ASSESSMENT OF SEDIMENT QUALITY IN PROPOSED MAYDON WHARF BERTH DEEPENING DREDGING FOOTPRINT IN DURBAN BAY

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Executive Summary

Transnet National Ports Authority intends deepening numerous berths in Maydon Channel and part of Congella Basin in the Port of Durban, as part of the Maydon Wharf Berth 5-11&15 Upgrade Project. The intent is to dispose of the dredged material at an open water dredged spoil disposal site off Durban, or to potentially use the sediment beneficially within Durban Bay.

This report provides the findings of the physical and chemical analysis and toxicity testing of sediment sampled in May 2024 in the proposed Maydon Wharf Berth 5-11&15 Upgrade Project dredging footprint. The purpose is to provide Transnet National Ports Authority with information required for the completion of a permit application to the Department of Forestry, Fisheries and the Environment to cover the open water disposal of the dredged sediment. The report also provides officials from the Department of Forestry, Fisheries and the Environment with information for reaching an informed decision on the permit application.

Sediment sampled at each berth was analysed for its grain size, total organic carbon content, and the concentrations of 15 metals. Elutriates of the sediment were tested for toxicity using the sea urchin embryo-larval toxicity test.

The sediment at all stations was dominated by mud. The sediment at a station in Congella Basin was fairly significantly enriched with particulate organic matter, but not the sediment at stations in Maydon Channel. Apart from the chromium concentration in sediment at three stations and the zinc concentration in sediment at one station, metal concentrations were within the baseline range for Durban Bay. In the case of the enriched metal concentrations, they fall only slightly above the baseline range and reflect low level contamination. Metal concentrations in the sediment were below sediment quality guidelines that the Department of Forestry, Fisheries and the Environment uses to decide if sediment identified for dredging in South African ports is suitable for open water disposal.

Undiluted elutriates prepared using sediment sampled at four stations were slightly or marginally toxic, but not those prepared using sediment sampled at other stations. The 75% and 50% strength elutriates for the four stations were not toxic. The proportion of embryos that developed to a normal 4-arm pluteus in the 100% elutriate was not reduced by >20% relative to the control treatment and a 25% dilution of the elutriates was sufficient to render the elutriates non-toxic. Acute toxicity is not anticipated when sediment dredged in the proposed dredging footprint is disposed at the open water dredged material disposal site off Durban. The sediment is also unlikely to pose a risk if it is placed elsewhere in Durban Bay, noting placement of the dredged material elsewhere in the Bay will pose environmental impacts not considered in this study. However, based on historical data the sediment used for placement in Durban Bay should ideally exclude that dredged in Congella Basin, where contamination has been pronounced in the past.

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1. Background and Report Purpose

Transnet National Ports Authority intends deepening numerous berths in Maydon Channel and part of Congella Basin in the Port of Durban, as part of the Maydon Wharf Berth 5-11&15 Upgrade Project. The intent is to either dispose of the dredged material at an open water dredged spoil disposal site off Durban, or if it is not significantly contaminated to potentially use the material beneficially within Durban Bay.

Dredging poses numerous environmental impacts. These include an increase in the suspended sediment concentration and turbidity in the water column, the removal, injury, and disturbance of biological communities in the dredging footprint, and the remobilisation of toxic chemicals that might have accumulated in sediment into the water column. There is no South African environmental legislation that governs the act of dredging, but the dredging party is expected to exercise a duty of care to limit environmental degradation. The National Environmental Management Act: Integrated Coastal Management Act, 2008 (Act No. 24 of 2008) governs the open water disposal of dredged material. The open water disposal of dredged material requires a permit from the Department of Forestry, Fisheries and the Environment. The permitting procedure is in line with the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter of 1972 (the London Convention) and 1996 Protocol thereto, to which South Africa is a signatory. To comply with the Act, Transnet National Ports Authority will need to make an application to the Department to dispose sediment dredged in Durban Bay at the open water dredged spoil disposal site off Durban. The Department decides if dredged sediment may be disposed at open water dredged spoil disposal sites based largely on metal concentrations in the sediment.

This report provides the findings of the physical and chemical analysis and toxicity testing of sediment sampled in May 2024 in the proposed Maydon Wharf berth deepening dredging footprint. The purpose is to provide Transnet National Ports Authority with information required for the completion of a permit application to the Department of Forestry, Fisheries and the Environment to cover the open water disposal of the dredged sediment. The report also provides officials from the Department of Forestry, Fisheries and the Environment with information for reaching an informed decision on the permit application.

2. Material and Methods

2.1 Fieldwork

Sediment was sampled on 28 May 2024. At Maydon Wharf Berths 5-11 and 15, 2-3 sediment samples were collected and combined, to provide a composite sample per berth. (Figures 1 and 2; see Appendix 1 for station Global Positioning System coordinates). The grain size, total organic carbon content, and concentrations of 15 metals were analysed in the sediment sampled at each station. Elutriates of the sediment were also tested for toxicity to sea urchin embryo-larvae.

The upper 5-10 cm of sediment was sampled using a van Veen grab. On retrieval, water overlying sediment in the grab was bled through a bleeder hole in upper corner of the grab, taking care to lose as little fine-grained material as possible in the process. Sediment from the 2-3 grab samples collected per berth was composited in a glass bowl and inspected. If the sediment was deemed acceptable it was homogenised in the glass bowl using a high-density polyethylene scoop. Small stones, plastic items, and other material not representative of the sediment was removed if encountered. Characteristics of the sediment, such as its colour, texture, and aroma were noted on field data sheets and the sediment was photographed. Aliquots of the sediment were then distributed between pre-cleaned high-density polyethylene and amber glass jars depending on the required analyses. The samples were held on ice in the field and frozen (-18^{o}C) on return to the laboratory apart from the sediment destined for toxicity testing, which was refrigerated at 4^{o}C. The grab and sediment processing equipment was rinsed in site water, scrubbed with a brush if necessary and rinsed again in site water, sprayed with acetone, and again rinsed in site water before sampling the sediment at a new station to limit cross contamination.

