Annex F1

Air Quality Assessment
AIR QUALITY ASSESSMENT FOR THE MAMATHWANE COMPILATION YARD AND COMMON USER FACILITY EIA PROJECT

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AIR QUALITY ASSESSMENT FOR THE MAMATHWANE COMPILATION YARD AND COMMON USER FACILITY EIA PROJECT

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When used as a reference this report should be cited as follows:

# Glossary of Acronyms, Terms and Units

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Term/Description</th>
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<tbody>
<tr>
<td>AEL</td>
<td>Atmospheric Emission License</td>
</tr>
<tr>
<td>AELA</td>
<td>Atmospheric Emission Licensing Authority</td>
</tr>
<tr>
<td>BTEX</td>
<td>Benzene, toluene, ethyl benzene and xylene</td>
</tr>
<tr>
<td>CO</td>
<td>Carbon monoxide</td>
</tr>
<tr>
<td>°C</td>
<td>Degrees Celsius</td>
</tr>
<tr>
<td>DEA</td>
<td>Department of Environmental Affairs</td>
</tr>
<tr>
<td>Emission</td>
<td>The direct or indirect release of substances from individual or diffuse sources in an installation into the air</td>
</tr>
<tr>
<td>EIA</td>
<td>Environmental Impact Assessment</td>
</tr>
<tr>
<td>ERM</td>
<td>Environmental Resources Management</td>
</tr>
<tr>
<td>LOAEL</td>
<td>Lowest observed adverse effect level</td>
</tr>
<tr>
<td>Mn</td>
<td>Manganese</td>
</tr>
<tr>
<td>m/s</td>
<td>Meters per second</td>
</tr>
<tr>
<td>Mtpa</td>
<td>Million tons per annum</td>
</tr>
<tr>
<td>NOAEL</td>
<td>No observed adverse effect level</td>
</tr>
<tr>
<td>NO₂</td>
<td>Nitrous oxide</td>
</tr>
<tr>
<td>NOₓ</td>
<td>Oxides of nitrogen, ( NO_x = NO + NO_2 )</td>
</tr>
<tr>
<td>PM₁₀</td>
<td>Particulate matter less than 10 microns</td>
</tr>
<tr>
<td>PM₂.₅</td>
<td>Particulate matter less than 2.5 microns</td>
</tr>
<tr>
<td>RFC</td>
<td>Reference concentration for Chronic Inhalation Exposure</td>
</tr>
<tr>
<td>SAWS</td>
<td>South African Weather Service</td>
</tr>
<tr>
<td>TSP</td>
<td>Total suspended particulates</td>
</tr>
<tr>
<td>SO₂</td>
<td>Sulphur dioxide</td>
</tr>
<tr>
<td>VOC</td>
<td>Volatile organic compounds</td>
</tr>
<tr>
<td>μg/m³</td>
<td>Micrograms per cubic meter</td>
</tr>
<tr>
<td>US EPA</td>
<td>United States Environmental Protection Agency</td>
</tr>
<tr>
<td>WHO</td>
<td>World Health Organisation</td>
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1. INTRODUCTION

Transnet SOC (State-owned Company) Limited (Transnet) intends to construct a new compilation yard at Mamathwane, Northern Cape, as part of a broader project to expand the capacity of the existing manganese ore railway line from Hotazel in the Northern Cape to the Port of Ngqura in the Eastern Cape. Transnet has appointed Hatch Africa (Pty) Ltd (Hatch) to project manage the planning and engineering aspects as well as the associated studies for the railway upgrade. Hatch has subsequently appointed Environmental Resources Management Southern Africa (Pty) Ltd (ERM), as independent environmental consultants to undertake the Environmental Impact Assessment (EIA) process for the construction of the new compilation yard at Mamathwane.

The Mamathwane compilation yard will be constructed adjacent to the main line approximately 20 km south of Hotazel in the Northern Cape (Figure 1). Amongst others, it will comprise five yard lines with crossovers, a wagon servicing slab and storage and handling facilities for manganese and iron ore. Coal and ore storage and handling facilities not on mines that are designed to hold more than 100 000 tons of coal or ore are classified as Listed Activities in terms of Government Notice 248 of 31 March 2010 as contemplated in Section 21(1)(a) of the National Environmental Management: Air Quality Act (Act No. 39 of 2004). In order to operate, Listed Activities require an atmospheric emission license (AEL) as part of the environmental authorisation process. An air quality specialist study is required as part of the EIA and to support the AEL application.

ERM has appointed uMoya-NILU Consulting (Pty) Ltd to undertake the air quality specialist study for the EIA. The scope of the specialist study is listed in Section 2. The methodology is presented in Section 3 followed by an overview of the Mamathwane compilation yard freight line upgrade project and the potential sources of air pollution in Section 4. An overview of the pollutants and their potential impacts is presented in Section 5. Section 6 addresses the regulatory requirements with respect to air quality. The impact assessment is presented in Section 7, with recommendations for mitigation and management actions in Section 8.
2. SCOPE OF THE STUDY

The scope of the air quality study is to:

- Describe the current state of the receiving environment with respect to air quality;
- Assess the impacts resulting from emissions of dust and other pollutants during construction and operations at the Mamathwane compilation yard and common user facility on the surrounding receiving environment;
- Make recommendations on appropriate mitigation to reduce the impacts; and
- Provide input for the management of activities to ensure impacts are minimised.

3. METHODOLOGY

The description of the climate in the study area is based on available meteorological information for the Northern Cape. The description of the state of air quality in the vicinity of the Mamathwane compilation yard and common user facility is based on an assessment of the sources of atmospheric emissions, the nature of the pollutants that are released and information in the Initial State of Air Report (DEA, 2005).

The assessment of impacts resulting from the emissions is done in three stages. The first is the development of a qualitative emission inventory for the main sources. Secondly to estimate ambient concentrations ($\text{PM}_{10}$, $\text{PM}_{2.5}$, $\text{SO}_2$, $\text{NO}_x$, benzene) and dust deposition using the US-EPA approved (US-EPA, 2012) and DEA recommended (DEA, 2012) SCREEN 3 dispersion model, and lastly to assess the impacts by comparing the predicted concentrations with ambient air quality standards or guidelines.

The dust emissions methodology that has been used in this study is based on activity data, emission factors and control factors. Activity data in terms of estimated throughputs (tonnages) railed and design specifications for the proposed operations were obtained from the Final Scoping Report (ERM, 2013) and personal communication with Tania Swanepoel, Principal Consultant at ERM Southern Africa. The configuration of the Proposed Mamathwane Compilation Yard operations in terms of the compilation yard and common user facility is based on the plant layout as provided in the Final Scoping Report (ERM, 2013).

The SCREEN3 model is the recommended tool to calculate screening-level impact estimates for stationary sources. The model is based on steady-state Gaussian plume algorithms and is applicable for estimating ambient impacts from point, area, and volume sources out to a distance of about 50 km. In addition, SCREEN3 can be used to model flares. SCREEN3 also includes algorithms for addressing building downwash influences, including the cavity recirculation region, and incorporates the valley 24-hour screening algorithm for estimating complex terrain impacts. The SCREEN3 model uses a matrix of meteorological conditions covering a range of wind speed and stability categories. The model is designed to estimate the worst-case impact based on the meteorological matrix for use as a conservative screening technique. The SCREEN3 model does not use hourly meteorological data. Instead, the user can select one of the following options:

- Full Meteorology – model uses a predefined matrix of meteorological conditions that references all stability classes (A through F) and associated wind speeds, where the maximum wind speed is stability-dependent;
• Single Stability Class – user selects a single stability category, and the model automatically examines all wind speeds appropriate for that category; or
• Single Stability Class and Wind Speed – user selects a single stability category and wind speed combination.

The Full Meteorology option is used for routine application of the SCREEN3 model.

SCREEN3 is a single source model. It is not a multi-source model. Nevertheless, the impacts from multiple SCREEN3 model runs can be summed to conservatively estimate the impact from several sources. The SCREEN3 Model User’s Guide (US EPA, 1995) can be consulted for more technical information on the model.

Recommendations on appropriate mitigation to reduce the impacts are based on best practice and the nature of the emitting activity. Input to the management of activities to ensure that impacts are minimised analyses the proposed activities to identify alternative approaches or methods to achieve the end result, but reducing the impact.

