Remediation Strategy: Relocation and Decommissioning of the Tank Farm and Manganese Facility at the Port Elizabeth Harbour

Phase 3 – Deliverables 2.7 “Investigate legal and financial implications of remediation” and 2.8 “Develop options for remediation and make recommendations”

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Accronyms

BTEX	Benzene, toluene, ethylbenzene, and xylenes.
DEA	Department of Environmental Affiars
DEA&T	Department of Environmental Affairs and Tourism
DWAF	Department of Water Affairs and Forestry
DWA	Department of Water Affairs
ERL	Effects range-low
ERM	Effects range-medium
MCM	Marine and Coastal Management
NEMA	National Environmental Management Act
NMBM	Nelson Mandela Bay Municipality

1. Introduction

CEN Integrated Environmental Management Unit and Africoast Engineers have been appointed by the Linkd Environmental Services (Pty) Ltd to analyse the issues and potential approach to remediation of the land freed up by the decommissioning and relocation of the Tank Farm and Manganese Facility at the Port Elizabeth Harbour.

The Manganese Ore Terminal and Storage Facility and Tank Farm at the Port Elizabeth Harbour are situated on Erf 578 to the south of the harbour and are operated by Transnet Port Terminals.

The principle contaminants of concern in the tank farm area are hydrocarbon based products. There is documented evidence of major fuel spills and leaks within the area which have percolated into the underlying soils and contaminated both the soil matrix and the groundwater below the site. The hydrocarbon products will have undoubtedly settled above the groundwater table and will be subject to migration off site due to tidal activity and hydraulic gradients generated further inland. The site also currently poses a risk to site users as they are exposed to Volatile Organic Compounds (VOC) which will be released from the contaminated areas and can be inhaled. Hydrocarbon based products are toxic to health and the environment, and therefore present a risk to future site users and off-site neighbours if left in place.

With respect to the manganese ore terminal, the manganese ore that is being stored on the site will contain within its matrix heavy metal contaminants which are both hazardous to human health and the surrounding environment. Since these stockpiles are open to the weather, there is no doubt that heavy metal contamination will have leached from the stockpiles and percolated down to the groundwater below the site. As is the case with the hydrocarbons, these heavy metal products have a variety of documented health impacts and therefore present a risk to future site users and off site neighbours.

Any future development of this site will require the remediation of the water and soils in order to reduce the risk of exposure to the public and the environment. The purpose of this study was to investigate what variables need to be considered for effective and efficient remediation of the land (including soil, groundwater, surface water and the adjacent marine environment), and to suggest a possible approach to remediation based on available literature.

It must be noted that the field of environmental remediation is expanding and new and more effective methods for remediating contaminated land and water in a sustainable and economic manner are being discovered.

2. Legal Considerations

The following pieces of legislation are relevant to decommissioning and remediation of the site:

- The Constitution of the Republic of South Africa, No 108 of 1996
- National Environmental Management Act No 107 of 1998 as amended
- National Environmental Management Act: Air Quality Act No 39 of 2004
- National Environmental Management: Integrated Coastal Management Act No 24 of 2008
- National Environmental Management Act: Waste Act No 59 of 2008
- National Health Act No 61of 2003

- National Water Act No 36 of 1998
- Marine Living Resources Act No 18 of 1998
- Environmental Conservation Act No 73 of 1989
- Nelson Mandela Bay Metropolitan Municipality Municipal Health By-Law
- Nelson Mandela Bay Municipality Waste Management By-Laws
- Environmental Impact Assessment Regulations (2010)

Of particular relevance to the Remediation Strategy are the provisions for the remediation of contaminated land stipulated in the NEMA: Waste Act No. 59 of 2008. During the course of developing and implementing the remediation strategy, regulations and norms and standards designed to give effect to the provisions in the Waste Act are likely to be promulgated, and it will be necessary to ensure that the remediation strategy is aligned with requirements in terms of these.

In particular, it will be necessary to report the contamination and have the land in question added to the register of contaminated land on the basis of the site inspection, which will need to meet DEA's requirements.