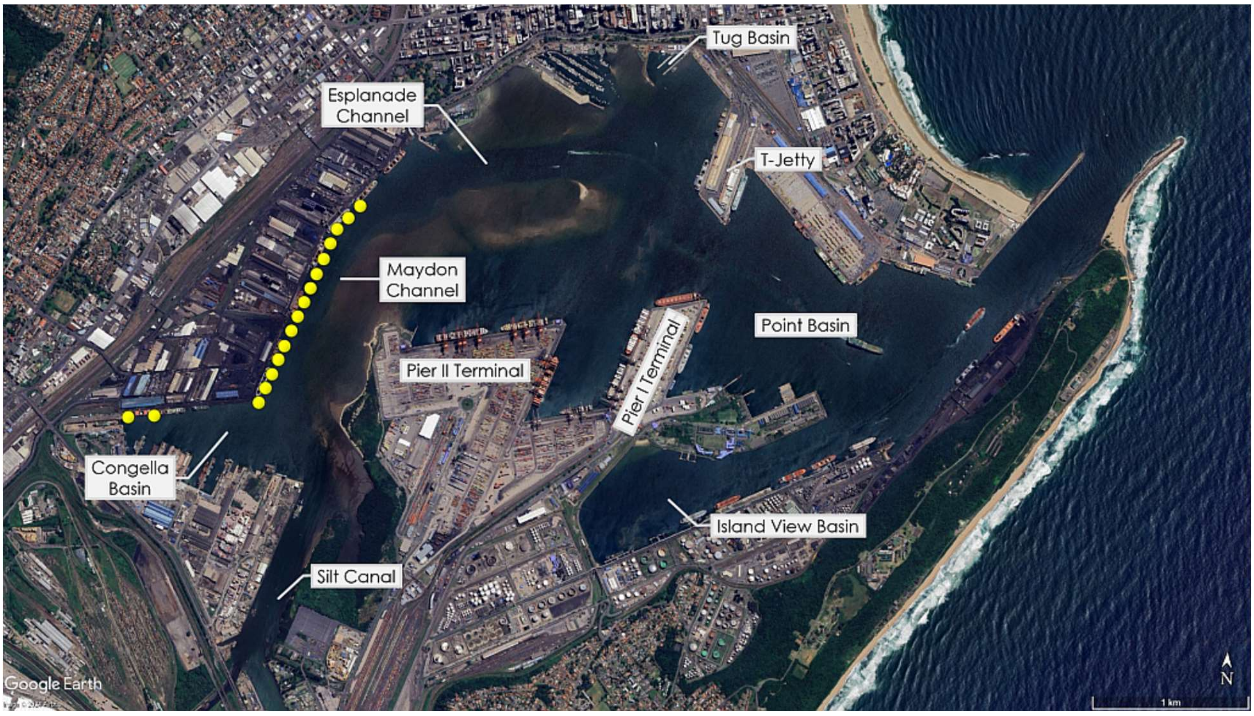

Figure 1. Aerial view of Durban Bay showing place names mentioned in the text.

Figure 2. Aerial view of Durban Bay showing the positions (stations) where sediment was sampled in the proposed Maydon Wharf berth deepening dredging footprint for physical and chemical analysis and toxicity testing on May 2024.

2.2 Laboratory analyses

2.2.1 Analytical laboratories

Analyses on sediment were performed at the Environmental Chemistry and Marine Ecotoxicology laboratories at the CSIR campuses in Stellenbosch and Durban respectively. The CSIR Environmental Chemistry Laboratory is accredited by the South African National Accreditation System (SANAS) for the analysis of marine water, sediment, and biological tissue (Appendix 2).

2.2.2 Grain size

Sediment grain size composition was determined by wet and dry sieving the sediment into five grain size classes, namely mud (<0.075 mm), fine fine-grained sand (0.075-0.150 mm), medium fine-grained sand (0.150-0.250 mm), coarse fine-grained sand (0.150-0.425 mm), and coarse-grained sand (0.5-2.0 mm).

2.2.3 Total organic carbon

Approximately 50 g of sediment was oven dried at 60°C, lightly pulverised in a mortar and pestle, weighed into a flat bottom flask, and 150 ml of hydrogen peroxide added. The samples were heated to 70°C on a hot plate and swirled to avoid bubbling over. After completed reaction with the hydrogen peroxide the samples were placed in an oven to evaporate remaining hydrogen peroxide. The samples were then reweighed. The difference between the initial and final sample weights was used to determine the total organic content.

2.2.4 Metals

The sediment was freeze dried and ball milled. About 1 g was weighed into a digestion vessel and digested in a mixture of HNO_3-HCl-H_2O_2 according to United States Environmental Protection Agency (USEPA) method 3050B. This is a 'near-total' digestion method that dissolves most elements that could be 'environmentally available', but it is not designed to dissolve metals tightly incorporated in silicate structures (*i.e.* refractive metals). The digestate was filtered (0.45 µm), diluted to volume with Milli-Q water, and the concentrations of various major, minor and trace metals detected and quantified using Inductively Coupled Plasma Optical Emission (ICP-OES) and Mass Spectroscopy (ICP-MS). Mercury was analysed using a direct mercury analyser (DMA).

Method blanks were analysed to assess laboratory contamination. The precision and extraction efficiency of the analytical procedures was evaluated by analysing marine sediment reference standard PACS-2 (National Research Council of Canada) and laboratory duplicates. Since the reference material is certified for total digestion but a near-total extraction procedure was used in this study, the recovery of several refractory metals (*e.g.* aluminium, chromium) was somewhat below 100% (Appendix 3). The recoveries are within limits defined by the CSIR for quality assurance and quality control purposes based on the results of repeated analysis of the CRM. All metals were at a concentration below the method detection limit in method blanks. The Relative Standard Deviation for all metals in a laboratory duplicate was within the data quality objective of 10% (Appendix 3).

Although arsenic is technically a metalloid (*i.e.* semi-metal), in the interests of simplicity it is referred to as a metal in this report.

2.2.5 Toxicity testing

The sediment was homogenised in the sample containers using a stainless-steel homogeniser until it was of a uniform texture and colour. Sediment was then transferred to a glass sample bottle to the 100 mL mark, whereafter 400 mL of clean filtered (5 µm) seawater (salinity of 35) was added. The bottles were sealed and placed on a rotary shaker for 1 hr at 200 revolutions per minute. The contents were allowed to settle for 30 minutes, whereafter the aqueous fraction (elutriate) was extracted. The elutriates were turbid, and were thus centrifuged at 1500 × *g* for 5 minutes to allow for the observation of test organisms. Aliquots (20 mL) of the elutriates were transferred to each of four glass vials per sample. The elutriates were also diluted to 75% and 50% of the original and aliquots were similarly transferred to each of four glass vials per sample. Sea urchin (*Echinometra mathaei*) embryos fertilised in the laboratory were then added to the vials. The vials were placed randomly in an environmental chamber at 23°C and a 12 hr light:dark cycle. After 72 hr, a small volume of formalin was added to each vial to end the test.

Seawater treated in the same way as the elutriate samples above but containing no sediment was used as a negative control to verify the test setup did not adversely affect developing embryo-larvae. A second negative control consisting of filtered seawater from Vetch's Beach in Durban was tested to verify organism health. The control from a concurrent reference toxicant test (see below) was used for this purpose.

A reference toxicant test (positive control) was performed concurrently with the elutriate test to evaluate test organism health and sensitivity relative to the results of historical testing. The test consisted of eight copper concentrations in seawater plus a control treatment (5 µm filtered seawater collected at Vetch's Beach in Durban).

