ROBBEN ISLAND WASTEWATER TREATMENT WORKS

ODOUR RISK ASSESSMENT

01 JULY 2022

CONFIDENTIAL

ROBBEN ISLAND WASTEWATER TREATMENT WORKS

ODOUR RISK ASSESSMENT

ROBBEN ISLAND MUSEUM

CONFIDENTIAL

PROJECT NO.: 41103532-004
DATE: JULY 2022

WSP
1ST FLOOR, PHAROS HOUSE,
70 BUCKINGHAM TERRACE,
WESTVILLE, 3629
SOUTH AFRICA

T: +27 31 240 8909
F: +27 31 240 8801
WSP.COM

WSP Environmental (Pty) Ltd.

QUALITY MANAGEMENT

ISSUE/REVISION	FIRST ISSUE	REVISION 1	REVISION 2	REVISION 3
Remarks	Draft	Final		
Date	10 June 2022	01 July 2022		
Prepared by	L. Dyer	L. Dyer		
Signature				
Checked by	N. Shackleton	N. Shackleton		
Signature				
Authorised by	B. Keiser	B. Keiser		
Signature				
Project number	41103532-004			
File reference	\\corp.pbwan.net\za\Central_Data\Projects\41100xxx\41103532 - Robben Island WWTW BA\41 AQ\01-Reports			

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DECLARATION OF INDEPENDENCE - PRACTITIONER

Name of Practitioner: Loren Dyer

I, Loren Dyer, declare that I am independent of the applicant. I have the necessary expertise and have performed the work relating to this assessment in an objective manner, even if this resulted in views and findings that are not favourable to the applicant. I have disclosed all material information in my possession that reasonably has or may have the potential of influencing any decision to be taken with respect to this application. The information provided in this report is, to the best of my knowledge, in all respects factually true and correct. I am aware that the supply of false or misleading information in this report would be a criminal offence.

Signed at Westville on this 1st day of July 2022

SIGNATURE

Air Quality Specialist

CAPACITY OF SIGNATORY

EXECUTIVE SUMMARY

Robben Island Museum (RIM) is a public entity responsible for the management and maintenance of the Robben Island national estate and World Heritage Site. Robben Island is an island in Table Bay, approximately 7 km west of the coast of Bloubergstrand, Cape Town. Facilities include the maximum and medium security prison complexes, Robert Sobukwe House, curio and village shops, World War II memorials, as well as power generation and water processing infrastructure.

At present, there is no formal wastewater treatment works (WWTW) on Robben Island and untreated sewage generated on the island is discharged offshore. RIM is proposing to establish a competent sewage management system for the treatment of domestic effluent and to mitigate the risks posed by discharging untreated sewage to sea. Environmental authorisation (EA) was secured for RIM's proposed WWTW in 2015; however, the project failed to commence within the EA validity period and a new EA application is now required. Odour nuisance was identified as a potential impact of the proposed WWTW for which a specialist Odour Risk Assessment (ORA) is required as part of the EA application.

This study assessed the potential impacts associated with normal operating conditions using a Level 2 (AERMOD) dispersion modelling assessment. An emissions inventory was developed for odour and odorous constituent gases specifically, ammonia (NH_3) and hydrogen sulphide (H_2S), using emission factors developed by peer reviewed studies and reputable international environmental bodies for input into the dispersion model. Emission rates were quantified for the various WWTW components; however, components designed as covered or enclosed to aid with odour control, were excluded as emission sources from the model simulation. Simulated dispersion outputs were compared to international guidelines (as applicable) to assess the degree of impact.

Key findings are as follows:

- Simulated concentrations at sensitive receptors fall below the relevant international nuisance guidelines.
- Peak concentrations occur along the southwestern, northwestern and southeastern fencelines of the proposed WWTW development site.
- Offsite exceedances of odour nuisance guidelines are predicted beyond the boundary of the proposed WWTW development site; however, these are limited to within 20 m of the operational fenceline. This impact area extends to the gravel roads that run adjacent to the proposed development site. These roads are only used by maintenance staff and are not roads used by the Island's residents or tourists.
- Based on odour impact rating criteria provided by the United Kingdom (UK) Institute of Air Quality Management (IAQM) guidance, the predicted impact significance for sensitive receptors is determined to be 'negligible'.
- Based on impact rating criteria guidance provided by South Africa's national department for environmental management (Department of Environmental Affairs and Tourism, 2002), the predicted impact significance for the immediate vicinity of the proposed WWTW is determined to be 'very low'.

Although impacts were determined to be negligible or very low based on the risk rating criteria, WSP proposes the following mitigation measures for RIM's consideration:

- Establishing a vegetative environmental buffer (VEB) around the proposed WWTW will create a natural barrier and chemical sink for odorous constituent gases.
- Complaints and any actions arising from a complaint should be recorded in a complaints register maintained by site management. Should a complaint necessitate follow-up investigation, fenceline measurements of H_2S will provide a real-time indicator of odour impact.
- Warning communities to expect potential odour events during upset conditions (e.g. during desludging or when extended maintenance is scheduled) will generate increased trust and facilitate communication between parties.
- Maintenance/desludging of the WWTW should be scheduled for times when fewer tourists are expected in the area, or strategically planned so as not to coincide with proximate community events, if any.
- Maintenance/desludging should be scheduled (where possible) for periods with dry and cool conditions, particularly when prolonged repair work or sludge drying is anticipated. Drier conditions will accelerate sludge drying, shortening the duration in which peak impacts may occur. Odorous emissions are generally higher in warmer months due to increased gas volatility.