The Remediation Plan itself will also need to be submitted to DEA for approval, and DEA's requirements for post-remediation monitoring will need to be met in order to ensure the lifting of restrictions on land use and possible removal from the register of contaminated lands.

The consultant tasked with producing the Remediation Plan will need to meet the standards and/or accreditation requirements established by DEA through regulations in terms of the measures for the remediation of contaminated land.

3. A Step-Wise Approach to Remediation

The following step-wise approach to remediation of the site is proposed, based on current legislative requirements.

Step 1: Setting the Remediation Outcome

As a first step, it is important that a goal for remediation is set which will specify the end objective of the remediation exercise. This should be developed in consultation with all stakeholders, including neighbouring land owners and regulatory bodies (e.g. MCM, DWA, DEA, NMBM). As a minimum requirement, the goal of remediation should be to remove or minimise the level of contaminants in the environment to be in compliance with national, municipal (where available) or international standards. Standards and/or targets that have been set for the safe use of or exposure to natural (terrestrial, aquatic and marine) environments by humans and biota occurring in those environments must be consulted (a list of some available targets is given in Annexure One). Where targets are not available for specific attributes, these must be established in consultation with stakeholders and the regulating body. Other considerations include the future land use potential and socio-economic considerations.

Step 2: Contaminant Investigation

Contaminants due to the Manganese Terminal

A full spectrum elemental analysis of the ore should be done to define its chemical signature to determine whether there are harmful elements associated with the ore other than manganese. Based on a spot sample of dust analysed in 2005, it is expected that chromium, copper, nickel, lead, selenium, thallium and zinc may be present in addition to manganese (Shipley, 2005).

Contaminants due to the Tank Farm

The following substances are currently stored at the Tank Farm and are potential sources of contamination:

Table 1: Substances currently stored at the Tank Farm (Source: SRK, 2009)

Substance	**Description**	**Substance**	**Description**
ULP	Unleaded Petrol	AVGAS	High Octane Aviation Fuel
Firetex M 93	Fire protection epoxy	JET A1	Aviation Fuel
ULSD	Ultra-low Sulfur Diesel	MFO	Marine Fuel Oil
MOGAS 95	Unleaded Petrol	LRP	Lead Replacement Petrol
AGO (Feedstock)	Atmospheric Gas Oils – crude oils	FUREX	ARAPROL 1000 (viscous aromatic process oil)
1 KERO (IP)	Kerosene (Illuminating Paraffin Oil)	XYLENE	Aromatic hydrocarbon isomer
LAWS	Light Aromatic White Spirits	TOLUENE	Aromatic hydrocarbon
HFO	Heavy Furnish Oil	IK	Illuminating Kerosene
DGO	Diesel	HYDRO OIL	Bio-degradable hydraulic oil

All potential contaminants must be characterised in terms of their physical and chemical properties. This will help in understanding how they may move and behave in the environment.

Step 3: Analysis of Sediment and Groundwater

Before remediation options can be considered, it is important to have a clear understanding of the underlying soils and geology, as well as the lateral and vertical extent of the aquifer. The physical, chemical and biological characteristics need to be analysed in the context of remediation. The rate of groundwater flow must be calculated under different tidal conditions, and the aquifer dispersion characteristics must be described. The facilities are situated on fill material which is highly porous, thus the movement of groundwater through this zone must also be considered. Geo-chemistry of the sediments and the aquifer must be understood. It would be useful to identify the dominant micro-flora communities present in soil and groundwater since this will be an important factor in bio-remediation as a treatment option.

This assessment should allow for a comprehensive understanding of the physical and biogeochemical processes involved in the bioavailability and transport of contaminants, and their ultimate fate in the environment. This information will be used in Step 4 for the quantification of exposure pathways based on site-specific information, as well as an analysis of best-suited remediation options (Step 5).

Step 4: Risk Assessment

A site contamination analysis must be done where the presence and levels, and spatial extent, of contaminants in the surrounding environment are investigated. This will highlight what contaminants are present at which concentration, where they occur, and in what form.

It must also be determined whether contamination is expected to continually migrate and intensify, or whether the extent defined above can be considered as finite. This will be directly influenced by the lifespan of operations at the Tank Farm and Manganese Facility, amongst other physical and bio-geochemical processes that would have been highlighted in Step 3.