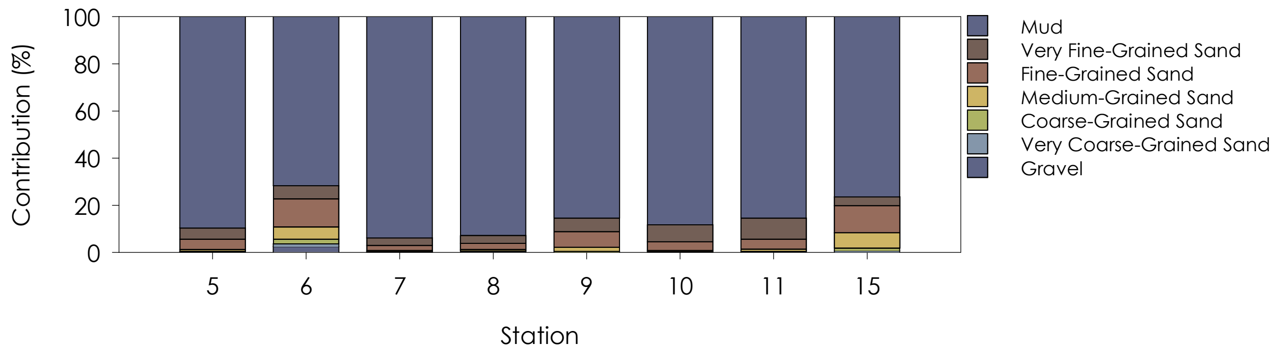

Figure 3. Contribution of various grain sizes to the bulk weight of sediment sampled in the proposed Maydon Wharf berth deepening dredging footprint in May 2024.

Fertilised eggs were added to 20 mL of each copper concentration in four replicate glass vials per concentration and exposed for 72 hr under the same conditions as the elutriate test. At the end of the exposure period the test was terminated by adding formalin to the vials. The proportion of embryos that developed to the normal 4-arm pluteus was determined by examining the 100 individuals observed per replicate under an optical microscope.

The proportion of embryos that developed to the normal 4-arm pluteus in all treatments was determined by examining the first 100 individuals observed per replicate under an optical microscope.

3. Results and Discussion

3.1 Grain size composition

In a geologically homogenous area, grain size is the most important factor that controls the natural concentrations of metals in sediment because aluminosilicates, the major natural metal-bearing phase of sediment, predominate in clay. Sand, in contrast, is comprised largely of metal deficient quartz (silica) and acts as a diluent of metal concentrations. Muddy sediment thus naturally has a higher metal content than sandy sediment. Mud also sequesters metals that are anthropogenically introduced in solution to surface waters because of the large surface area provided by the grains for adsorption and because their surface is electrically charged, rendering them chemically reactive. Metals and other particle reactive contaminants also attach to and are transported with suspended particulate matter in the water column, ultimately settling and accumulating in depositional zones. These are areas where the sediment is dominated by fine-grained material (*e.g.* mud) and form where water currents are so weak that fine-grained suspended material and any associated contaminants settle from the water column. Generally, naturally occurring and anthropogenically introduced metal concentrations are highest in muddy sediment and lowest in sandy sediment. There may be exceptions in ports since coarse-grained sediment may contain high metal concentrations due, for example, to the inclusion of metal flecks and metal-impregnated antifouling coating flakes from vessel maintenance operations, and metal concentrate and ore particles spilled during the loading of vessels.

The grain size composition of sediment thus provides important information for identifying areas in the Maydon Wharf dredging footprint where particle reactive contaminants have a propensity to accumulate. Anomalously high metal concentrations in sandy sediment provides indirect information on the likelihood the metals were present as a solid (*i.e.* a largely non-bioavailable form), which has implications for understanding the toxicological risk.

The sediment sampled at all stations in the proposed Maydon Wharf berth deepening dredging footprint was dominated by mud, which contributed 71.6 - 93.8% of the bulk sediment weight (Figure 3; data in Appendix 4).

3.2 Total organic carbon

Particulate organic matter in sediment also provides a site for the adsorption of contaminants, including metals such as cadmium and mercury and

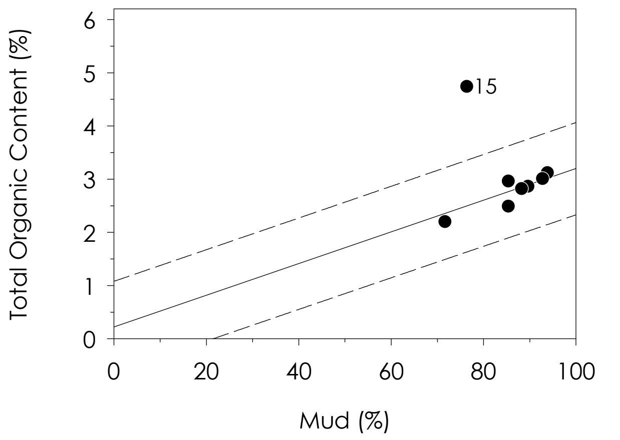

Figure 4. Baseline model for the total organic content in sediment in Durban Bay, with the total organic content in sediment sampled in the proposed Maydon Wharf berth deepening dredging footprint in May 2024 superimposed. Selected data are highlighted by station identifiers.

organic contaminants such as polycyclic aromatic hydrocarbons. Metals and other contaminants that are particle reactive attach to and are transported with suspended particulate organic matter in the water column, ultimately settling and accumulating in depositional zones. Due to its fine-grained nature, particulate organic matter is deposited on and winnowed from sediment concurrently with mud depending on the prevailing current regime. Mud and particulate organic matter tend, therefore, to accumulate in or be depleted from sediment in the same areas. The total organic carbon content of sediment thus provides important information for identifying major sources of, and depositional zones for particulate organic matter in Durban Bay, and therefore, for identifying parts of the Bay that are susceptible to the accumulation of contaminants that preferentially adsorb onto this matter. The total organic carbon content is also monitored to determine if the sediment is so enriched with particulate organic matter that its exposure during dredging will likely result in an excessive oxygen demand by microorganisms that degrade this matter. Since dissolved oxygen is a fundamental requirement for the survival of most forms of aquatic life an excessive oxygen demand is of obvious ecological concern.

In aquatic ecosystems where the sediment is not enriched with particulate organic matter from anthropogenic sources there is often a strong positive relationship between the mud fraction and total organic content of the sediment due to the similar deposition and winnowing from sediment of these fine-grained materials by currents. The relationship is beneficial since it can be used to identify sediment that has an anomalous total organic content. Scientists from the Coastal Systems and Earth Observation research group of the CSIR have defined a baseline model for the total organic content of sediment in the Durban Bay using the results from previous monitoring and research (Figure 4). The baseline model comprises a linear regression and 99% prediction limits (oblique solid and dashed lines respectively in Figure 4). The regression defines the average total organic content at co-occurring mud fractions in sediment at baseline locations in Durban Bay, while the upper and lower prediction limits define the range around the average in which 99% of measurements should fall if the sediment is not enriched with particulate organic matter and the data are normally distributed. A total organic content that plots above the upper prediction limit indicates the sediment has a total organic content in excess of the baseline and is thus deemed to be enriched with particulate organic matter.