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1 INTRODUCTION

Robben Island Museum (RIM) is a public entity responsible for the management and maintenance of the Robben Island national estate and World Heritage Site. Robben Island is an island in Table Bay, approximately 7 km west of the coast of Bloubergstrand, Cape Town. Facilities include the maximum and medium security prison complexes, Robert Sobukwe House, curio and village shops, World War II memorials, as well as power generation and water processing infrastructure.

At present, there is no formal wastewater treatment works (WWTW) on Robben Island and untreated sewage generated on the island is discharged offshore via a 465 m pipeline. RIM is therefore proposing to construct a WWTW with a daily throughput capacity of 200 m^3 on the eastern seaboard of Robben Island. The purpose is to establish a competent sewage management system and to mitigate the risks posed by discharging untreated sewage offshore. It is proposed that treated effluent will gravitate from the WWTW to the existing sewage collector sump, located adjacent to the proposed development site, from where it will be pumped along the existing outfall sewer pipeline to discharge offshore.

Environmental authorisation (EA) was secured for the proposed WWTW in 2015; however, the authorised operations failed to commence within the EA validity period. In terms of National Environmental Management Act (Act No. 107 of 1998) (Republic of South Africa, 1998), referred to hereafter as 'NEMA', a new EA application is required. Odour nuisance was identified as a potential impact of the proposed WWTW for which a specialist Odour Risk Assessment (ORA) is required as part of the EA application.

This ORA pertains to the proposed WWTW on Robben Island only and the study meets the minimum requirements specified by the *Regulations Regarding Air Dispersion Modelling* (hereafter referred to as 'the *Modelling Regulations*') (Department of Environmental Affairs, 2014).

2 PROJECT BACKGROUND

2.1 FACILITY INFORMATION

Facility details are presented in **Table 2-1** below.

Table 2-1: Facility information

Enterprise Name	Robben Island Museum
Trading As / Site Name	Robben Island Museum
Type of Enterprise, e.g. Company/Close Corporation/Trust, etc.	Public entity (established by the Department of Arts and Culture, now the Department of Sport, Arts and Culture)
Company/Close Corporation/Trust Registration Number	N/A
Registered Address	Suite 206, Clock Tower, Victoria & Alfred Waterfront, Cape Town
Postal Address	P O Box 51806, V & A Waterfront, 8002
Telephone Number (General)	+27(0)21 413 4200
Fax Number (General)	+27(0)21 419 1057
Industry Type/Nature of Trade	Tourism
Land Use Zoning as per Town Planning Scheme	Open Space
Land Use Rights if outside Town Planning Scheme	National and World Heritage Site
Physical Address of the Facility	Robben Island, Ward 54 of the City of Cape Town, Western cape
Description of Site (Where No Street Address)	Eastern seaboard of Robben Island, adjacent to Murray's Bay beach
Coordinates of Approximate Centre of Operations	33.804574°S; 18.376891°E
Extent of property (km²)	0.001
Elevation Above Mean Sea Level (m)	6
Province	Western Cape
Metropolitan/District Municipality	City of Cape Town Metropolitan
Local Municipality	N/A
Designated Priority Area	N/A
EIA reference number	Authorisation pending
Modelling consultant	WSP Group Africa (Pty) Ltd

2.2 LOCALITY AND STUDY SITE

The proposed site for the WWTW is on the eastern seaboard of Robben Island, located in Table Bay and approximately 7 km west of Bloubergstrand, City of Cape Town Metropolitan Municipality (CCT), Western Cape, South Africa (**Figure 2-1**). The proposed WWTW components will be contained in an area approximately 0.001 km^2 in extent.