Assumptions and Limitations
• The impact assessment is based on worst-case meteorological conditions. It is therefore likely that predicted ambient concentrations are higher than would actually be expected;
• Local emissions factors for manganese terminals and associated infrastructure in South Africa are not readily available. In the absence of these, US EPA AP-42 or Australian NPI emission factors have been used instead. The reliance on AP42 and NPI emission factors is considered acceptable for this investigation as it is widely used in many South African studies;
• Particle size distribution from ore samples obtained from the existing manganese grades exported on the rail line (Umoya-NILU, 2013) were used to determine the relative fraction of PM10 and PM2.5 in the emission calculation;
• The dimensions of area sources to represent the regions where emissions occur were estimated using available information provided in the Scoping Report (ERM, 2013) and general knowledge of manganese terminals;
• The assessment is only based on emissions from the proposed Mamathwane Compilation Yard, including the Common User Facility. Background concentrations to account for "nearby" and "other" background sources have not been taken into account;
• An estimate of the duration and frequency of the ‘worse-case’ concentrations at any particular point cannot be determined. The role of the surrounding topography of the area cannot be taken into consideration in determining the ground-level concentrations of the pollutant, when using the Screen3 model; and
• Emissions from ore handling activities are assumed to be constant, while emissions from stockpiles are wind dependent. Modelling in Screen3 presents a worst case scenario.
4. PROJECT DESCRIPTION AND AIR QUALITY

4.1 Project description

The project site is located at Mamathwane, Gamagara Local Municipality which falls within the John Taolo Gaetsewe District Municipality, in the Northern Cape Province. The Mamathwane Compilation Yard will be located approximately 3.5 km south of the existing Mamathwane yard, adjacent to the Mamathwane mine which forms part of the Kalahari manganese fields (Figure 1). Approximately 131 ha of the project site is currently designated for agricultural use, with current agricultural practices comprising sheep and cattle farming. Land use in the surrounding area includes further sheep and cattle farming and extensive mining.

The compilation yard layout is indicated in Figure 2. It will cover an area of 120 ha and will comprise of five rail lines and a balloon loop. Included in the compilation yard is a wagon servicing slab for the servicing of rail wagons and a diesel refuelling facility for locomotives. A triangle is included in the layout to allow for locomotives to turn around. A locomotive maintenance shed will be used for some minor servicing of locomotives. A treatment facility is included for the handling and management of oily waste water.

A common user facility (consisting of ore storage and handling infrastructure) will be constructed allowing the storage and loading of ore from smaller/junior mining operations. Junior mines do not have access to rail infrastructure. Manganese ore from these mines will therefore be transported to the common user facility by trucks. It is not envisaged that any direct loading of railway wagons from road trucks will take place. Ore will be stockpiled for an agreed period, or until a predetermined number of wagons can be filled. It will then be reclaimed from the bins with front end loaders or other methods (possibly gravity-feed conveyors) as determined by the terminal operator; and loaded either for pre-loading or directly into designated rail wagons. If a pre-loading system is used, wagons will be placed under the loading equipment and the wagons will be loaded either simultaneously or sequentially. No coverage of any facilities is planned.

There are three farm portions which will be directly affected by the project, namely Portion 3 of Remainder of the farm Moab No. 700, Portion of Remainder of Portion 1 of the farm Shirley No 367, and a portion of Remainder of Portion 2 of the farm Walton No 390. All three farms are privately owned. The farms are used for agricultural purposes, specifically activities associated with cattle, sheep and game farming. On farm Walton No 390, the landowner mines sand.
Legend

- Contours (20m)
- Dry Water Course Centre Line
- Main Road
- Other Roads
- Existing Railway
- Buildings
- Centreline Track
- Centreline Future Track
- Culvert
- Fence
- Roads
- Service Road Edge

Project Layout Mamathwane Station

Title: Project Site Layout of the Transnet Mamathwane Compilation Yard - North and South Sections

Client: Transnet SOC Ltd

Scale: 1:2500

Date: June 2013

Drawn by: [Name]

Approved by: [Name]

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Tel: +27 21 981 5400
Fax: +27 21 986 073

ERMMAT-0035

Scale: 1:2500

South Section

North Section

South Section

North Section
4.2 Sources of air pollution

4.2.1 Construction

Most civil construction activities generate dust and the emission of particulates into the atmosphere is through vegetation clearing and levelling, vehicle dust entrainment, excavation, earthmoving activities etc. In most cases the dust is relatively coarse, but may include fine respirable particles (PM$_{10}$ and PM$_{2.5}$). Emissions are released close to ground level and have little or no buoyancy, which limits their dispersion. As a result the coarse particulates generally settle relatively close to the emission source. Finer particulates may be transported further from the point of release, as they are easily carried by wind. Exhaust emissions from construction vehicles and equipment typically include particulates (including PM$_{10}$ and PM$_{2.5}$), carbon monoxide (CO), nitrogen oxides (NO$_x$), sulphur dioxide (SO$_2$) and volatile organic compounds (VOCs) including benzene.

4.2.2 Operations

Compilation yard

The consolidation and deconsolidation of train wagons by diesel locomotives in the compilation yard will result in exhaust emissions which include particulates, oxides of nitrogen (NO$_x$) and volatile organic compounds (VOCs) including benzene. The power rating of the locomotives and hours of operation are important factors in determining the emission. The movement of vehicles and equipment in the compilation yard may generate dust. Dust may also be entrained from open areas in the compilation yard by the wind. Evaporative losses of VOCs result from fuel handling and storage in bulk above-ground tanks. The evaporative loss depends on a number of factors including the volatility of the fuel, the annual throughput, the design of the storage tanks, and on loading and refuelling. The VOCs typically associated with diesel are benzene, toluene, ethyl benzene and xylene, the so-called BTEX group of compounds.

Common user facility

Manganese ore will be road hauled to the Common User facility from various smaller outlying mines without rail loading infrastructure. It is envisaged that the road hauling will take place by utilizing side tipper road vehicles with a total load of approximately 44 tons per vehicle. Dust may be entrained by the wind from ore stockpiles, from ore handling such as stacking and reclaiming activities as well as from open areas. Air pollutants will result in the common user facility from exhaust emissions and from haulage vehicles. Dust may be entrained by vehicles and equipment operating in the compilation yard.

4.3 Potential impacts

The potential impacts of construction and operations at the Mamathwane compilation yard and common user facility on air quality and health in the environment surrounding the different aspects of the project are:

Potential impact 1: Construction
Most civil construction activities generate dust and the emission of particulates into the atmosphere is through vehicle dust entrainment, demolition, excavation, earthmoving and ground levelling, etc. Exhaust emissions from construction vehicles and equipment typically include particulates (including PM\textsubscript{10} and PM\textsubscript{2.5}), carbon monoxide (CO), nitrogen oxides (NO\textsubscript{X}), sulphur dioxide (SO\textsubscript{2}) and of volatile organic compounds (VOCs) including benzene.

**Potential impact 2: Benzene emissions from fuel storage**

Benzene is classified by the US-EPA as a toxic pollutant as it is a known or suspected carcinogen. Benzene is found in diesel and is released from storage facilities through evaporative losses and during fuel handling. The resultant ambient concentrations of benzene may pose a health risk if they exceed the South African ambient air quality standard of 10 μg/m\textsuperscript{3} in areas where people spend an extended period of time, i.e. residential areas.

**Potential impact 3: Diesel locomotive emissions**

Respireable particulate matter (PM\textsubscript{10} and PM\textsubscript{2.5}), sulphur dioxide (SO\textsubscript{2}), oxides of nitrogen (NO\textsubscript{X}) and benzene are classified as criteria pollutants as they are known to pose a risk to human health. The resultant ambient concentrations of these pollutants from locomotive emissions may pose a health risk if they exceed the South African ambient air quality standards in areas where people spend an extended period of time, i.e. residential areas.

**Potential impact 4: Emissions from manganese ore storage and handling**

Windblown dust and dust generated from handling and storing manganese ore contains respirable particulate matter and manganese oxides. The resultant ambient concentrations PM\textsubscript{10}, PM\textsubscript{2.5} and Manganese from the storage area emissions may pose a health risk if they exceed the South African ambient air quality standards and other health-based guidelines. The resultant deposition of dust from the storage area may pose a nuisance risk if it exceeds the South African dust deposition limits.

**Potential impact 5: Emissions from manganese ore transport**

Windblown dust from the ore in loaded wagons contains respirable particulate matter and manganese oxides. The resultant ambient concentrations of PM\textsubscript{10}, PM\textsubscript{2.5} and Manganese resulting from this source in the compilation yard area emissions may pose a health risk if the South African ambient air quality standards and other health-based guidelines are exceeded in the ambient environment.

### 4.4 Air pollutant overview

An overview of the air pollutants commonly mentioned above and commonly associated with construction activity and bulk ore handling and storage is presented here.

**Particulate matter**
In the ambient environment airborne particulates are ranked according to size. Coarse particles associated with dust fallout or deposition are regarded as nuisance impacts, through accumulation and possible discoloration. Finer dust is categorised into sub-classes depending on its size and the associated human health impacts. The coarsest of the fine dust refers to all dust with a diameter of less than 100 μm, known as total suspended particulates (TSP). The fraction of TSP that is inhalable and associated with health impacts has a diameter equal to or smaller than 10 μm and is known as PM_{10}. When exposed to particulate matter through normal nasal breathing, particles larger than 10 μm would be removed in the passage of the air stream through the nose and upper respiratory airways, and particles between 3 μm and 10 μm would be deposited in the upper airways. Finer particles with a diameter equal to or less than 2.5 μm (PM_{2.5}) have yielded stronger associations with health impacts than PM_{10} as these particles can infiltrate deeper into the lung. Sources of PM_{2.5} include combustion processes and the formation of atmospheric aerosols during chemical transformations in the atmosphere. Health effects of PM depend on particle size and chemical composition. While the deposition of particulates on to surfaces may pose a nuisance, they may also be a potential risk to human health and wellbeing. PM_{10} and PM_{2.5} are classified as criteria pollutants and national ambient air quality standards apply. These are presented in Table 1.