Superimposing the total organic content in the sediment sampled in the proposed Maydon Wharf berth deepening dredging footprint in May 2024 onto the baseline model identifies the sediment at Station 15 as fairly significantly enriched (Figure 4; data in Appendix 4). The magnitude of enrichment is, however, too low to suspect the liberation of the particulate organic matter if the sediment were to be dredged will significantly deplete the dissolved oxygen concentration.

3.3 Metals

It is easy to determine if sediment is contaminated by some chemicals since they do not occur naturally in the environment but are manmade. The mere presence of these chemicals in sediment indicates it is contaminated. Determining if sediment is metal contaminated is more complicated because metals are a ubiquitous, naturally occurring component of sediment. The mere presence of metals in sediment does not automatically imply it is contaminated. Metal concentrations in uncontaminated sediment can vary naturally by several orders of magnitude over a relatively small spatial scale depending on the sediments mineralogy, granulometry and organic content amongst other factors (Loring and Rantala, 1992; Kersten and Smedes, 2002). High metal concentrations in sediment do not imply contamination but might simply reflect the mineralogy of the parent material and its grain size and organic content. As a further complication, despite input and transport dissimilarities, naturally occurring and anthropogenically introduced metals tend to accumulate in the same areas (Hanson *et al.*, 1993). As a result of these complexities, an identical metal concentration in two sediment samples from the same aquatic system may reflect contamination in one instance but not the other, because of a difference in the grain size and organic content of the sediment. A low metal concentration might reflect contamination, but a higher concentration might not for the same reason.

To meaningfully interpret metal concentrations in sediment it is necessary to compensate for factors that control their natural variation before background or baseline concentrations can be differentiated from enriched concentrations, which might reflect contamination. This is usually accomplished by the procedure of geochemical normalisation, wherein metal concentrations are mathematically normalised to a co-occurring conservative element in the sediment that provides a tracer of crustal decomposition (Hanson *et al.*, 1993; Kersten and Smedes, 2002). The purpose of geochemical normalization is to compensate for the variables that influence the natural variation of metal concentrations in sediment (principally grain size) such that after normalization concentrations in equally contaminated or uncontaminated sediment with a different granulometry do not differ significantly (Kersten and Smedes, 2002).

In a geologically homogenous area, metals are usually found at relatively constant proportions in uncontaminated sediment (Wedepohl, 1995; Kersten and Smedes, 2002), with their absolute concentration largely controlled by the sediment grain size (Horowitz, 1991; Loring, 1991). There is usually a strong linear relationship between metal concentrations and the silt and clay (mud) fraction, and between concentrations of different metals in sediment. It is these relationships that provide the basis for geochemical normalization, wherein the relationships between a metal and an element that provides a conservative tracer of the natural metal-bearing phases of sediment is modelled through simple linear regression analysis (Hanson *et al.*, 1993; Kersten and Smedes, 2002). Simple linear regression models and associated prediction limits that describe the relationship between a metal and co-occurring normaliser are referred to as baseline metal concentration models, or simply baseline models.

Scientists from the Coastal Systems and Earth Observation research group of the CSIR have defined baseline models for metals in sediment in Durban Bay. The models define the range in concentrations that can be expected for any metal in baseline sediment of a differing grain size. The procedure used to define the baseline models is too voluminous to discuss in this report. Briefly, metal concentrations were plotted against corresponding aluminium concentrations and a simple linear regression and 99% prediction limits were fitted to the data. Metal concentrations falling outside the prediction limits were deemed outliers and trimmed, starting with the concentration with the largest residual, reiterating the regression, and proceeding in this way until all concentrations fell within the prediction limits. The models represent baseline rather than background concentrations as some concentrations in the models may reflect low magnitude contamination of sediment considering the sediment was sampled in a port. It is not possible to discriminate perfectly between background and contaminated sediment.

The baseline models for metals in sediment in Durban Bay are provided in Figure 5, with aluminium normalised metal concentrations measured in sediment sampled in the Maydon Wharf dredging footprint in May 2024 superimposed (data are provided in Appendix 5).

Aluminium was used as the normaliser of metal concentrations because it is (a) highly refractory, (b) is structurally combined to the major metal-bearing phases of sediment, (c) co-varies in proportion to naturally occurring concentrations of other metals, (d) is insensitive to inputs from anthropogenic sources, and (e) is stable and not