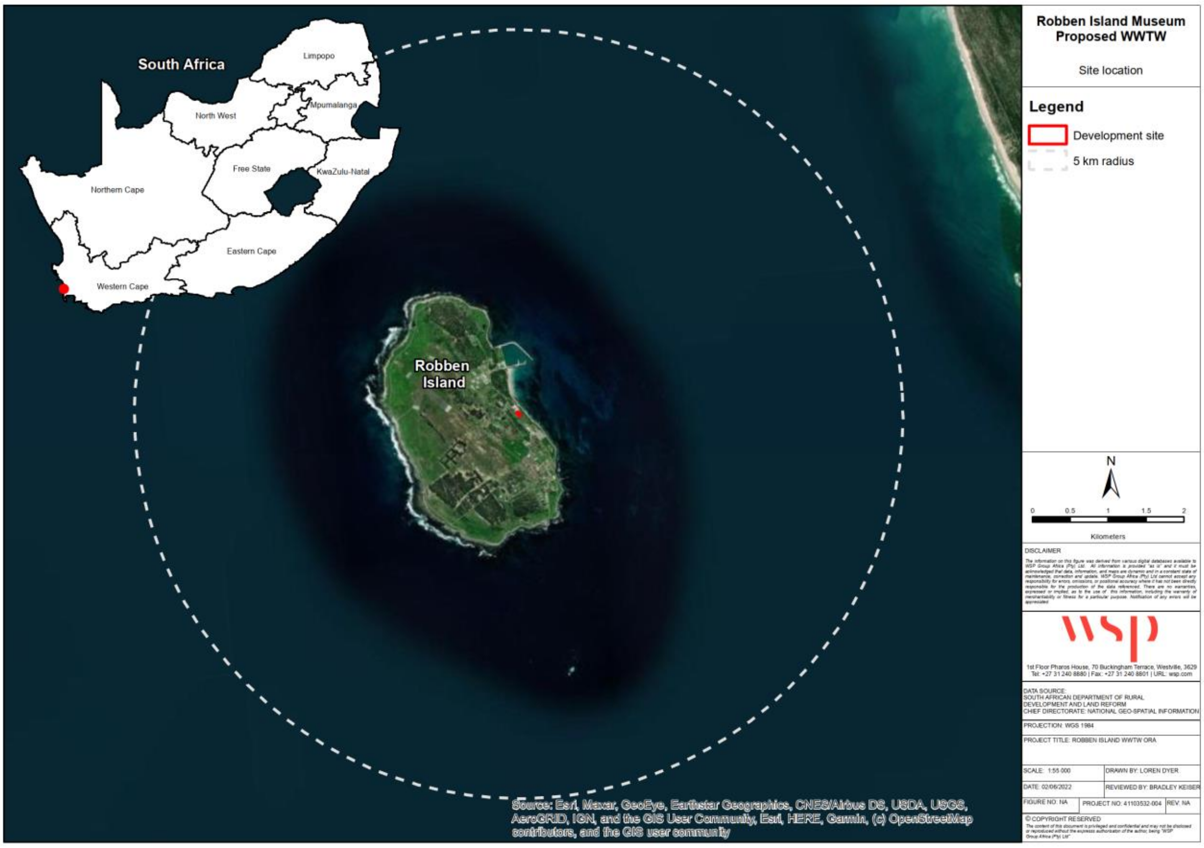

Figure 2-1: Site location

The proposed site is undeveloped and unoccupied and thus the current land use is deemed as 'Open Space'. Robben Island is not formally zoned but is recognised as a World Heritage Site. Proximate land uses include Murray's Bay beach (~50 m northeast), the Dog Unit (~30 m north), Murray's Road (~80 m west) and the Robben Island Village (~500 m southeast). The proposed site is at an elevation of 6 m above mean sea level. Elevations within the surrounding landscape gently undulate between 0 - 30 m and thus the local terrain is considered flat. Sensitive receptors (i.e. places where sensitive individuals may be impacted, such as residences, or places accessed by the general public) selected for evaluation in this assessment are listed in **Table 2-2** and presented in **Figure 2-2**.

Table 2-2: Sensitive receptors

ID	Receptor Name	Receptor Type	Distance from site (km)	Direction	Latitude (°S)	Longitude (°E)
SR1	Robben Island Museum	Tourism	0.53	Northwest	33.799860	18.372384
SR2	Robert Sobukwe House	Tourism	0.06	Northwest	33.803843	18.376464
SR3	Church	Religious	0.08	South	33.805486	18.376654
SR4	Robben Island Village	Residence	0.38	Southwest	33.807887	18.379303
SR5	Robben Island Clinic	Medical	0.48	South-southwest	33.809339	18.377784

Figure 2-2: Sensitive receptors

2.3 PROCESS DESCRIPTION

The WWTW is designed to treat up to 200 m³ of wastewater per day. The facility will receive domestic effluent generated by the tourist and residential establishments located on Robben Island. The intended wastewater treatment process is described below. For consistency and ease of understanding, each process is numbered in line with the respective component numbers provided in the process flow diagram (**Figure 2-5**) and design layout plan (**Figure 2-6**) that follows hereafter.

INLET STRUCTURE (2)

Raw sewage will flow into the WWTW through a simple civil concrete inlet structure. The structure will be fitted with a hand rake screen for removing foreign matter and objects from the sewage influent stream. The screen will be cleaned daily with a rake and the screenings disposed of in a solid waste bin. Accessible covers will be placed over the inlet structure to aid in odour containment.

PRIMARY SETTLING (3)

Screened sewage will flow into a septic tank where suspended solids and grit will settle out over a 24-hour retention period. The system is designed with features to prevent sludge blockages. The septic tank will comprise of two chambers:

- Anaerobic reactor - for oxidation and removal of organic material by settlement.
- Anoxic reactor - for de-nitrification and further reduction of organic material.