**Oxides of nitrogen (NO\textsubscript{x})**

Nitrogen dioxide (NO\textsubscript{2}) and nitric oxide (NO) are formed simultaneously in combustion processes and other high temperature operations such as metallurgical furnaces, blast furnaces, and internal combustion engines. NO\textsubscript{x} is a term commonly used to refer to the combination of NO and NO\textsubscript{2}. The route of exposure to NO\textsubscript{2} is inhalation and the seriousness of the effects depend more on the concentrations inhaled rather than the length of exposure. The site of deposition for NO\textsubscript{2} is the distal lung (because NO\textsubscript{2} does not readily dissolve in the moist upper respiratory system) where NO\textsubscript{2} reacts with moisture in the fluids of the lower respiratory tract to form nitrous and nitric acids (WHO, 1997). About 80 to 90% of inhaled nitrogen dioxide is absorbed through the lungs (CCINFO, 1998). Nitrogen dioxide (present in the blood as the nitrite ion) oxidises unsaturated membrane lipids and proteins, which results in loss of control of cell permeability. Nitrogen dioxide causes decrements in lung function, particularly increased airway resistance. People with chronic respiratory problems and people who work or exercise outside will be more at risk to NO\textsubscript{2} exposure (EAE, 2006). NO\textsubscript{2} is also a major source of secondary fine particulates which decreases visibility, and contributes to surface ozone formation through its reaction with VOCs in the presence of sunlight. NO\textsubscript{2} is a criteria pollutant and national ambient air quality standards apply (Table 1).

**Benzene**

Benzene is a volatile organic compound that is a natural component of crude oil, petrol, diesel and other liquid fuels and is emitted when these fuels are combusted. Diesel exhaust emissions therefore contain benzene. After exposure to benzene, several factors determine whether harmful health effects will occur, as well as the type and severity of such health effects. These factors include the amount of benzene to which an individual is exposed and the length of time of the exposure. For example, brief exposure (5–10 minutes) to very high levels of benzene (14000 – 28000 μg/m\textsuperscript{3}) can result in death (ATSDR, 2007). Lower levels (980 – 4200 μg/m\textsuperscript{3}) can cause drowsiness, dizziness, rapid heart rate, headaches, tremors, confusion, and unconsciousness. In most cases, people will stop feeling these effects when
they are no longer exposed and breathe fresh air. Inhalation of benzene for long periods may result in harmful effects on the tissues that form blood cells, especially the bone marrow. These effects can disrupt normal blood production and cause a decrease in important blood components. Excessive exposure to benzene can be harmful to the immune system, increasing the chance of infection. Both the International Agency for Cancer Research and the Environmental Protection Agency (EPA) have determined that benzene is carcinogenic to humans, as long-term exposure to benzene can cause leukaemia, a cancer of the blood-forming organs. Benzene is a criteria pollutant and national ambient air quality standards apply (Table 1).

**Manganese**

Manganese is a naturally occurring substance found in many types of rocks and soil, for example in manganese ore. Pure manganese has a silver colour, but it does not occur in the environment as a pure metal but requires refinement through a smelting process. Rather, it occurs as a compound combined with other elements. Manganese can exist in both inorganic (for example manganese dioxide (MnO₂) or manganese sulfate (MnSO₄)), and organic (for example methyl cyclopentadienyl manganese tricarbonyl (MMT)) forms. Manganese is used mainly in steel production to improve hardness, stiffness, and strength in products like carbon steel, stainless steel, high-temperature steel, tool steel, cast iron and superalloys. It is also used in a wide variety of other products, such as fireworks, dry-cell batteries, fertilizer, paints, and cosmetics and as an additive in petrol (MMT). Manganese occurs naturally in most foods and may be added to food or made available in nutritional supplements, because it is a trace element and is necessary for good health.

The toxicity of manganese compounds depends on concentrations and duration of exposure, but also on the route of exposure. If manganese is ingested it has relatively low toxicity at typical exposure levels and is considered a nutritionally essential trace element. In 2003, no neurological effects were seen in humans ingesting manganese sulphate at an average dose of 0.3 mg/kg body weight/day for eight weeks, but in a study in 2011, it was shown that a dose of 0.104 mg/kg bodyweight/day for about 70 days over a period of 5 years (from drinking water containing manganese), could have neurological effects (CDC, 2012). Another study (in 2007) showed a daily dose of manganese of 0.26 mg/kg bodyweight/day caused an increase in deaths among children below 1 year who drank water contaminated with manganese (CDC, 2012). However, inhalation of manganese is considered the major toxic pathway, mainly also because this route of exposure is more efficient in delivering the metal in high concentrations to the brain (IEH, 2007) and several studies on workers showed adverse effects (CDC, 2012; WHO, 2000).

Inhalation of inorganic manganese (for example MnO₂) can cause an inflammatory reaction in the lungs, as was found in studies on humans (workers) and animals (except rabbits) (CDC, 2012). It is believed that the inflammation was caused by the particles inhaled and not specifically by the manganese (CDC, 2012). Cardiovascular symptoms were found in workers from a ferromanganese plant (CDC, 2012). People with an iron deficiency are more susceptible to the effects of manganese (IEH, 2007).

The main concern about manganese and compounds is the neurological effects (effects on the nervous system) from repeated inhalation (CDC, 2012). In a study by Blond et al, (2007) on
Danish steel workers, cognitive function could not be distinguished between steel workers exposed to manganese at 0.070 mg/m$^3$ (70 μg/m$^3$) and controls but longitudinal analysis showed the workers’ ability to perform certain fast movements with their hands and fingers were impaired when compared with controls (CDC, 2012). Concentrations of manganese in air associated with neurological effects in workers who were exposed over a long time, ranged from about 0.07 to 0.97 mg manganese/m$^3$ (manganese in total dust or inhalable dust) (CDC, 2012). The US EPA has stated that due to inadequate evidence, manganese cannot currently be classified as carcinogenic or not (IRIS, 2006).

There is no South African ambient air quality standard for manganese, therefore international standards and or guidelines are used. The US-EPA IRIS Reference Concentration for Chronic Inhalation Exposure (RfC) of manganese is 0.05 μg/m$^3$. The RfC is based on a study with a Lowest Observed Adverse Effect Level (LOAEL) (the lowest concentration at which a health effect was seen) of 0.05 mg/m$^3$. This study has an uncertainty factor of 1000 (which means the LOAEL of 0.05 mg/m$^3$ has to be divided by 1000 to get to a “safe” concentration of 0.05 μg/m$^3$). The EPA has a medium confidence in this RfC.

The World Health Organization (WHO) reports a No Observed Adverse Effect Level (NOAEL) of 0.03 mg/m$^3$ for manganese (i.e. no health effects identified for a concentration of 0.03 mg/m$^3$), with an uncertainty factor of 200 (1999). The study was however of a short duration and the NOAEL was divided by an uncertainty factor of 200 to get a benchmark value. The WHO ambient annual guideline value (0.03 mg/m$^3$ divided by 200) to adjust for continuous exposure and to account for the uncertainty (WHO, 2000).

The Californian Environmental Protection Agency (Cal-EPA) guideline value or Reference Exposure Level (REL) for chronic exposure to manganese and compounds is 0.09 μg/m$^3$. This value was based on a time adjusted exposure concentration of 26 μg/m$^3$ and an uncertainty factor of 300 (based on the study by Roels et al in 1992 on exposure to MnO$_2$). The uncertainty factor makes provision for the exposure of children (Cal-EPA, 2008), which means that children exposed to the REL of manganese will be unlikely to develop adverse effects, as their susceptibility due to age, was taken into account when the REL was calculated.

The CDC set a new Minimal Risk Level (MRL) of 0.3 μg/m$^3$ for manganese in September, 2012. The MRL is based on a concentration of 0.142 mg manganese/m$^3$ divided by uncertainty factors including a factor of 10 for the use of different forms of manganese.

### 4.5 Ambient air quality standards and guidelines

Health-based ambient air quality standards have been established for criteria pollutants and one toxic air pollutant in South Africa. Being health-based, these standards imply that the ambient concentrations less than the standard do not pose a health risk, while concentrations above the standard may pose a risk. The national ambient air quality standard consists of a limit value and a permitted frequency of exceedance. The limit value is the fixed concentration level aimed at reducing the harmful effects of a pollutant. The permitted frequency of exceedance represents the tolerated exceedance of the limit value and accounts for high concentrations as a result of process upsets and meteorological variation. Compliance with the ambient standard therefore implies that ambient concentrations are below the limit value and
the frequency of exceedance does not exceed the permitted tolerance. The criteria pollutants that are of concern in this assessment are SO$_2$, NO$_2$, PM$_{10}$, PM$_{2.5}$ and benzene. These pollutants will be emitted from diesel locomotives and ore handling and storage. The ambient standards are listed in Table 1. Annual ambient guideline values for Mn are listed in Table 2.