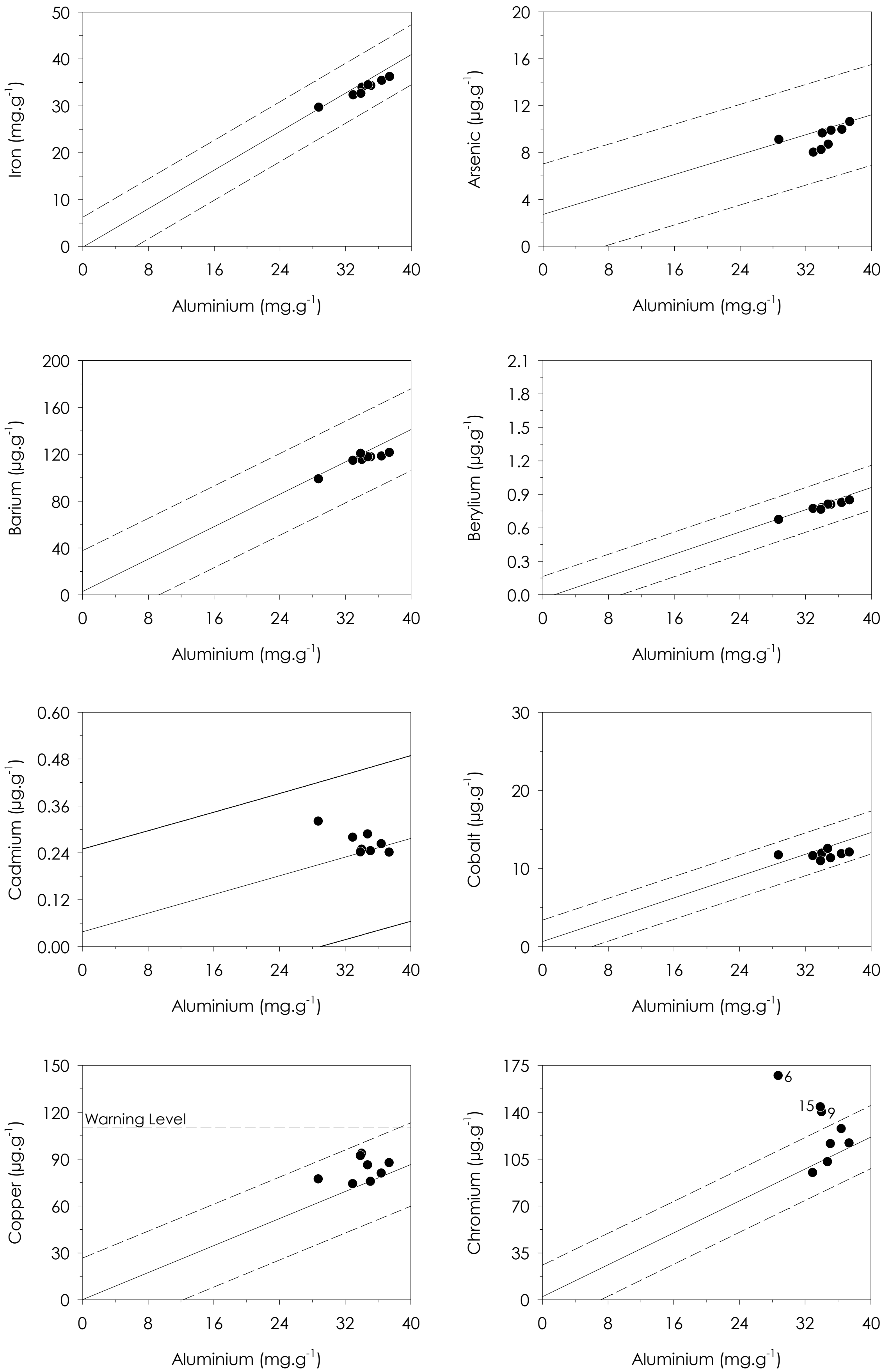

Figure 5. Baseline metal concentration models for sediment in Durban Bay, with metal concentrations in sediment sampled in the proposed Maydon Wharf berth deepening dredging footprint in May 2024 superimposed. Sediment quality guidelines used by the Department of Forestry, Fisheries and the Environment to decide if sediment identified for dredging in South African ports is suitable for open water disposal are included if they fall within the y-axis range. Some metal concentrations are highlighted by station identifiers.

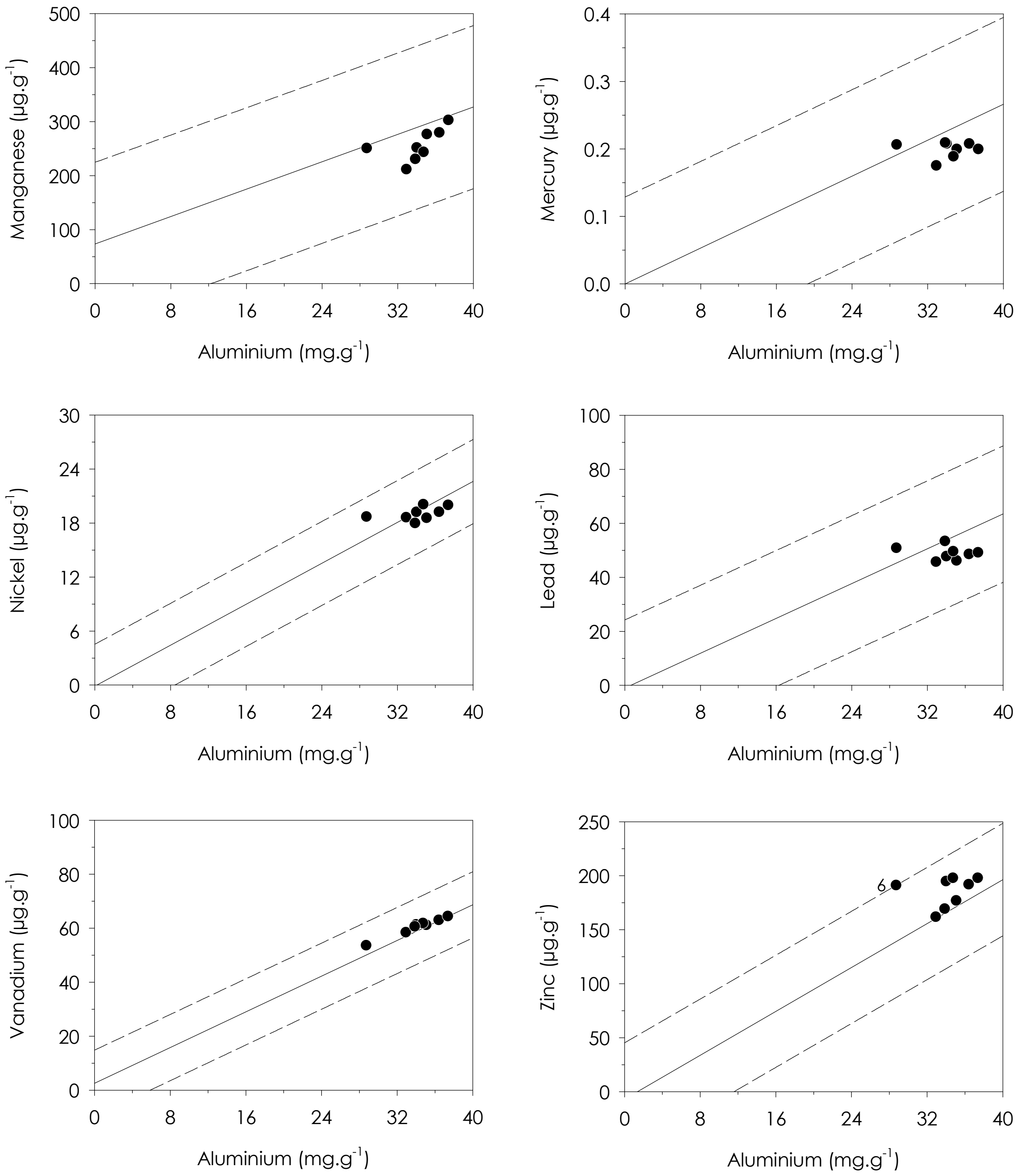

Figure 5 continued. Baseline metal concentration models for sediment in Durban Bay, with metal concentrations in sediment sampled in the proposed Maydon Wharf berth deepening dredging footprint in May 2024 superimposed. Sediment quality guidelines used by the Department of Forestry, Fisheries and the Environment to decide if sediment identified for dredging in South African ports is suitable for open water disposal are included if they fall within the y-axis range. Some metal concentrations are highlighted by station identifiers.

subject to environmental influences such as reduction/ oxidation, adsorption/desorption and other diagenic processes that may alter sediment concentrations. Aluminum is used as a proxy for the granulometric variation of sediment, and more specifically the variation in the silt and clay (mud) fraction. To demonstrate this point the aluminium concentration in sediment sampled in the proposed Maydon Wharf berth deepening dredging footprint in May 2024 is very strongly positively correlated to the mud fraction ($r = 0.885$, $p = 0.003$). The use of aluminium as the normaliser of metal concentrations in sediment sampled in Durban Bay is thus founded on valid geochemical principles.