The septic tank will be covered with a concrete slab (with manhole access) to aid in odour containment.

BIOLOGICAL TREATMENT (4)

Sewage from the settling tank will gravitate to the aerobic reactor comprising a Rotating Biological Contactor (RBC) for further organic reduction and ammonia nitrification. Aerobic conditions are achieved by the rotation of discs, on which micro-organisms grow, at a low speed of approximately three to four revolutions per minute. The RBC will comprise of six rotors, each capable of treating 30 m^3 of domestic sewage per day. The RBC is manufactured with a cover to aid in odour containment (**Figure 2-3**).

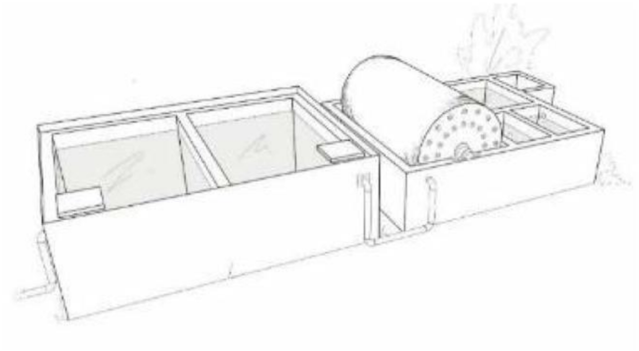

Figure 2-3: Schematic layout of a typical RBC treatment setup (left) and rotor and gearbox covers (right)

SECONDARY SETTLING (5)

Biological treatment is followed by secondary settling in an uncovered clarifier or 'humus' tank. A de-sludge pump will recirculate settled material to the first chamber of the septic tank for anaerobic digestion and to aid with maintaining the biological balance of the WWTW system.

DISINFECTION (6)

During disinfection, treated effluent is dosed with chlorine to neutralise microscopic organisms such as bacteria, viruses, protozoa and other pathogens. The chlorine contact channel, based on a chlorine tablet or pod system (**Figure 2-4**), will be sized to ensure a minimum disinfection period of 30 minutes.

Figure 2-4: Pod disinfection system

EFFLUENT DISCHARGE OR REUSE

The treated wastewater will be conveyed via the collector sump to the sewer connection point at the desalination plant. From there the treated effluent can be safely discharged offshore, in accordance with environmental discharge standards, or reused to flush the WWTW pipelines and prevent clogging during low flow conditions.

SLUDGE MANAGEMENT (7)

Surplus matter (i.e. settled sludge) will be processed through a sludge management system (as required). It is anticipated that the WWTW will generate approximately 66 m^3 of settled sludge annually, 70% of which will be water. The system will include drying beds for sun and wind assisted sludge drying. For this purpose, the beds must remain uncovered; however, netting will be placed over the drying beds to prevent the ingress of birdlife.

A process flow diagram and facility layout plan for Robben Island's proposed WWTW are presented in **Figure 2-5** and **Figure 2-6** respectively. **Figure 2-7** shows a 3D rendering of the proposed WWTW.