Draft National Dust Control Regulation (DEA, 2011) was published on 27 May 2011 for public comment. This regulation states that no person may conduct any activity in such a way as to give rise to dust in such qualities and concentrations that:

i) The dust, or dust fall, has a detrimental effect on the environment, including health, social conditions, economic conditions, ecological conditions or cultural heritage, or has contributed to the degradation of ambient air quality beyond the premises where it originates; or

a. The dust remains visible in the ambient air beyond the premises where it originates; or

b. The dust fall at the boundary and beyond the boundary of the premises where it originates exceeds:

ii) 600 mg/m$^2$/day averaged over 30 days in residential or light commercial areas measured using reference method ASTM D1739; or

iii) 120 mg/m$^2$/day averaged over 30 days in areas other than residential and light commercial areas measured using reference method ASTM D1739.

Table 1: National Ambient air quality standards (Republic of South Africa, 2009 and 2012)

<table>
<thead>
<tr>
<th>Pollutants</th>
<th>Averaging period</th>
<th>Limit value $\mu$g/m$^3$</th>
<th>Frequency of exceedance</th>
<th>Compliance date</th>
</tr>
</thead>
<tbody>
<tr>
<td>SO$_2$</td>
<td>10 min</td>
<td>500</td>
<td>526</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>1-hour</td>
<td>350</td>
<td>88</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>24-hour</td>
<td>125</td>
<td>4</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Annual</td>
<td>50</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>NO$_2$</td>
<td>1-hour</td>
<td>200</td>
<td>88</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Annual</td>
<td>40</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>PM$_{10}$</td>
<td>24-hour</td>
<td>120</td>
<td>4</td>
<td>1 Jan 2015</td>
</tr>
<tr>
<td></td>
<td>24-hour</td>
<td>75</td>
<td>4</td>
<td>1 Jan 2015</td>
</tr>
<tr>
<td></td>
<td>Annual</td>
<td>50</td>
<td>0</td>
<td>1 Jan 2015</td>
</tr>
<tr>
<td></td>
<td>Annual</td>
<td>40</td>
<td>0</td>
<td>1 Jan 2015</td>
</tr>
<tr>
<td>PM$_{2.5}$</td>
<td>24-hour</td>
<td>65</td>
<td>0</td>
<td>1 Jan 2016–31 Dec 2029</td>
</tr>
<tr>
<td></td>
<td>24-hour</td>
<td>40</td>
<td>0</td>
<td>1 Jan 2030</td>
</tr>
<tr>
<td></td>
<td>Annual</td>
<td>25</td>
<td>0</td>
<td>1 Jan 2030</td>
</tr>
<tr>
<td>Benzene</td>
<td>Annual</td>
<td>10</td>
<td>0</td>
<td>1 Jan 2015</td>
</tr>
</tbody>
</table>
Table 2: Ambient air quality guidelines for Mn

<table>
<thead>
<tr>
<th>Averaging Period</th>
<th>Concentration (μg/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual average</td>
<td>0.15</td>
</tr>
</tbody>
</table>

Inhalation benchmark values for manganese dust

<table>
<thead>
<tr>
<th>Inst</th>
<th>Benchmark (μg/m³)</th>
<th>Exposure duration (Acute/Chronic)</th>
<th>Uncertainty*’factor</th>
<th>Health effect</th>
<th>Study population</th>
<th>LOAEL/NOAEL (μg/m³)</th>
<th>Occ Std (mg/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EPA (IRIS)**1</td>
<td>0.05</td>
<td>Chronic</td>
<td>1000</td>
<td>Neuro-behaviour function</td>
<td>Workers exposed to MnO₂</td>
<td>50 (LOAEL)</td>
<td></td>
</tr>
<tr>
<td>CDC (ATSDR)*2</td>
<td>0.30</td>
<td>Chronic</td>
<td>500</td>
<td>Neurological effects</td>
<td>Workers exposed to Mn oxides</td>
<td>BMCL₁₀ of 142</td>
<td></td>
</tr>
<tr>
<td>WHO³</td>
<td>0.15</td>
<td>Chronic</td>
<td>200</td>
<td>Neurotoxic effects</td>
<td>Study on workers</td>
<td>30 (NOAEL)</td>
<td></td>
</tr>
<tr>
<td>South Africa (OEL)*4</td>
<td>Occupation al</td>
<td>Effect not stipulated</td>
<td></td>
<td>1.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cal-EPA*5</td>
<td>0.09</td>
<td>Chronic</td>
<td>300</td>
<td>Neurological effects</td>
<td>Workers</td>
<td>BMDL₁₀ of 74 (μg/m³)</td>
<td></td>
</tr>
</tbody>
</table>

*indicate the confidence in the benchmark value and is described below

3 WHO: [http://www.who.int/peh/air/Airqualitygd.htm](http://www.who.int/peh/air/Airqualitygd.htm)
4 SA OEL: DoL Government Gazette number 29276 5 October 2006
5 Cal-EPA: [http://www.oehha.ca.gov/air/hot_spots/2008/AppendixD1_final.pdf#page=170](http://www.oehha.ca.gov/air/hot_spots/2008/AppendixD1_final.pdf#page=170)

Given that guidelines and standards are only available for manganese and not manganese ore, and that the proposed manganese facility would handle and store manganese ore (mainly consisting of MnO), a conversion factor of 1.29 for manganese was used when assessing health risks associated with the manganese in the ore. Ore samples obtained from the existing manganese grades exported on the rail line (Umoya-NILU, 2013) were analysed as the ore originates from the same area in the Northern Cape and results showed that the ore contains...
on average approximately 53% MnO. A conversion factor is based on the mass percentage of manganese in the ore (41.7%). The aforementioned information was used to determine the mass of manganese per volume (μg/m³) in the modelled PM_{2.5} because PM_{2.5} is the respireable fraction of PM. These concentrations of manganese were then compared with the guidelines.

5. THE REGULATORY REQUIREMENTS

5.1 Atmospheric emission license

Government Notice 248 of 31 March 2010 as contemplated in Section 21(1)(a) of the National Environmental Management: Air Quality Act (Act No. 39 of 2004) defines Listed Activities as those that the Minister reasonably believes have or may have a significant detrimental effect on the environment. Minimum emission standards and special conditions are defined for Listed Activities in GN 248. Section 37 of the AQA details the requirements of an Atmospheric Emission License for all Listed Activities.

Ore storage and handling

Transnet proposes to store and handle up to 4 Mtpa of manganese ore per annum at the Mamathwane common user facility. According to Category 5 (Mineral processing, storage and Handling and sub-category 5.1 (Storage and handling of ore or coal) of GN 248 of Listed Activities, all installations that are not situated on a mine and hold more than 100 000 tons (the facility will be capable of storing up to 10% of the total annualised throughput at any one time, i.e. up to 400 000 tons) of ore or coal are classified as a Listed Activity. Transnet is therefore required to apply for an AEL and this should be supported by an atmospheric impact report (Section 30 of the AQA). The application should be lodged with the AEL Authority, either at the John Taolo Gaetsewe District Municipality in Kuruman, or the Northern Cape Department of Environmental Affairs and Nature Conservation in Kimberley.

The principal condition of sub-category 5.1 is that dust fall is measured in eight principal wind directions and the 3-month running average does not exceed the limit values for the adjacent land-use, according to the Draft National Dust Control Regulation (DEA, 2011b) (published on 27 May 2011) for public comment) which formalises the SANS recommendations.

This regulation states that no person may conduct any activity in such a way as to give rise to dust in such quantities and concentrations that:

a) The dust, or dust fall, has a detrimental effect on the environment, including health, social conditions, economic conditions, ecological conditions or cultural heritage, or has contributed to the degradation of ambient air quality beyond the premises where it originates; or

b) The dust remains visible in the ambient air beyond the premises where it originates; or

c) The dust fall at the boundary and beyond the boundary of the premises where it originates exceeds:
   i) 600 mg/m²/day averaged over 30 days in residential or light commercial areas measured using reference method ASTM D1739; or
ii) 1200 mg/m²/day averaged over 30 days in areas other than residential and light commercial areas measured using reference method ASTM D1739.

6. AIR QUALITY STATUS

6.1 Climate

The climate of any location is determined primarily by its latitude, elevation and distance from the sea. Secondary influences are the general atmospheric circulation, the nature of the earth’s surface, vegetation and the orientation of topographical features. The Northern Cape climate is classified as a southern steppe climate, receiving about 250 mm of rain annually, almost exclusively due to summer showers and thundershowers. Climate data at Kuruman clearly illustrates this (Figure 3) with 336 mm of the annual rainfall of 457 mm falling between October and March. Daytime summer temperatures are hot, but mild at night, winter daytime temperatures are mild and nights are cold. Winds are generally northwesterly, and reach their maximum strength in the afternoons. During thunderstorms strong and gusting southwesterly winds can occur.