As stated above, the baseline models comprise a regression line and upper and lower 99% prediction limits (oblique solid and dashed lines in Figures 5 and 6). The regression line defines the average concentration for a metal at co-occurring aluminium concentrations in sediment at baseline locations, while the upper and lower prediction

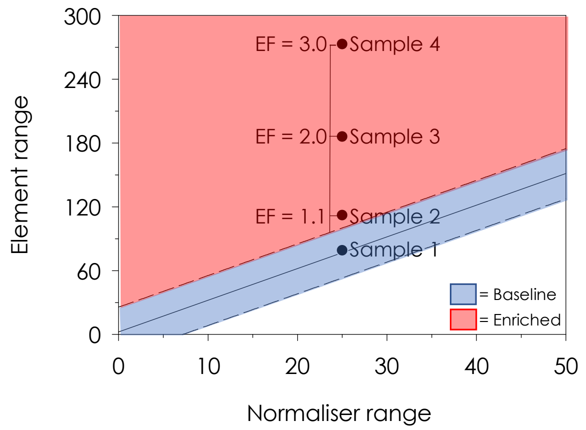

Figure 6. Schematic of a baseline model. The oblique solid line and flanking dashed lines are the linear regression and upper and lower 99% prediction limits respectively. The prediction limits define the baseline concentration range for an element at any co-occurring normaliser concentration (blue shaded area). If an element concentration falls within the prediction limits, as is the case for hypothetical Sample 1, then the element is interpreted as falling in the baseline concentration range (not enriched). If an element concentration falls above the upper dashed line (upper prediction limit), as is the case for hypothetical Samples 2, 3, and 4, then the element is interpreted as enriched. The concentration for hypothetical Sample 2 is only slightly higher than the upper prediction limit and reflects a low level of enrichment and does not reflect contamination. The concentrations for hypothetical Samples 3 and 4 considerably exceed the upper prediction limit and represent a much higher level of enrichment that reflects contamination.

limits define the range in which 99% of concentrations should fall if the sediment is not enriched and the concentrations used to define the baseline model are normally distributed. Metal concentrations that exceed the upper prediction limit when superimposed onto a baseline model are in excess of the baseline and indicate the sediment is enriched (see Figure 6). A concentration that exceeds the upper prediction limit does not imply it was enhanced by an anthropogenic contribution but rather that it is atypical of the data used to define the model. Several reasons other than an anthropogenic input can result in a metal concentration exceeding the upper prediction limit. These include analytical variability and errors, poor model assumptions, the probability that metal concentrations in some samples will naturally exceed the upper prediction limit (in a normally distributed population, at the 99% prediction limit one in every 100 concentrations could conceivably naturally exceed the limit), and natural enrichment not captured by the baseline data set (Schropp *et al.*, 1990; Rae and Allen, 1993).

Interpretation whether metal enrichment reflects contamination thus requires consideration of ancillary factors that include biogeochemical processes that may naturally lead to the enrichment of some metals, the absolute difference between a metal concentration and upper prediction limit, the location of enriched sediment relative to known or potential anthropogenic sources of metals, and an assessment of the number of metals in a sediment sample that exceed upper prediction limits. The larger the difference between a metal concentration and upper prediction limit (see Figure 6) and the greater the number of metals enriched in a sediment sample the more likely this reflects contamination. This is because the sediment in ports is commonly enriched by several metals rather than a single metal, particularly if the anthropogenic sources are diffuse (*e.g.* stormwater runoff). This said, enrichment of sediment by one metal may occur in areas where metal ores are exported and there are few other anthropogenic sources of metals in the area. However, even in these cases other metals are commonly enriched in the sediment as they are impurities of ores.

Apart from the chromium concentration in sediment at three stations and zinc concentration in sediment at one station, metal concentrations in the sediment sampled in the proposed Maydon Wharf berth deepening dredging footprint in May 2024 fall within baseline model prediction limits (Figure 5). In other words, the metal concentrations are within the baseline range for sediment in Durban Bay. The enriched metal concentrations fall only slightly above the baseline model upper prediction limit, which is indicative of very mild contamination. In the case of the zinc concentration at Station 6, the concentration so marginally exceeds the baseline model upper prediction limit that it is in fact impossible to conclude this represents enrichment.

3.4 Comparison of chemical concentrations to sediment quality guidelines

The Department of Forestry, Fisheries and the

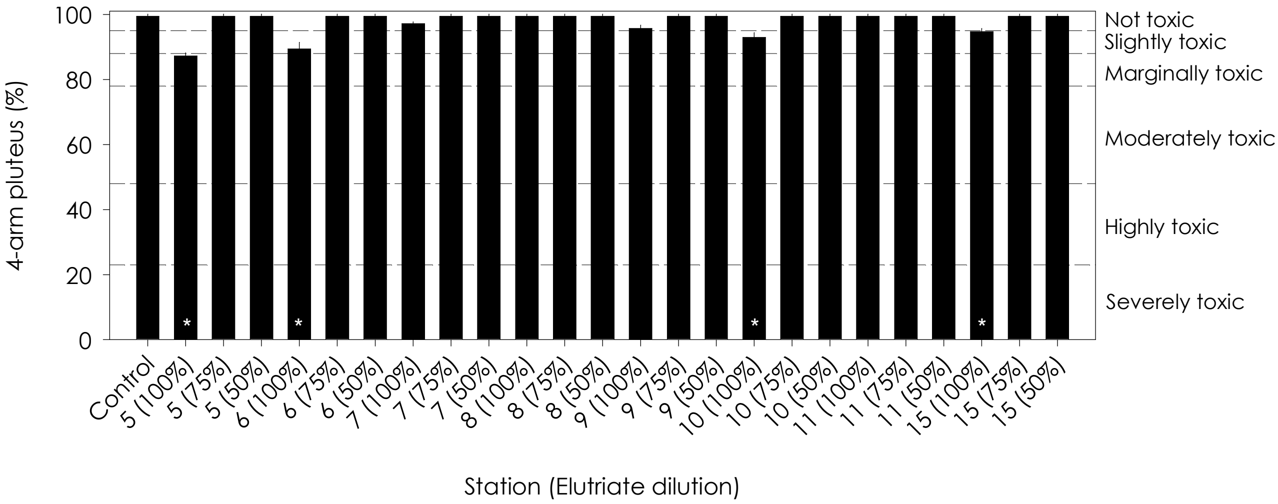

Figure 7. Proportion (mean ± standard deviation) of sea urchin (*Echinometra mathaei*) embryos that developed normally to the 4-arm pluteus after exposure to elutriates prepared using sediment sampled in the proposed Maydon Wharf berth deepening dredging footprint in May 2024.