Pathways of exposure must be defined based on information gathered in Step 3 as well as the detailed site contamination analysis done in this stage. Here the key transport and attenuation processes will be quantified from source to receptor.

Risk receptors must be identified – these may include surrounding residents, recreational users of Kings Beach, employees at the Manganese Facility and Tank Farm and in the harbour, and ecological users in the surrounding coastal environment.

Results of this investigation must be compared with available information on safe exposure levels for risk receptors identified above to determine the significance of the risk. Where no standards or targets are available, these must be developed in consultation with key stakeholders (e.g. Department of Health, epidemiologist (occupational and environmental), DWA, MCM, DEA, marine specialists).

Step 5: Consider remediation options

There are numerous ex- and in-situ remediation techniques available for both hydrocarbon and metal contamination of soils, groundwater and the marine environment. Important factors to consider ensuring sustainability of the selected option are:

1. Does the selected treatment option address the risk posed by the contaminant?

2. Will the option be effective – i.e. will the selected strategy be the most effective option in removing and/or minimising the specific contaminant in the particular zone being targeted? It may be necessary to consider alternative treatment options for different contaminants (or phases thereof) in different zones across the site.
3. Is the selected option economically and resource-use feasible?
4. Will the selected option result in the least possible environmental impact?
5. What areas must be prioritised - the quantification of risk will play an important role here, as will the goal of remediation identified in Step 1?

Internationally, the traditional method of excavation of contaminated material and disposal to landfill is no longer used or acceptable. It appears as if in-situ remediation technologies have a number of advantages including:

- Large volumes of contaminated material do not need to be removed from site
- Reduced costs: transport, landfill tax, replacement material, infrastructure, long-term treatment
- Less environmentally-intrusive
- Reduced emissions from trucks

A few treatment options that can be considered for the remediation of hydrocarbon and metal contaminants are:

- Free-phase skimming of light non-aqueous phase liquids for the removal of fuel and oil located at the groundwater interface.

- Dual Phase Vacuum Extraction for the simultaneous extraction of contaminated groundwater and soil vapour.
- Multi Phase Extraction for the controlled extraction of heavy lubricant and crude oils (dense non-aqueous phase liquid) present at depth.
- Intrinsic bio-remediation: rely on natural micro-organisms and other natural attenuation processes to prevent contaminant migrations to sensitive receptors. It is integral to first develop a method to determine or assess the efficiency of natural biodegradation processes. Key factors to consider will be hydrology, geochemistry and microbiology. The availability of potential electron acceptors, particularly dissolved oxygen, must be investigated.
- Engineered bio-remediation systems: the basic principle is to relieve the lack of electron acceptors and nutrients naturally occurring in the system, and increase the rate of contaminant degradation by engineered mechanisms (i.e. adding electron acceptors and nutrients). The system can be further manipulated by physical measures (e.g. circulating groundwater, infiltration galleries etc). Careful consideration must be given to the physical and bio-geochemical properties of the environment and the phase of contaminant targeted for removal prior to selecting the engineered intervention.
- Air-sparging: air is injected directly into the water-saturated aquifer which physically purges contaminants form groundwater and simultaneously adds oxygen to stimulate hydrocarbon degradation.
- Bio-slurping: physical removal of free product hydrocarbons on the water table surface. Oxygen is drawn in through the unsaturated zone which helps in aerobic biodegradation.

- Biopiles and composting for hydrocarbon contaminated soil.
- Permeable reactive barriers for metals in groundwater.

Once the preferred treatment option(s) have been selected, it would be advisable to run a pilot study in the field to determine the effectiveness of the option. A methodology and testing framework for the monitoring of the treatment option and the validation of the effectiveness thereof must be devised to measure whether the method will serve the remediation goal.

Step 6: Finalise Remediation Strategy

If the pilot study shows that the selected remediation option is effective and efficient, a detailed remediation strategy must be established and submitted for regulatory approval. It is important that the methodology followed in attaining the final strategy is clearly presented as outlined in Steps 1 to 5 above. The strategy must include a detailed work method statement and site plan; including timing, necessary equipment and expertise, required resources, and stakeholder involvement. A monitoring plan must be included to determine the long-term success of the remediation strategy. This will determine whether remediation actions have achieved goals and targets set in Step 1 and will indicate whether the site is fit for future use. Monitoring should occur throughout the remediation process, and for at least 6 months thereafter.