![Figure 3: Average monthly maximum and minimum temperature and average daily temperature in °C and average monthly rainfall in mm at Kuruman for the 30-year period 1961-1990 (SAWS, 1998)](image)

The annual wind rose for Kathu is presented in Figure 4. Wind roses simultaneously depict the frequency of occurrence of wind from the 16 cardinal wind directions and wind speed classes, for a single site. Wind direction is given as the direction from which the wind blows, i.e. southwesterly winds blow from the southwest. Wind speed is given in meters per second (m/s), and each arc represents a percentage frequency of occurrence (4% in this case).

The Kathu meteorological station is the most is well exposed to the prevailing synoptic-scale winds, showing a high frequency of winds from the north and south to southwest sectors (making up about 35% of all winds). The area is characterised by calm winds. Wind speeds are generally below 5.4 m/s and seldom reach 8.5 m/s. The annual average wind speed here is 3.4 m/s with a calms frequency of 1.8%. The strongest winds are from the north and north-northeast sectors. The annual average wind speed here is of 3.4 m/s, with a calms frequency of 1.8 %. The Kathu wind data is reliable with a data capture rate of more than 99%.
6.2 Ambient air quality

Mamathwane is a remote site that is currently mostly under farming and the land use in the surrounding area includes further sheep and cattle farming and extensive mining. There are no measurements of ambient air quality at Mamathwane. Ambient monitoring of manganese has been done at Van Zyl's Rus and Kuruman since 1999 (DEA. 2009b). Measured concentrations at these two residential sites are below the WHO annual ambient air quality guideline of 0.15 μg/m³. The fraction of manganese in the airborne dust is consistently less than 2% at both sites. With no major sources of air pollution in the project area other than the mines, and on the evidence of the monitoring results, air quality is expected to be relatively good at Mamathwane.

7. ASSESSMENT OF IMPACTS

Ambient concentration and deposition for the various pollutants are predicted for each source at the proposed facility. For discussion purposes, sources are grouped into the following categories:

- Diesel storage tanks;
- Compilation yard; and
Common user facility (mainly includes material handling of the ore and wind erosion of stockpiles).

SCREEN3 generates 1-hour concentration estimates. For some pollutants, South African air quality standards are only applicable for 24-hr and annual averaging periods. To make meaningful comparisons with the standards, the 1-hour concentration estimates are converted to 24-hour and annual average concentration values using a factor of 0.15 and 0.03 respectively. This is based on the Colorado multiplying factors (CDPHE, 2002) for area sources. Screen3 does not model dry deposition. TSP ambient concentrations were converted to deposition values using an average dry deposition velocity of 2m/s (Hsi-Hsien et al., 2005). Screen3 does not take wind direction and topography into account. The model calculates concentrations at specified distances, but these may occur in any direction from the source. The prevailing wind directions can be used to obtain an indication of the general direction in which the pollution plume would travel.

Predicted ambient concentration curves for PM$_{10}$, PM$_{2.5}$, SO$_2$, NO$_x$, benzene and dust deposition for each source category are shown up to a distance of 5 km around the source. In all cases, there is a sharp increase in estimated ground-level concentration (and deposition) from the area of release until a maximum concentration (and deposition) is reached; thereafter the pollutant’s concentration (and deposition) decreases steadily. Screen3 models dispersion only (pollutants are treated as inert particles), thus the shape of the curves for all pollutants are relatively similar, with only the magnitude of concentration being different.

### 7.1 Potential impact 1: Construction

Most civil construction activities generate dust and the emission of particulates into the atmosphere through vehicle dust entrainment, demolition, excavation, ground levelling, etc. In most cases the dust is relatively coarse, but may include fine respirable particles (PM$_{10}$). The emissions are released close to ground level and have little or no buoyancy. As a result the coarse particulates generally settle to ground relatively close to the emission source. Finer particulates may be transported further from the point of release, as they are easily carried by wind.

Exhaust emissions from construction vehicles and equipment typically include particulates (including PM$_{10}$ and PM$_{2.5}$), carbon monoxide (CO), nitrogen oxides (NO$_x$), and volatile organic compounds (VOCs) including benzene. The construction activities are typically short lived, the intensity of the emission is low and the pollutants are released close to ground level. As a result dispersion of pollutants is generally limited to the construction site and resultant ambient concentrations are very low. Considering these factors and uninhabited nature of the area surrounding the Mamathwane compilation yard the magnitude of the impacts of construction is expected to be minor. The characteristics and the significance of the potential air quality impacts on human health from construction are presented in Table 3.

<table>
<thead>
<tr>
<th>Type</th>
<th>Extent</th>
<th>Duration</th>
<th>Scale</th>
<th>Likelihood</th>
<th>Magnitude</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct</td>
<td>Site only</td>
<td>Temporary</td>
<td>Negligible</td>
<td>Unlikely</td>
<td>Minor</td>
<td>Negligible</td>
</tr>
</tbody>
</table>

Table 3: Characteristics and significance of air quality impacts from construction
### 7.2 Potential impact 2: Emissions from fuel storage

Benzene is a volatile organic compound that is classified by the US-EPA as a toxic pollutant as it is a known or suspected carcinogen. In South Africa it is a classified as a criteria pollutant and ambient air quality standards have been set (Table 1).

Fuel storage results in evaporative emissions, known as working and standing losses. Working losses occur when the vapor in the vapor space over the liquid is displaced from the tank during tank filling. Working losses depend on the annual amount of material pumped, the vapor pressure of the material stored, and the ambient temperature. Standing losses occur because changes in temperature affect the vapor space pressure inside storage tanks. Vapors expand with an increase in temperature and contract with a decrease in temperature.

The locomotive refuelling facility at Mamathwane is proposed to be relatively small with a total capacity of 124 m$^3$. The fuel will be stored in two 62 300 litre storage tanks. The combined capacity of the fuel storage facility is well below the threshold of 500 m$^3$ for which depots require an AEL. Benzene has a relatively low volatility, with a vapour pressure of 0.1 kPa. Fixed roof tanks are the required technology for fuels with a vapour pressure of less than 14 kPa (Sub-category 2.2: Storage and Handling of Petroleum Products, DEA, 2010). Each of the six locomotives at the facility is expected to consume 2 573 litres of diesel daily, or 5 635 m$^3$ annually.

The US-EPA Tanks software application was used to estimate emissions from the diesel refuelling tanks. The equations used in the model were developed by the American Petroleum Institute (API). These are well-documented in Chapter 7 of the US EPA AP-42 (US-EPA, 2005). TANKS allows the input of specific information on storage tanks (e.g. tank type, dimensions, construction, paint condition), liquid fuel contents, handling protocols (e.g. type of fuel, annual product throughput, number of turnovers per year) and site-specific ambient meteorological information. The following assumptions apply to the emission estimation:

- The annual diesel throughput is 5 635 m$^3$,
- The diesel is stored in two vertical fixed roof tanks that vent to the atmosphere,
- Each tank has a capacity of 62 300 litres (62.3 m$^3$),
- The external shells are well maintained.

The loss of vapours from filling and extracting activities involving refined petroleum products into and out of the shunting locomotives is the subject of the US EPA’s AP-42, Section 5.2, entitled “Transportation and Marketing of Petroleum Liquids”. The US EPA has developed expressions for the estimation of petroleum emissions from loading operations with a probable error of ± 30%. Inputs to the expressions include the quantities of products loaded, their vapour pressures and their molecular weights. The expressions also require saturation factors which were determined by the US-EPA through empirical tests. Saturation factors are dependent on the type of loading. The highest saturation factors occur for splash loading, whereas the lowest occur for submerged and bottom loading. Emissions from the loading gantry is based on the annual throughput of fuel used by the locomotives and is based on a worst-case loading method, where fuel is loaded at the top of the locomotive tanks (splash method).
Speciation of emissions into its resultant components is based on the composition of the components in their liquid phases. The common compounds associated with diesel are benzene, toluene, ethyl benzene, and xylene. was also used as input to;

The model also requires the input of representative meteorological and climate data. Wind data for 2012 from the South African Weather Service (SAWS) station at Kathu; and long-term climate statistical data of temperature, pressure and solar radiation from the SAWS station at Kuruman (South African Weather Services, 1992) was used as input for the Tanks Model. Benzene emissions from the diesel tanks and loading gantry is presented in Table 4.

|bensene emissions from the diesel tanks and loading gantry in tons per year |
|---|---|---|
|Diesel tanks| Loading gantry| Total |
|Benzene |5.44E-05|1.64E-09|5.44E-05|

Predicted Benzene concentrations

Predicted annual average benzene concentrations resulting from diesel tanks in the compilation yard are shown in Figure 5. The predicted ground-level ambient concentrations are well below the current and future South African ambient air quality standards of 10 μg/m³ and 5 μg/m³, respectively. The highest predicted annual average ambient concentration of 0.0013 μg/m³ occurs about 38 m from the source.