Environment uses an Action List (sediment quality guidelines) 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 (Table 1). 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 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.

Metal concentrations in the sediment sampled in the Maydon Wharf dredging footprint in May 2024 were below the sediment quality guidelines (Figure 5). The sediment is thus suitable for open water disposal.

3.5 Toxicity testing

The purpose of elutriate toxicity testing is to estimate the short-term toxicity of contaminants that might be released from dredged material into the water column to pelagic organisms during and shortly after open water disposal. Since dredged material is suspended in the water column for a relatively short period during disposal and the time to disperse the dissolved contaminant plume is also relatively short, elutriate tests expose test organisms for a relatively short period (48 - 96 hours). The elutriate is tested as prepared (100%). Dilutions are also tested to simulate the dispersion and dilution of contaminant concentrations that might be released from dredged material. According to decision criteria provided by USACE (2023), acute toxicity is not anticipated during dredged material disposal for developmental

Table 1. Action List used by the Department of Forestry, Fisheries and the Environment to decide if sediment identified for dredging in South African ports is of a suitable quality for open water disposal. Concentrations are in µg.g^{-1}.

Chemical	Warning Level	Level I	Level II
Arsenic	42	57	93
Cadmium	1.2	5.1	9.6
Chromium	135[a]/250[b]	260	370
Copper	110	230	390
Mercury	0.43	0.84	1.5
Nickel	62[a]/88[a]	140	370
Lead	110	218	530
Zinc	270	410	960

a - for Eastern and Western Cape, b - for KwaZulu-Natal toxicity tests if the endpoint (*e.g.* proportion of embryos that develop to a normal 4-arm pluteus) in a 100% elutriate is not reduced by >20% relative to the control treatment.

The proportion of sea urchin embryos that developed to a normal 4-arm pluteus following exposure to elutriates prepared using sediment sampled at stations in the proposed Maydon Wharf berth deepening dredging footprint in June 2024 is provided in Figure 7 (data provided in Appendix 6). The undiluted (*i.e.* 100%) elutriates prepared using sediment sampled at Stations 5, 6, 10, and 15 was slightly or marginally toxic, but not the undiluted elutriates prepared using sediment sampled at other stations. The 75% and 50% strength elutriates for Stations 5, 6, 10, and 15 were not toxic.

The proportion of embryos that developed to a normal 4-arm pluteus in the 100% elutriate for Stations 5, 6, 10, and 15 was not reduced by >20% relative to the control treatment, and 25% dilution diluted toxicants causing the toxicity in the 100% treatment to a concentration that was no longer toxic. Acute toxicity is thus not anticipated when sediment dredged in the proposed Maydon Wharf berth deepening dredging footprint is disposed at the open water dredged material disposal site off Durban.

4. Conclusions

The sediment sampled in some parts of the proposed Maydon Wharf berth deepening dredging footprint in May 2024 was slightly contaminated by chromium. Metal concentrations in the sediment are below sediment quality guidelines used by the Department of Forestry, Fisheries and the Environment to decide if sediment identified for dredging in South African ports is suitable for open water disposal. The toxicity testing of elutriates prepared from sediment sampled in the proposed dredging footprint also suggests toxicity to pelagic organisms is not anticipated when the dredged material is disposed at the open water dredged material disposal site off Durban. Transnet National Ports Authority is also considering the potential use of the dredged material beneficially within Durban Bay. The sediment is unlikely to pose a toxic risk if it is placed elsewhere in Durban Bay, noting placement of the dredged material elsewhere in the Bay will pose environmental impacts not considered in this study. Furthermore, based on historical data the sediment used for placement in Durban Bay should ideally exclude that dredged in Congella Basin, where contamination has been pronounced in the past.

5. References

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6. Appendices

Appendix 1

Global Positioning System coordinates of stations sampled in the proposed Maydon Wharf berth deepening dredging footprint in Durban Bay in May 2024.

Station	Latitude	Longitude
5a	29°52'19.40"S	31°00'36.30"E
5b	29°52'22.01"S	31°00'33.67"E
5c	29°52'24.43"S	31°00'31.15"E
6a	29°52'27.45"S	31°00'29.77"E
6b	29°52'30.75"S	31°00'28.41"E
7a	29°52'33.91"S	31°00'26.93"E
7b	29°52'36.86"S	31°00'25.68"E
8a	29°52'39.82"S	31°00'24.37"E
8b	29°52'42.84"S	31°00'23.07"E
9a	29°52'45.84"S	31°00'21.79"E
9b	29°52'49.06"S	31°00'20.35"E
10a	29°52'51.87"S	31°00'19.11"E
10b	29°52'54.91"S	31°00'17.81"E
11a	29°52'57.84"S	31°00'16.47"E
11b	29°53'00.90"S	31°00'15.08"E
15a	29°53'04.86"S	30°59'44.12"E
15b	29°53'04.58"S	30°59'50.39"E

Appendix 2

Copy of South African National Accreditation System (SANAS) certificate for the environmental chemistry laboratory at the CSIR campus in Stellenbosch.

sanas
South African National
Accreditation System

CERTIFICATE OF ACCREDITATION

In terms of section 22(2) (b) of the Accreditation for Conformity Assessment, Calibration and Good Laboratory Practice Act, 2006 (Act 19 of 2006), read with sections 23(1), (2) and (3) of the said Act, I hereby certify that:-

**COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH
ANALYTICAL LABORATORY**

STELLENBOSCH

Facility Accreditation Number: **T0093**

is a South African National Accreditation System accredited facility
provided that all conditions and requirements are complied with

This certificate is valid as per the scope as stated in the accompanying schedule of accreditation, Annexure "A", bearing the above accreditation number for

CHEMICAL ANALYSIS

The facility is accredited in accordance with the recognised International Standard

ISO/IEC 17025:2017

The accreditation demonstrates technical competency for a defined scope and the operation of a quality management system

While this certificate remains valid, the Accredited Facility named above is authorised to use the relevant accreditation symbol to issue facility reports and/or certificates

Mr T Baleni
Acting Chief Executive Officer

Effective Date: 01 August 2023
Certificate Expires: 31 July 2028

Appendix 3

Quality Assurance and Quality Control Results

Recovery (%) of metals from standard reference material PACS-3 (National Research Council of Canada).