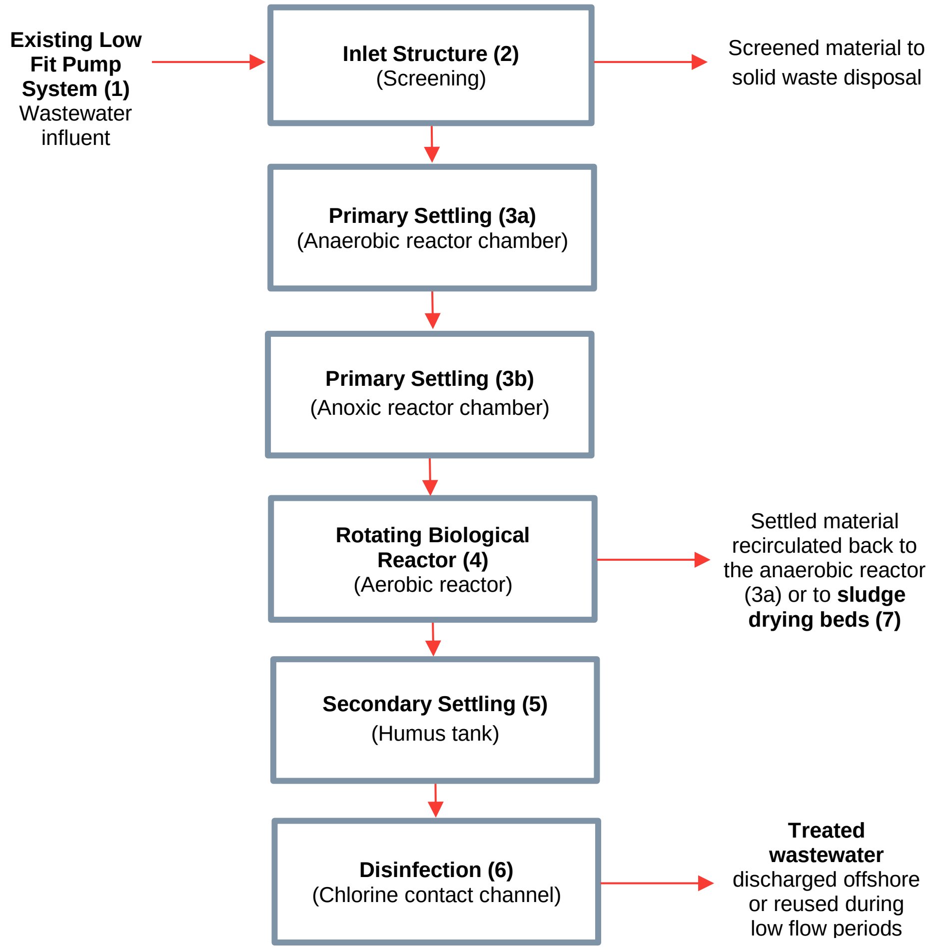

Figure 2-5: Process flow

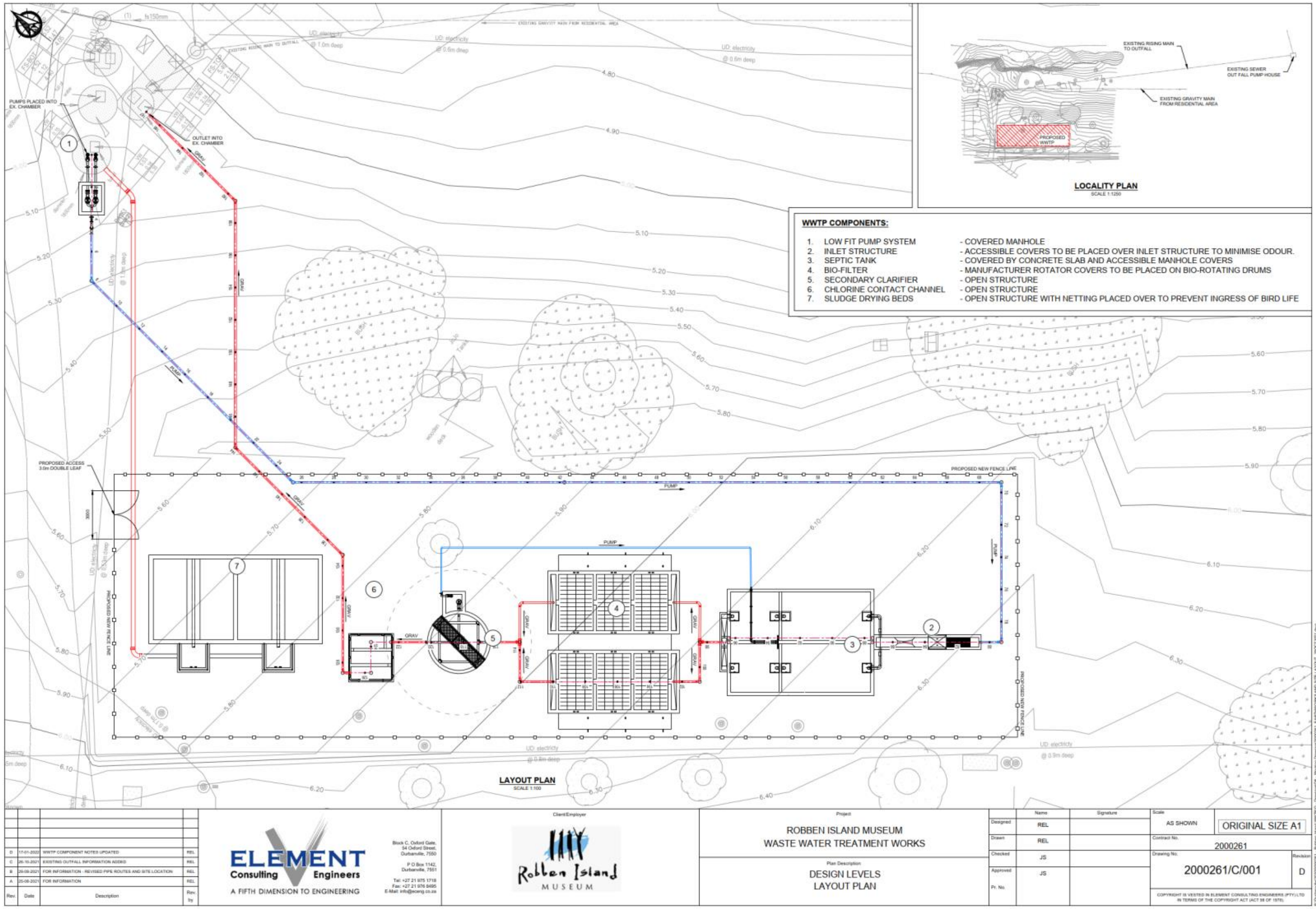

Figure 2-6: Site layout plan

Figure 2-7: 3D rendering of the proposed WWTW for Robben Island

3 REGULATORY FRAMEWORK

The complex and dynamic nature of odour, the variability of the constituent gases over time, the influence of meteorological conditions and the subjectivity of olfactory perception, complicate the effective regulation of odour (Belgiorno, Naddeo, & Zarra, 2013). Environmental odour can have a negative impact on both quality of life and economic activity even if the constituent gases at ambient concentrations pose little threat to human health (in the generally accepted meaning of the term[1]). According to the World Health Organisation (WHO), health is not only the absence of disease but includes physical, mental, and social well-being. In general, the regulation of odour internationally is framed around a nuisance impact, either under air quality or nuisance regulations. In South Africa, odour regulations have not been promulgated.