Step 7: Project Management

In order to successfully achieve the goals of remediation a project management plan must include the following: a detailed project budget, tender documentation, drawings and specifications, establish site performance criteria, quality control standards, health and safety policies and procedures and cost management systems for on site management. Adherence to these criteria must be accurately managed throughout.

Step 8: Final Remediation Report

On completion of remediation and the required six month monitoring process, a final report must be compiled detailing all activities, for presentation to the Regulatory Authorities, the land owner, available to future land owners and placed online for the general public.

4. Check-list for remediation strategy

Below is a check-list of items that need to be addressed in a remediation strategy as a minimum requirement:

1. Has a clear goal for remediation been set?
2. Has the goal been set by consulting national, local and international standards/targets and/or via consultation with relevant stakeholders (in particular, with approval by DEA in terms of the measures for the remediation of contaminated land in the Waste Act)?
3. Has a clear description of primary source contaminants been given, describing their physical and chemical properties?
4. Have the physical and bio-geochemical properties of the affected environment been described?
5. Has a site contamination analysis been done, as outlined by the Waste Act, describing what contaminants are present at which concentration, where they occur, and in what form?

6. Have pathways of exposure been defined which quantify the key attenuation processes from source to receptor?
7. Have risk receptors been identified?
8. Has the significance of risk been quantified?
9. Have sufficient remediation strategies been considered in light of sustainability and effectiveness?
10. Has a pilot study been conducted to determine whether the selected treatment option will be effective in attaining the remediation goals?
11. Has a monitoring plan, in accordance with the Waste Acte, been developed to measure effectiveness of the selected remediation option?
12. Has a final report been planned for?

5. Conclusions

Depending on findings regarding the extent of contamination, and the remediation option that is chosen, the Tank Farm could take between three to four years to remediate and the Manganese ore terminal could take between one to two years to remediate.

There is a complex array of legislation governing the remediation process, and a logical step-wise approach to planning and undertaking remediation needs to be followed. Most importantly, the extent of contamination of the site needs to be fully documented and analysed, before a consideration of the available options for remediation can be undertaken. The final option that is chosen will have major implications for future development of the site as well as adjacent sites, and should be done in consultation with landowners and stakeholders in the area. The remediation strategy that is finally adopted and submitted for regulatory approval should as far as possible reflect a consensual approach that addresses the concerns of adjacent landowners, public stakeholders and the municipality.

It is recommended that a specialist Consulting Engineer be appointed to lead the management of the remediation and considering the estimated timelines it is recommended that this appointment be expedited with urgency in order to meet the timelines and project objectives for the decommissioning of the Manganese terminal and Tank Farm.

References

Shipley, H., “Statue of Freedom and Surrounds: State of the Environment Report”, A report by ENVIROS Consulting, 2005

SRK Consulting, “Investigation into LNAPL Contamination at the Dom Pedro Quay, Port Elizabeth Harbour”, Interim Report No 1. Report No. 403045/interim/1, September 2009

Annexure One

- **Water Quality**
  - Lusher, J.A. (ed) (1984). Water quality criteria for the South African coastal zone. *S. Afr. Nat. Sci. Progr. Rep.* 94, 43 pp.
    - Target water quality guideline for Polycyclic Aromatic Hydrocarbons (PAHs) in South African coastal waters that should not exceed 0.3 $\mu g.l^{-1}$.
    - Maximum concentrations recommended for all beneficial users, other than mining and cooling water ($5 \mu g.l^{-1}$):
      - Arsenic: 12
      - Cadmium: 4
      - Chromium: 8
      - Copper: 5
      - Lead: 12
      - Mercury: 0.3 $\mu g.l^{-1}$ as total Mercury
      - Nickel: 25 $\mu g.l^{-1}$ as total Nickel
      - Silver: 5 $\mu g.l^{-1}$ as total Silver
      - Zinc: 25 $\mu g.l^{-1}$ as total Zinc