Replicate	Al	Fe	As	Be	Cd	Cu	Cr	Mn	Hg	Ni	Pb	V	Zn
1	45.5	81.4	75.1	51.0	97.6	87.8	109.5	63.6	94.5	79.9	84.6	69.7	89.1
2	45.5	81.0	75.8	51.9	97.7	87.2	123.2	63.5	101.0	81.2	84.2	69.6	88.7
Mean	45.5	81.2	75.4	51.4	97.6	87.5	116.3	63.5	97.8	80.5	84.4	69.7	88.9
Standard deviation	0.0	0.3	0.5	0.6	0.0	0.4	9.7	0.1	4.6	0.9	0.3	0.1	0.3
Minimum	45.5	81.0	75.1	51.0	97.6	87.2	109.5	63.5	94.5	79.9	84.2	69.6	88.7
Maximum	45.5	81.4	75.8	51.9	97.7	87.8	123.2	63.6	101.0	81.2	84.6	69.7	89.1
Variance	0.0	0.1	0.3	0.4	0.0	0.2	94.3	0.0	20.8	0.9	0.1	0.0	0.1
Precision	0.0	0.4	0.7	1.2	0.0	0.5	8.3	0.1	4.7	1.2	0.3	0.2	0.3

Laboratory duplicate report for metals in sediment sampled in the proposed Maydon Wharf berth deepening dredging footprint in Durban Bay in May 2024. RSD = Relative Standard Deviation.

Metal	Original Result $\mu g.g^{-1}$	Duplicate Result $\mu g.g^{-1}$	RSD %	Acceptable RSD %
Al	35123	35008	0.23	10
Fe	34310	34325	0.03	10
As	9.89	9.88	0.07	10
Ba	117.85	117.73	0.07	10
Be	811.63	809.5	0.19	10
Cd	246.48	244.04	0.70	10
Co	11.35	11.34	0.06	10
Cu	74.97	76.78	1.69	10
Cr	109.45	123.18	8.35	10
Mn	277.08	277.38	0.08	10
Hg	199.83	200.09	0.09	10
Ni	18.47	18.68	0.80	10
Pb	46.1	46.32	0.34	10
V	60.85	61.59	0.85	10
Zn	178.48	174.71	1.51	10

Appendix 4

Contribution (%) of grain size class fractions and total organic content to the bulk weight and mean grain size (mm) of sediment sampled in the proposed Maydon Wharf berth deepening dredging footprint in Durban Bay in May 2024.

Station	Gravel	Very Coarse-Grained Sand	Coarse-Grained Sand	Medium-Grained Sand	Fine-Grained Sand	Very Fine-Grained Sand	Mud	Total Organic Content
5	0.0	0.2	0.2	0.9	4.3	4.8	89.6	2.9
6	2.4	1.3	1.9	5.2	11.9	5.7	71.6	2.2
7	0.0	0.0	0.3	0.5	2.2	3.2	93.8	3.1
8	0.0	0.3	0.3	0.8	2.6	3.4	92.7	3.0
9	0.0	0.0	0.5	1.7	6.6	5.8	85.4	3.0
10	0.0	0.0	0.3	0.5	3.7	7.3	88.2	2.8
11	0.0	0.2	0.2	0.9	4.2	9.0	85.4	2.5
15	0.2	0.5	1.2	6.5	11.5	3.8	76.3	4.7

Appendix 5

Metal concentrations (Al and Fe as mg.g^{-1}, other metals as µg.g^{-1} dry weight) in sediment sampled in in the proposed Maydon Wharf berth deepening dredging footprint in Durban Bay in May 2024. Al - aluminium, Fe - iron, As - arsenic, Ba = barium, Be = beryllium, Cd =cadmium, Co = cobalt, Cu = copper, Cr = chromium, Mn = manganese, Hg = mercury, Ni = nickel, Pb = lead, V = vanadium, Zn = zinc, < = concentration below the method detection limit as indicated. Bold text in coloured cells indicates the concentration exceeds the Warning Level, Level I and Level II of the sediment quality guidelines used by Branch Oceans and Coasts of the Department of Forestry, Fisheries and the Environment to decide if sediment identified for dredging in South African ports is of a suitable quality for open water disposal.

Station	Al	Fe	As	Ba	Be	Cd	Co	Cu	Cr	Mn	Hg	Ni	Pb	V	Zn
5	35.066	34.318	9.9	118	0.811	0.245	11.3	75.8	117	277	0.200	18.6	46.2	61.2	177
6	28.714	29.706	9.1	99	0.675	0.321	11.7	77.3	167	251	0.207	18.7	50.9	53.7	191
7	36.388	35.427	10.0	119	0.826	0.263	11.9	81.0	128	280	0.208	19.3	48.6	63.1	192
8	37.347	36.254	10.6	122	0.850	0.242	12.1	87.8	117	303	0.200	20.0	49.2	64.5	198
9	34.000	33.958	9.7	116	0.782	0.249	12.0	93.8	140	252	0.208	19.2	47.8	61.4	195
10	34.725	34.484	8.7	118	0.812	0.288	12.6	86.3	103	244	0.189	20.1	49.6	61.9	198
11	32.911	32.332	8.0	115	0.773	0.280	11.6	74.3	95	212	0.176	18.6	45.8	58.5	162
15	33.849	32.632	8.2	121	0.765	0.242	11.0	92.3	144	231	0.209	18.0	53.5	60.7	170
Warning Level	-	-	42	-	-	1.2	-	110	250	-	0.43	88	110	-	270
Level I	-	-	57	-	-	5.1	-	230	260	-	0.84	140	218	-	410
Level II	-	-	93	-	-	9.6	-	390	370	-	1.5	370	530	-	960

Appendix 6

Proportion of sea urchin (*Echinometra mathaei*) embryos that developed to a normal 4-arm pluteus after the exposure to elutriates of sediment sampled in the proposed Maydon Wharf berth deepening dredging footprint in Durban Bay in May 2024.

Station/ Treatment	Elutriate Dilution %	Normal 4-arm pluteus Replicate 1 %	Normal 4-arm pluteus Replicate 2 %	Normal 4-arm pluteus Replicate 3 %	Normal 4-arm pluteus Replicate 4 %
Seawater Control	-	100	100	99	99
Salt Control	-	100	100	99	99
Elutriate Control	-	100	100	99	99
5	100	88	88	87	86
5	75	100	100	99	99
5	50	100	100	99	99
6	100	90	88	92	88
6	75	100	100	99	99
6	50	100	100	99	99
7	100	97	97	98	97
7	75	100	100	99	99
7	50	100	100	99	99
8	100	100	100	99	99
8	75	100	100	99	99
8	50	100	100	99	99
9	100	95	95	96	97
9	75	100	100	99	99
9	50	100	100	99	99
10	100	91	93	94	94
10	75	100	100	99	99
10	50	100	100	99	99
11	100	100	100	99	99
11	75	100	100	99	99
11	50	100	100	99	99
15	100	96	95	94	94
15	75	100	100	99	99
15	50	100	100	99	99