of species per unit area.
Station	A sampling location within a study area or site, where physical, chemical, or biological sampling and/or testing occurs.
Taxon (taxa)	Any group of organisms considered to be sufficiently distinct from other groups to be treated as a separate unit (*e.g.* species, genera, families).
Total Suspended Solids	A measure of the total weight of particles in the water column, and is analysed in the laboratory from field samples.
Toxic	Poisonous, carcinogenic, or otherwise directly harmful to life.
Toxicant	A chemical capable of producing an adverse response (effect) in a biological system, seriously injuring structure or function or producing death (*e.g.* pesticides and metals).
Toxicity	A measure of the impact on a chosen biological process or condition.
Trophic level	The position occupied by an organism in the food chain, e.g. green plants occupy the first trophic level, herbivores the second, and carnivores which eat herbivores the third.
Tubular pile	A pile consisting of a steel tube driven into the ground and filled with concrete after the enclosed earth has been removed.
Turbidity	Turbidity is a measure of water clarity or murkiness. It is an optical property that expresses the degree to which light is scattered and absorbed by molecules and particles.
Water column	A conceptual column of water from the surface to the bottom.
Water quality	Water quality describes the condition of a water body and its related suitability for different purposes (also known as environmental values). In a healthy water body, the water quality supports a rich and varied community of organisms, sustains public health and/or agricultural applications.
Water Quality Guideline	A parameter concentration (*e.g.* nitrate) or narrative statement (*e.g.* no algal blooms) that is used to assess whether a declared water value is being sustained. If the guideline is not met, the water maybe under threat and investigation is warranted to ascertain if the cause is anthropogenic or due to natural phenomena.

10. Details of Specialist Study Author

To add – Abantu env template?

11. Declaration of Independence

To add – Abantu env template?