3.1 NATIONAL ENVIRONMENTAL MANAGEMENT: AIR QUALITY ACT

Until 2004, South Africa's approach to air pollution control was driven by the Atmospheric Pollution Prevention Act (Act no. 45 of 1965) (APPA) which was repealed with the promulgation of National Environmental Management: Air Quality Act (Act 39 of 2004) (NEM:AQA) (Republic of South Africa, 2005). NEM:AQA represents a shift in South Africa's approach to air quality management, from source-based control to integrated effects-based management. The objectives of NEM:AQA are to:

- Protect the environment by providing reasonable measures for:
  - The protection and enhancement of air quality.
  - The prevention of air pollution and ecological degradation.
  - Securing ecologically sustainable development while promoting justifiable economic and social development.
  - Give effect to everyone's right "*to an environment that is not harmful to their health and well-being*" (Republic of South Africa, 1996)

Significant functions detailed in NEM:AQA include:

- The National Framework for Air Quality Management (Department of Environmental Affairs, 2018).
- Institutional planning matters, including:
  - The establishment of a National Air Quality Advisory Committee.
  - The appointment of Air Quality Officers (AQOs) at each level of government.
  - The development, implementation and reporting of Air Quality Management Plans (AQMP) at national, provincial and municipal levels.
- Air quality management measures including:
  - The declaration of Priority Areas where ambient air quality standards are being, or may be, exceeded.
  - The listing of activities that result in atmospheric emissions and which have the potential to impact negatively on the environment and the licensing thereof through an Atmospheric Emissions License (AEL).
  - The declaration of Controlled Emitters.
  - The declaration of Controlled Fuels.
  - Procedures to enforce Pollution Prevention Plans or Atmospheric Impact Reporting for the control and inventory of atmospheric pollutants of concern.
  - Requirements for addressing dust and offensive odours.

With respect to odour control, Section 35 of NEM:AQA (under Part 6: Control measures in respect of dust, noise and offensive odours) states the following:

[1] The Oxford dictionary defines 'health' as a state of being free from illness or injury.

- The minister or MEC may prescribe measures for the control of offensive[2] odours emanating from the specified activities.
- The occupier of any premises must take all reasonable steps to prevent the emission of any offensive odour caused by any activity on such premises.

3.2 NUISANCE

Common law entitles everyone to the undisturbed use and enjoyment of his or her land as long as s/he complies with legislation and as long as that use poses no threat to anyone or their property[3]. Conversely, common law imposes duties on neighbours to tolerate and to endure to a certain extent their neighbour's reasonable exercise of ownership powers or rights. If one neighbour exceeds the regulatory demarcation of tolerance; however,, s/he has exceeded the legal limit of reasonable exercise of his or her ownership rights and this constitutes a nuisance.

If the issue cannot be addressed between the neighbours, a written complaint can be made to the Local Authority before the Court is approached. Should this prove unsuccessful, then the offended neighbour can approach the court for an interdict to prevent the nuisance. Not all forms of nuisance are actionable. An actionable nuisance occurs when the actions of the offending property are outside of what is proper, befitting and socially adequate in the light of the convictions of the society – *secundum bonos mores* (Regal v African Superslate (Pty) Ltd 1963 (1) SA 102 (AD)). If the application for an interdict is successful, but the offending neighbour persists with his or her unlawful actions, he or she may be found guilty of contempt of court, in which case the court may impose a fine or imprisonment.

The CCT's Environmental Health By-law (City of Cape Town, 2003) defines the term 'health nuisance' as *"any activity, conditions, premises or thing which, on account of effluent, vapours, chemical effluvia, odours, noise, vibration…or on account of any other cause or practice whatsoever, is in the opinion of the Director: City Health…potentially injurious or dangerous to health or which is offensive…"* (pg. 5 of 26). Further, this by-law states that *"no person shall – cause or permit a stream, pool, ditch, gutter, watercourse…on any land or premises to that owned or occupied by him or of which he is in charge to be or to become so foul or in such a state or to be so situated or constructed so as to be a health nuisance"* (pg. 8 of 26). This by-law binds all persons under the jurisdiction of the CCT. Any person convicted of an offence under this by-law shall be liable to a fine and/or imprisonment for a period not exceeding two years, with an additional 10-day imprisonment for each day on which such offense continues.

While the CCT's Air Quality Management By-law (City of Cape Town, 2016) addresses the prohibition of emissions that cause nuisance, this is presented in the context of fumes, dust and smoke only. Since this by-law does not make any reference to odour, it is not considered relevant for this assessment.