![Figure 5: Predicted annual average benzene concentrations in μg/m³ resulting from diesel tanks at the proposed Mamathwane compilation yard](chart)

The intensity of the emission is expected to be very low from the fuel storage facility. With the pollutants being released relatively close to ground level dispersion is likely to be limited to the immediate vicinity of the tanks and the compilation yard. The resultant ambient concentrations are predicted to be very low. Considering these factors and uninhabited nature of the area surrounding the Mamathwane compilation yard the magnitude of the impacts resulting from
fuel storage are expected to be minor. The characteristics and significance of potential air quality impacts on human health from emissions from fuel storage are presented in Table 5.

Table 5: Characteristics and significance of air quality impacts from fuel storage

<table>
<thead>
<tr>
<th>Type</th>
<th>Extent</th>
<th>Duration</th>
<th>Scale</th>
<th>Likelihood</th>
<th>Magnitude</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct</td>
<td>Site only</td>
<td>Permanent</td>
<td>Small</td>
<td>Unlikely</td>
<td>Minor</td>
<td>Minor</td>
</tr>
</tbody>
</table>

The current regulation (DEA, 2010) requires vapour recovery systems to be fitted and operated on fuel facilities with an annual throughput of 5 000 m³. The revised regulation which is under review increases this threshold to 50 000 m³ per annum. In the case of the regulation not being approved the installation of a vapour recovery unit may be necessary. However, considering the low predicted significance of the impact it might be argued that the capital cost of a vapour recovery unit is not justified.

7.3 Potential impact 3: Diesel locomotive emissions

Locomotive exhaust emissions contain particulate matter, including respirable particulate matter (PM₁₀ and PM₂.₅), oxides of nitrogen (NOₓ) and benzene. These are criteria pollutants as they are known to pose risks to human health if the resultant ambient concentrations exceed the South African ambient air quality standards.

Emissions from the operation of diesel powered locomotives in the compilation yard are based on the amount of diesel fuel consumed by the diesel locomotives and relevant emission factors (Table 6). Six diesel powered shunting locomotives will be in operation per day, each operating 24 hours/day (on average +/- 22 hours shunting and 2 hours idling). In total, the six locomotives will use 15 438 litres of diesel per day, or 5 635 kilolitres (1 kilolitre = 1 m³) per annum. The NPI is a source of good emission factors and is developed by the Australian Government - Department of the Environment, Water, Heritage and the Arts. The emission factor for benzene is taken from the Emissions Estimation Technique Manual for Aggregated emissions from Railways (NPI, 1999). Emission factors for NOₓ, SO₂, PM₁₀ and PM₂.₅ were taken from the Emission Estimation Technique Manual for Railway Yard Operations (NPI, 2008).

Screen3 was set up to model a 1 km segment of the compilation yard. The modelled ambient concentrations are the same for each of these model segments, anywhere along the compilation yard.
### Table 6: Emissions from the diesel locomotives in the compilation yard

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Volume of diesel used (L/year)</th>
<th>Emission factor (g/L)</th>
<th>Emissions (g/year)</th>
<th>Emissions (tons/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benzene</td>
<td>5 634 870</td>
<td>0.105</td>
<td>591 661</td>
<td>0.59</td>
</tr>
<tr>
<td>NOx</td>
<td>5 635</td>
<td>44.37</td>
<td>250 019</td>
<td>250</td>
</tr>
<tr>
<td>PM10</td>
<td>5 635</td>
<td>3.53</td>
<td>19 891</td>
<td>19.9</td>
</tr>
<tr>
<td>PM2.5</td>
<td>5 635</td>
<td>3.39</td>
<td>19 102</td>
<td>19.1</td>
</tr>
<tr>
<td>SO2</td>
<td>5 635</td>
<td>0.835&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4 705</td>
<td>4.7</td>
</tr>
</tbody>
</table>

<sup>a</sup> The SO2 emission factor in the NPI manual is 0.0167, but this is based on a maximum diesel sulphur content of 10 ppm as per the Australian Diesel Fuel Standard. The sulphur content of fuel in South Africa is 500 ppm. The NPI emission factor is therefore multiplied by 50 to obtain a more representative emission factor for South African fuel.

### Predicted NOX concentrations

Predicted 1-hour maximum and annual average NOX concentrations resulting from the locomotives (diesel combustion) in the compilation yard are shown in Figure 6. There is no ambient standard for NOX, but only for NO2. The predicted ground-level ambient concentrations exceed the South African ambient air quality standard of 200 μg/m^3^ up to 2 km away from the source and is thereafter in compliance. The highest predicted 1-hour ambient concentration of 502 ug/m^3^ occurs about 597 m from source. This is a worst case prediction and the frequency of occurrence is not determined in this form of modelling. The annual average NOX concentrations resulting from the locomotives is well below the South African ambient air quality standard of 40 μg/m^3^, with a highest predicted concentration of 15 μg/m^3^, which occurs about 597 m from source.
Predicted SO₂ concentrations

Predicted 1-hour and 24-hour maximum SO₂ concentrations resulting from the locomotives in the compilation yard are shown in Figure 7. The predicted 1-hour and 24-hour ground-level ambient concentrations are well below the South African ambient air quality standard of 350 μg/m³ and 125 μg/m³ respectively. The highest predicted 1-hour ambient concentration of 9.5 μg/m³ occurs about 597 m from source, while the highest predicted 24-hour ambient concentration of 1.4 μg/m³ also occurs at about 597 m from source. It is expected that the annual average SO₂ concentrations resulting from the locomotives is also well below the South African ambient air quality standard of 50 μg/m³, and is therefore not shown.
Predicted PM\textsubscript{10} concentrations

Predicted 24-hour maximum PM\textsubscript{10} concentrations resulting from the locomotives in the compilation yard are shown in Figure 8. The predicted ground-level ambient concentrations are well below the current and future 2015 South African ambient air quality standards of 120 \(\mu\text{g/m}^3\) and 75 \(\mu\text{g/m}^3\), respectively. The highest predicted 24-hour ambient concentration of 6 \(\mu\text{g/m}^3\) occurs about 597 m from source. It is expected that the annual average PM\textsubscript{10} concentrations resulting from the locomotives is also well below current and future 2015 South African ambient air quality standards, and is therefore not shown.

Predicted PM\textsubscript{2.5} concentrations

Predicted 24-hour maximum PM\textsubscript{2.5} concentrations resulting from the locomotives in the compilation yard are shown in Figure 8. The predicted ground-level ambient concentrations are well below the current and future 2015 South African ambient air quality standards of 65 \(\mu\text{g/m}^3\) and 40 \(\mu\text{g/m}^3\), respectively. The highest predicted 24-hour ambient concentration of 5.75 \(\mu\text{g/m}^3\) occurs about 597 m from source. It is expected that the annual average PM\textsubscript{2.5} concentrations resulting from the locomotives is also well below the current and future 2015 South African ambient air quality standards, and is therefore not shown.
Figure 8: Predicted 24-hour PM$_{10}$ and PM$_{2.5}$ concentrations in μg/m$^3$ resulting from
the locomotives (diesel combustion) at the proposed Mamathwane compilation yard

Predicted Benzene concentrations

Predicted annual average benzene concentrations resulting from the locomotives in the
compilation yard are shown in Figure 9. The predicted ground-level ambient concentrations are
well below the current and future South African ambient air quality standards of 10 μg/m$^3$ and
5 μg/m$^3$, respectively. The highest predicted annual average ambient concentration of 0.036
μg/m$^3$ occurs about 597 m from source.

Figure 9: Predicted annual average benzene concentrations in μg/m$^3$ resulting from
the locomotives (diesel combustion) at the proposed Mamathwane compilation yard
With the exception of NO\textsubscript{x}, the intensity of the emissions in general, is expected to be very low from locomotives in the compilation yard. With the pollutants being released relatively close to ground level dispersion is likely to be limited to the immediate vicinity of the compilation yard. The resultant ambient concentrations are predicted to be very low. Considering these factors and uninhabited nature of the area surrounding the compilation yard the magnitude of the impacts resulting from the locomotives are expected to be minor. The characteristics and significance of potential air quality impacts on human health from emissions from locomotives for PM\textsubscript{10}, PM\textsubscript{2.5}, SO\textsubscript{2} and benzene are presented in Table 7.

For NO\textsubscript{x}, maximum ambient concentrations resulting from locomotive emissions up to 2 km downwind of the compilation yard. This is a worst case prediction and the frequency of occurrence is not determined in this form of modelling. Considering the uninhabited nature of the area surrounding the Mamathwane compilation yard the magnitude of the impacts resulting from the locomotive emissions are expected to be low. The characteristics and significance of potential air quality impacts on human health from emissions from locomotives for NO\textsubscript{x} are presented in Table 7.