- The South African Water Quality Guidelines for Coastal Marine Waters (DWAF, 1995)
    - Target values for metals are expressed as total values (e.g. the target value for Cu is 5 µ $g.l^{-1}$ as total Copper). Targets are given for the following:
        - Cadmium: 4 µ $g.l^{-1}$ as total Cadmium
        - Chromium: 8 µ $g.l^{-1}$ as total Chromium
        - Copper: 5 µ $g.l^{-1}$ as total Copper
        - Lead: 12 µ $g.l^{-1}$ as total Lead
        - Mercury: 0.3 µ $g.l^{-1}$ as total Mercury
        - Nickel: 25 µ $g.l^{-1}$ as total Nickel
        - Silver: 5 µ $g.l^{-1}$ as total Silver
        - Zinc: 25 µ $g.l^{-1}$ as total Zinc
    - No target values are given for total petroleum hydrocarbons. However, concentrations of the water soluble fraction of oils that have showed effects on certain organisms is listed
    - Volume 4: Mariculture gives published effects of changes in metal concentrations and water soluble fractions of oil on species used in the mariculture industry
    - Volume 1: Natural Environment. Chapter 5 gives published effects of changes in metal concentrations and water soluble fractions of oil on species in the natural environment. Chapter 4 lists average concentrations of selected metals measured in South African marine waters.

      - This series does not give target values for recreational use for metals or oils and fuels

  - DWAF (2004). Operational Policy for the Disposal of Land-Derived Water containing waste to the marine environment of South Africa: "no parameter should exceed its local background value by more than 10% unless sufficient evidence exists to suggest that such deviations will not adversely affect marine ecosystem functioning."

  - California regional water control board (2000 and 2001) water quality guidelines:

      - BTEX:

          - Recreational use: 0.005 $mg.l^{-1}$

          - Aquatic environment: 0.005 $mg.l^{-1}$

  - Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2000)

      - BTEX:

          - Recreational use: 0.001 $mg.l^{-1}$

          - Aquatic environment: 0.5$mg.l^{-1}$

      - Polycyclic aromatic hydrocarbons: 0.01 $\mu g.l^{-1}$ for safe recreational user of coastal water

  - Water quality guidelines and standards in the marine environment, United Kingdom

- BTEX:
    - Recreation use: n/a
    - Aquatic environment: 0.3mg.l^{-1}
- Total petroleum hydrocarbons: 0.3 mg.l^{-1} for safe recreational user of coastal water

❖ Sediment Quality Guidelines

- National Sediment Quality Guidelines for Canada (Long *et al.*, 1995)
- Informal Sediment Quality Guidelines for Florida
    - Two guideline values namely "effects range-low" (ERL) and "effects range-medium" (ERM) were established (Long et al. 1995). Concentrations below the ERL value represent a minimum effects range; a range intended to estimate conditions in which effects would be rarely observed. Concentrations equal to or above the ERL, but below the ERM (effects range median), represent a possible-effects range within which effects would occasionally occur (DEA&T 1999). Finally, the concentrations equivalent to and above the ERM value represent a probable-effects range within which effects would frequently occur. All values in the following discussion refer to concentration on a dry mass basis.
- DEA&T sediment quality guidelines (1999):
    - Mercury: guideline: 0.5 mg/g, prohibition value: anything > 0.5mg/g
    - Copper:

    - lower limit of special care level: 50 µg/g;
    - ERL value: 34 µg/g (Long et al, 1995)
- Chromium:
    - lower limit of special care level: 50 µg/g
    - ERL value: 81 µg/g (Long et al, 1995)
- Cadmium:
    - Lower limit of action level: 1.5 µg/g
    - ERL value: 1.2 µg/g (Long et al, 1995)
- Lead:
    - lower limit of special care level: 100 µg/g
    - ERL value: 46.7 µg/g (Long et al, 1995)
- Zinc:
    - lower limit of special care level: 150 µg/g
    - ERL value: 150 µg/g (Long et al, 1995)
- No sediment guidelines exist for iron or aluminum since they are not considered toxic