3.3 STANDARDS AND GUIDELINES

3.3.1 NATIONAL AMBIENT AIR QUALITY STANDARDS

Ambient air quality standards are defined as those "*targets for air quality management which establish the permissible concentration of a particular substance in, or property of, discharges to air, based on what a particular receiving environment can tolerate without significant deterioration*" (Department of Environmental Affairs, 2000). South Africa's National Ambient Air Quality Standards (NAAQS) (Department of Environmental Affairs, 2009; Department of Environmental Affairs, 2012) regulate a range of pollutants deemed to be commonly occurring yet which pose a threat to human health and the environment. None of the pollutants currently regulated by South Africa's NAAQS are associated with nuisance odour and thus these are not considered further in this ORA. Where national standards have not been established for individual compounds in South Africa, guidance can be sought from internationally recognised institutions and databases.

[2] 'Offensive odour' is defined by NEM:AQA as any smell which is considered to be malodorous or a nuisance to a reasonable person.
[3] Section 36 of the Constitution provides that no right is absolute; all rights can be limited if this is just and equitable in our democratic society.

3.3.2 INTERNATIONAL GUIDANCE

ODOUR ASSESSMENT CRITERIA

While South Africa's odour legislation is limited to the prevention of unreasonable nuisance, nations of the European Union, North America and Australasia have well established odour regulations, many of which incorporate odour standards or impact criteria. Assessment tools such as dynamic olfactometry and dispersion modelling are applied to determine nuisance potential. Complaints are also investigated by trained inspectors, who use a checklist to characterise the odour based on hedonic tone, frequency and intensity (Minnesota Pollution Control Agency, 2004). When an offense has been committed (including failure to comply with permit conditions), the regulator has reasonable grounds to suspend the activity or take enforcement action.

Odour impact criteria guidelines assist with the assessment of model simulated nuisance impacts. By definition, the limit of detection of an odour by an average human nose under laboratory conditions is 1.0 European odour unit per metre cubed of air (OU_E/m^3) (Bull, *et al.*, 2018).

Criteria limits for acceptable odour exposure have been established for international jurisdictions although with significant variation in application (**Table 3-1**).

Table 3-1: Criteria limits for acceptable odour exposure associated with wastewater treatment

Region	Limit value (OU/m^3)	Percentile	Averaging period	Applicability
New South Wales (Australia)	2 (urban) - 7 (rural)	99th	1-second	Limit value dependent on population density surrounding the odour source (i.e. rural vs urban population densities)
Germany	1	90th	1-second	Residential areas
Hong Kong	5	100th	5-second	Nearest sensitive receptor
Ontario (Canada)	1	99.5th	10-min	At sensitive receptors
Tasmania	2	99.5th	1-hour	-
New Zealand	5	99.5th	1-hour	Moderate sensitivity (all conditions)
Norway	1	99th	1-hour	Nearest residential receptor
France	5	98th	1-hour	Bio-stabilisation plants
Catalonia (Spain)	5	98th	1-hour	Moderately offensive odour (e.g. WWTW).
Colombia	3	98th	1-hour	Treatment and disposal of non-hazardous wastes, transfer plants, wastewater treatment plants
Netherlands	1	98th	1-hour	WWTW built after 1996, (outside urban areas)
United Kingdom	1.5	98th	1-hour	Highly offensive odour (e.g. septic effluent).
Ireland	1.5	98th	1-hour	Target value for all situation (excl. pig production)
Belgium	0.5	98th	1-hour	Target for very unpleasant odours in high sensitivity areas
	2			Limit for very unpleasant odours in high sensitivity areas

The odour impact criteria established by the United Kingdom (UK) have been selected as an appropriate guideline with which evaluate the degree of odour nuisance impact for this assessment. Expressed as the 98th percentile of the hourly mean odour concentrations, a value of 6.0 OU_E/m^3 is suggested as appropriate for 'less offensive' odours, 3.0 OU_E/m^3 for 'moderately offensive' odours and 1.5 OU_E/m^3 for the 'most offensive' odours. Odours from WWTW are usually cited as an example of odours in the most offensive category.

This impact assessment will be based on predicted odour concentrations at identified sensitive receptors in line with the UK Institute of Air Quality Management (IAQM) guidance (Bull, et al., 2018). The IAQM classifies sensitive receptors into low, medium, or high sensitivity as described in **Table 3-2**.

Table 3-2: Receptor Sensitivity Classification

High Sensitivity Receptor	Surrounding land where: — Users can reasonably expect enjoyment of a high level of amenity. — People would reasonably be expected to be present here continuously, or at least regularly for extended periods, as part of the normal pattern of use of land. Examples may include residential dwellings, hospitals, schools/education, tourist/cultural and food retail/processing.
Medium Sensitivity Receptor	Surrounding land where: — Users can reasonably expect enjoyment of a high level of amenity. — People wouldn't reasonably be expected to be present here continuously, or at least regularly for extended periods, as part of the normal pattern of use of land. Examples may include places of work, commercial/retail premises and sports/recreation fields.
Low Sensitivity Receptor	Surrounding land where: — The enjoyment of amenity would not reasonably be expected. — There is transient exposure, where the people would reasonably be expected to be present only for limited periods of time as part of the normal pattern of use of land. Examples may include industrial use, farms footpaths and roads.