Table 7: Characteristics and significance of air quality impacts from locomotive emissions

<table>
<thead>
<tr>
<th>Type</th>
<th>Extent</th>
<th>Duration</th>
<th>Scale</th>
<th>Likelihood</th>
<th>Magnitude</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct\textsuperscript{1}</td>
<td>Site only</td>
<td>Permanent</td>
<td>Small</td>
<td>Unlikely</td>
<td>Minor</td>
<td>Minor</td>
</tr>
<tr>
<td>Direct\textsuperscript{2}</td>
<td>Local</td>
<td>Permanent</td>
<td>Small</td>
<td>Likely</td>
<td>Low</td>
<td>Low</td>
</tr>
</tbody>
</table>

1 PM\textsubscript{10}, PM\textsubscript{2.5}, SO\textsubscript{2} and benzene
2 NO\textsubscript{x}

7.4 Potential impact 4: Emissions from manganese ore storage and handling

The planned operating model for the common user facility is outlined in Figure 10. Manganese ore will be road hauled to the common user facility from various smaller outlying mines without access to the rail or loading infrastructure. It is envisaged that the road hauling will take place using side tipper road vehicles with a total load of approximately 44 tons per vehicle. Manganese ore will then be off-loaded from road trucks at specific designated ‘bins’ in the terminal. The minimum bin live capacity should be 6300 tones, while the maximum capacity will depend on the operational philosophy and system disturbances. The physical dimensions are not available, but it will be influenced by the reclaiming method.
It is not envisaged that any direct loading of railway wagons from road trucks will take place. Ore will be stockpiled for an agreed period, or until a predetermined number of wagons can be filled. Ore will be reclaimed from the bins with front end loaders or other methods (possibly gravity-feed conveyors) as determined by the terminal operator; and loaded either for pre-loading or directly into designated rail wagons. If a pre-loading system is used, wagons will be placed under the loading equipment and the wagons will be loaded either simultaneously or sequentially. No coverage of any facilities is planned.

Front end loaders will predominantly be used for the movement of ore in the terminal, including housekeeping i.e. stockpiling of material. Ore could be stacked by stackers or front-end loaders, depending on the preferred operating methodology that the operator prefers. Ore is stacked in stockpiles (designated bins) in the terminal.

Diesel locomotives will move empty trains and loaded trains (consisting of 100 wagons) between the loading area and Mamathwane compilation yard. Trains comprise two train sets, of 100 wagons each, so a train set can carry 6300 tons of ore, equating to the average bin size. A minimum of four trains (each of 200-wagons) per day are planned to depart from the terminal translating into ~4Mtpa at maximum design capacity of the channel.

In order to achieve an annual throughput capacity of 4 Mt, the stockyard must be capable of storing a maximum of 10% of the annual throughput (400 000 tons) and in order to achieve this an area of approximately 3600 m² is required.

The main atmospheric emissions from operations at the proposed manganese ore facility result from wind-entrained dust and materials handling. Dust may also be generated during loading of trains, both from the loaders and from dust escaping from the hold of the train as a result of air displacement. The amount of dust that is generated and emitted to the atmosphere depends on the dust control measures that are employed and on the type of loading activity.

Dust emissions from material handling operations are based on the default dust emission factors in the NPI EET manual for “high” moisture content ores. The default factor has been used as the alternative equation for batch/continuous drop operations gives unrealistically low emissions (NPI, 2001) and is not recommended. A summary of the dust emission factors, used
in this study are presented in Table 8. All emission factor equations and default emission factors listed in Table 8 are for uncontrolled emissions, i.e. no dust suppression.

Emission factors are also available for PM$_{10}$ in the NPI EET manual. However, data from the particle size distribution (PSD) analysis was used to determine the percentage of PM$_{10}$ as well as PM$_{2.5}$ in the manganese ore. As a proxy for the type of material expected to be railed during the proposed operation of the manganese facility, six samples of product material obtained from the existing manganese ore transported along the rail (Umoya-NILU, 2013) were analysed. The silt content in each sample was obtained from PSD analysis of the samples collected. Based on the above analysis, it is assumed that PM$_{10}$ is 8.9 % of TSP, rounded up to 9% for the emission calculations, to be conservative. Similarly, it is assumed that PM$_{2.5}$ is 3.4 % of TSP.

The estimation of particulate emissions from the manganese stockpiles is based on the US-EPA methodology for wind erosion of silt (0.002 mm to 0.063 mm) from open ore or aggregate storage piles and exposed areas in industrial facilities provided in Chapter 13 of the US-EPA 42 (US-EPA, 2006a). Average daily wind speed and direction measured by the South African Weather Service meteorological station at Kathu (28 km south of the Mamathwane) is used.

Annual average emissions predicted for the ore handling activities and the stockpiles are presented in Table 8. The main types of mitigation measures are in the form of water spraying, for example, water cannons will be used to damp down the stockpile surface and water sprays will be installed at conveyor transfer points. Table 8 clearly demonstrates that large emission reductions can be achieved by implementing the proposed dust reduction methodologies. Control factors for the equipment are based on NPI recommendations. It is evident that the largest source of particulates, before and after mitigation, is the ore stockpiles.

Windblown dust and dust generated from handling and storing manganese ore contains respirable particulate matter containing manganese oxides. The resultant ambient concentrations of PM$_{10}$, PM$_{2.5}$ and Mn; and dust from the storage area emissions may pose a health risk if they exceed the South African ambient air quality standards and other health-based guidelines. The resultant deposition of dust from the storage area may pose a nuisance risk if it exceeds the South African dust deposition limits.
Table 8: Emission generated from handling and storing manganese ore at the common user facility

<table>
<thead>
<tr>
<th>Operation/Activity</th>
<th>TSP Default Emission Factor ¹ (kg/t)</th>
<th>Uncontrolled emissions</th>
<th>Control measure</th>
<th>Normal operations - controlled</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TSP Emissions (t/year)</td>
<td>PM$_{10}$ Emissions (t/year)</td>
<td>PM$_{2.5}$ Emissions (t/year)</td>
<td>TSP Emissions (t/year)</td>
</tr>
<tr>
<td>Trucks unloading onto stockpiles</td>
<td>0.005</td>
<td>20</td>
<td>1.8</td>
<td>0.7</td>
</tr>
<tr>
<td>Front-end loaders stacking the stockpiles</td>
<td>0.005</td>
<td>10</td>
<td>0.9</td>
<td>0.4</td>
</tr>
<tr>
<td>Front-end loaders or reclaimer-conveyor system unloading from stockpiles</td>
<td>0.005</td>
<td>20</td>
<td>1.8</td>
<td>0.7</td>
</tr>
<tr>
<td>Front-end loaders or conveyor-stacker system loading trains or preloaders</td>
<td>0.005</td>
<td>20</td>
<td>1.8</td>
<td>0.7</td>
</tr>
<tr>
<td>Loading from preloaders to trains</td>
<td>0.005</td>
<td>10</td>
<td>0.9</td>
<td>0.4</td>
</tr>
<tr>
<td>Stockpiles</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. NPI uncontrolled TSP emission factor is based on ores with a high moisture content
Predicted dust deposition

Predicted 30-day average maximum dust deposition rates resulting from the common user facility are shown in Figure 11. The predicted ground-level deposition rates are well below the current South African dust fallout standards of 1200 mg/m²/day for non-residential areas and 600 mg/m²/day for residential areas. The highest predicted 30-day average deposition of 551 mg/m²/day occurs about 202 m from the source.

![Figure 11: Predicted 30-day average dust deposition rates in mg/m²/day resulting from dust generating activities at the proposed common user facility](image)

Predicted PM$_{10}$ concentrations

Predicted 24-hour maximum PM$_{10}$ concentrations resulting from the common user facility are shown in Figure 12. The predicted ground-level ambient concentrations are well below the current and future 2015 South African ambient air quality standards of 120 μg/m³ and 75 μg/m³, respectively. The highest predicted 24-hour ambient concentration of 31 μg/m³ occurs about 202 m from source. It is expected that the annual average PM$_{10}$ concentrations resulting from the locomotives is also well below current and future 2015 South African ambient air quality standards, and is therefore not shown.

Predicted PM$_{2.5}$ concentrations

Predicted 24-hour maximum PM$_{2.5}$ concentrations resulting from the locomotives in the compilation yard are shown in Figure 12. The predicted ground-level ambient concentrations are well below the current and future 2015 South African ambient air quality standards of 65 μg/m³ and 40 μg/m³, respectively. The highest predicted 24-hour ambient concentration of 5 μg/m³ occurs about 202 m from source. It is expected that the annual average PM$_{2.5}$ concentrations resulting from the locomotives is also well below the current and future 2015 South African ambient air quality standards, and is therefore not shown.
Predicted manganese concentrations

Taking into account the conversion factor, predicted ground-level ambient concentrations exceed the WHO ambient air quality guideline of 0.15 μg/m³ up to 1.6 km from the source (Figure 13). The highest predicted 24-hour ambient concentration of 0.42 μg/m³ occurs about 202 m from source. A moderate to high risk of adverse effects (neurological effects) is therefore expected to develop in people chronically exposed to these modelled concentrations. The South African occupational standard for exposure to respirable manganese is 1 mg/m³ (1 000 μg/m³). It is clear that the modelled concentration is orders lower.

Figure 12: Predicted 24-hour PM₁₀ and PM₂.₅ concentrations in μg/m³ resulting from dust generating activities at the proposed common user facility

Figure 13: Predicted annual average manganese concentrations in μg/m³ resulting from dust generating activities at the proposed common user facility
With the exception of manganese, the intensity of the emissions in general from the common user facility is expected to be very low. With pollutants being released relatively close to ground level dispersion is likely to be limited to the immediate vicinity of the common user facility. The resultant ambient concentrations are predicted to be very low. Considering these factors and uninhabited nature of the area surrounding the common user facility, the magnitude of the impacts resulting from this source are expected to be minor. The characteristics and the significance of the potential air quality impacts on human health from emissions from the common user facility for dust, PM$_{10}$ and PM$_{2.5}$ are presented in Table 9.

For manganese, ambient concentrations resulting from the common user facility exceed the health based guideline up to 1.6 km downwind. This is a worst case prediction and the frequency of occurrence is not determined in this form of modelling. Considering the uninhabited nature of the area surrounding the common user facility the magnitude of the impacts resulting from this source are predicted to be low. The characteristics and significance of potential air quality impacts on human health from emissions from the common user facility for manganese are presented in Table 9.

Table 9: Characteristics and significance of air quality impacts from the common user facility

<table>
<thead>
<tr>
<th>Type</th>
<th>Extent</th>
<th>Duration</th>
<th>Scale</th>
<th>Likelihood</th>
<th>Magnitude</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct$^1$</td>
<td>Site only</td>
<td>Permanent</td>
<td>Small</td>
<td>Unlikely</td>
<td>Minor</td>
<td>Minor</td>
</tr>
<tr>
<td>Direct$^2$</td>
<td>Site only</td>
<td>Permanent</td>
<td>Small</td>
<td>Unlikely</td>
<td>Minor</td>
<td>Minor</td>
</tr>
</tbody>
</table>

1 dust, PM$_{10}$, PM$_{2.5}$
2 manganese

7.5 Potential impact 5: Emissions from manganese ore transport

Windblown dust from the ore from moving freight wagons in the Mamathwane compilation yard contains respirable particulate matter and manganese oxides. The resultant ambient concentrations of respirable particulate matter (PM$_{10}$ and PM$_{2.5}$) may pose a health risk in the ambient environment if they exceed the South African ambient air quality standards.

Ore is brought to Mamathwane from the mines where it is offloaded and stored at the common user facility before being reloaded onto train wagons for the long freight haul to the Port of Ngqura. It is assumed that good practice prevails and that the ore wagons pass under a spray of water or chemical surfactant to capture any dust onto the ore as they leave the mines. The wagons arriving at Mamathwane are therefore not expected to be a significant source of dust. Trains will leave the Mamathwane common user facility once loaded when it is assumed that the ore is sprayed. The wagons departing from Mamathwane are therefore not expected to be a significant source of dust.

The intensity of the emission of windblown dust from ore wagons is expected to be very low due to generally low wind speeds and the ore being sprayed with water or chemical surfactants. As a result it is expected that the impact will be limited to the immediate vicinity of the railway line and the common user facility. The resultant ambient concentrations are therefore expected to be very low. Considering these factors and uninhabited nature of the area surrounding the Mamathwane compilation yard and common user facility the magnitude of the impacts are expected to be minor.
The characteristics and the significance of the potential air quality impacts on human health from construction are presented in Table 10.

<table>
<thead>
<tr>
<th>Type</th>
<th>Extent</th>
<th>Duration</th>
<th>Scale</th>
<th>Likelihood</th>
<th>Magnitude</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct</td>
<td>Site only</td>
<td>Permanent</td>
<td>Small</td>
<td>Unlikely</td>
<td>Minor</td>
<td>Minor</td>
</tr>
</tbody>
</table>

**8. MITIGATION AND MANAGEMENT ACTIONS**

The proposed ore handling and storage approaches at the Mamathwane common user facility and compilation yard are described in Section 7 including the proposed dust control measures. Dust control measures are summarised here, with comment on the efficacy of these measures and the resultant impact in the surrounding environment.

**Construction**

Dust entrained by vehicles and equipment on the construction site depends mostly on the amount of dust on the surface, the size and speed of the vehicles and the moisture content of the surface. Dust entrained from exposed areas by the wind depends largely on the surface moisture content. Diesel emissions from construction vehicles depend largely on the fuel quality, the engine technology, driving practices and the service history of the vehicle.

Sound on-site management practices on the construction site can reduce dust entrainment significantly. These include traffic management, such as vehicle speed, and surface wetting. Traffic management and routine vehicle servicing can reduce exhaust emissions from the construction fleet. Detail input for the management of dust and other pollutants is included in Table 11.

**Common user facility**

Dust may be generated during stacking and reclaiming ore (either by front-end loaders or stackers and reclaimers), as well as by wind entraining dust from the stockpiles and the stockyard in general. The amount of dust that is generated and emitted to the atmosphere from the stockyard and the related activities depends on the dust control measures that are employed and the effectiveness of these measures.

The proposed dust control measure in the common user facility is the use of water cannons to spray water to damp down the stockpile surfaces.

The stackers, if used, should spray water onto the manganese ore as it falls onto the stockpile with a maximum drop height of 1.5 m. If front-end loaders are used for stacking and reclaiming, water cannons will be used to damp down the stockpile surface at the point of contact. Detail input for the management of dust and other pollutants is included in Table 11.
Conveyor system

Dust can result from wind blowing across the loaded ore conveyors. Elevated sections of the conveyor system should be fitted with wind boards to limit windborne dust generation. The transfer points and surge bins should be enclosed and equipped with atomising sprays.

The control of dust is however not only dependent on the design and technologies, but is also dependant on their optimum operations and management. It is therefore critically important that operators are appropriately trained and are aware of the dust control requirement; that Standard Operating Procedures (SOPs) for the conveyor and transfer points consider the control of dust and that all equipment is operated and maintained according to the design specifications. Detail input for the management of dust and other pollutants is included in Table 11.

Spill management

Ore spillages and the accumulation of ore dust may occur at conveyor transfer points and in the loading area. These points of accumulation may be sources of windblown dust, particularly if the spill is pulverised to finer particles by vehicle tyres. Similarly, the accumulation of ore dust on roads and open areas may be a source of dust by wind entrainment and vehicle movement.

These spills can result in significant dust entrainment and a spillage management programme is proposed with wetting of unpaved roads and sweeping of paved roads. Such programs can be very effective in reducing the dust generated at such sites if appropriately designed and implemented. Standard Operating Procedures (SOPs) for spill management and site maintenance are required. Detail input for the management of dust and other pollutants is included in Table 11.
### Air Quality Mitigation/Management Action Summary Table

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Impact</th>
<th>Management Objectives</th>
<th>Recommended Mitigation/Management Actions</th>
<th>Monitoring</th>
</tr>
</thead>
</table>
| **Construction**           | Increased dust and other pollutants during construction                | Minimise the effect of dust on workers and the surrounding environment                 | • Limit access to construction site to construction vehicles only  
• Impose vehicle speed restrictions on the construction site  
• Maintain high moisture content on exposed surface and roads by spraying with water  
• Maintenance programme for construction vehicles to ensure optimum performance reduced emissions | Include dust management in contractors contract conditions  
On-going during construction  
Contractor |
| **Conveyor system**        | Dust deposition and ambient PM$_{10}$ and PM$_{2.5}$ concentrations in the neighbouring environment | Meet air quality standards                                                             | • Install wind board on stockyard conveyor  
• Enclose transfer points  
• Install water sprayers at transfer points and surge bins  
• Operate and maintain sprayer at transfer points and surge bins | Include in conveyor system design  
Develop SOPs for conveyor and transfer point maintenance  
On-going  
Developer |
| **Ore spill management**   | Dust deposition and ambient PM$_{10}$ and PM$_{2.5}$                  | Meet air quality standards                                                             | • Design and implement spill management programme to effectively clean spilt ore | Develop SOPs for managing spills  
On-going  
Ops manager |
<table>
<thead>
<tr>
<th>Aspect</th>
<th>Impact</th>
<th>Management objectives</th>
<th>Recommended Mitigation/Management actions</th>
<th>Monitoring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concentrations in the neighbouring environment</td>
<td></td>
<td></td>
<td>• Implement programme to vacuum spilt ore on paved surfaces and to avoid ore and dust accumulation</td>
<td>On-going</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Implement wetting programme for unpaved roads and open areas using chemical surfactant</td>
<td>On-going</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Vegetate open unused areas with suitable ground cover</td>
<td>On-going</td>
</tr>
</tbody>
</table>

Develop SOPs for cleaning paved surfaces
Develop SOPs for surface wetting
Implement and maintain planting programme

<table>
<thead>
<tr>
<th>Methodology</th>
<th>Frequency</th>
<th>Responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>On-going</td>
<td>Ops manager</td>
</tr>
<tr>
<td></td>
<td>On-going</td>
<td>Ops manager</td>
</tr>
<tr>
<td></td>
<td>On-going</td>
<td>Ops manager</td>
</tr>
</tbody>
</table>
AIR QUALITY ASSESSMENT FOR THE MAMATHWANE COMPILATION YARD AND
COMMON USER FACILITY EIA PROJECT

9. REFERENCES