The sensitivity classification of the receptor, as well as the predicted odour concentration at the receptor in question is then used to establish the impact significance at that specific receptor (**Table 3-3**). For example, a predicted 98th percentile concentration of 6 OU_E/m^3 at a low sensitivity receptor would result in a moderate significance.

Table 3-3: Odour effect descriptors for impacts predicted by modelling

Odour concentration (OU_E/m^3)	Receptor Sensitivity		
	Low	Medium	High
≥10	Moderate	Substantial	Substantial
5 - 10	Moderate	Moderate	Substantial
3 - 5	Slight	Moderate	Moderate
1.5 - 3	Negligible	Slight	Moderate
0.5 – 1.5	Negligible	Negligible	Slight
<0.5	Negligible	Negligible	Negligible

ASSESSMENT CRITERIA FOR ODOROUS CONSTITUENT GASES

In the absence of local standards for odorous compounds typically associated with WWTW, guidance from the international bodies described below is provided. A summary of the guidelines for nuisance impact from exposure to odour relevant pollutants is presented in **Table 3-4**.

WORLD HEALTH ORGANISATION

The WHO provide guidelines for protecting public health from the adverse effects of air pollutants and to eliminate or reduce exposure to those pollutants that are known or likely to be hazardous to human health or well-being. The guidelines are based on expert evaluation of current scientific evidence and are intended to inform policy makers and to provide targets for air quality management. In establishing pollutant levels below which exposure does not constitute a significant public health risk over a specified period of time, the guidelines provide a basis for setting standards or limit values for air pollutants. In general, the guidelines address single pollutants (identified to be of special environmental and health significance to countries of the European Region) whereas in reality, exposure to mixtures of chemicals occurs, with potentially additive, synergistic or antagonistic effects.

In dealing with practical situations or standard-setting procedures, therefore, consideration should be given to the interrelationships between the various air pollutants. In setting legally binding standards, considerations such as prevailing exposure levels, technical feasibility, source control measures, abatement strategies, and social, economic and cultural conditions also should be taken into account (World Health Organisation, 2000).

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

The Texas Commission on Environmental Quality (TCEQ) is the environmental agency for the state of Texas in the United States. TCEQ have developed Effects Screening Levels (ESLs) to evaluate impacts from pollutant concentrations predicted by dispersion modelling simulations. ESLs, which include both short- (1-hour) and long-term (annual) limit values, are chemical-specific concentration limits set to protect human health and welfare. They are not ambient air quality standards but rather a guideline as to whether airborne contaminants present adverse risk. Short-term ESLs are based on data concerning acute health effects, the potential for nuisance odour and effects on vegetation, while long-term ESLs are based on data concerning chronic health and vegetation effects. Welfare ESLs (i.e. odour and vegetation effects) are based on effect thresholds while health ESLs are based on toxicity factors and dose responses relevant to humans (Texas Commission on Environmental Quality, 2014).

Table 3-4: International odour-based annoyance guidelines for NH_3 and H_2S

Pollutant	Basis	Averaging period	WHO (µg/m^3)	TCEQ ESL (µg/m^3)
Ammonia	Odour	1-hour	-	3 600
Hydrogen sulphide	Odour	30-minute	7	-

4 METEOROLOGICAL CONTEXT

Seasonal and diurnal pollutant concentration levels fluctuate in response to the changing state of atmospheric stability, to variations in mixing depth and to the influence of mesoscale and macroscale wind systems. The Cape Town region has a Mediterranean climate according to the Köppen classification, with cool, wet winters and hot, dry summers (Western Cape Government, 2013). Winter weather is the result of cold fronts that develop over the Atlantic Ocean and reach as far north as the Cape during the southern hemisphere autumn, through winter and into spring. The approach of these frontal systems during winter results in north-westerly winds that ventilate the area and rains that cleanse the air. North-easterly berg winds and strong low-level inversions are a common occurrence, facilitating formation of brown haze in the region. South-easterly air flow, with highest frequency in summer, transports pollution seaward and away from the city. Higher average wind speeds and increased atmospheric turbulence in summer further alleviate air pollution accumulation (Jury, Tegen, Ngeleza, & DuToit, 1990).

Meteorological data, including hourly temperature, rainfall, humidity, wind speed and wind direction, were obtained from the nearest station operated by the South African Weather Service (SAWS) and analysed for the period January 2019 - December 2021 (i.e. three calendar years as required by the *Modelling Regulations*). Station details and data recovery information is given in **Table 4-1.** The SAWS Robben Island meteorological station is located approximately 1 km to the west-northwest of the proposed development site (**Figure 4-1**).

Table 4-1: Meteorological station details and data recovery

Station Name	Latitude (ºS)	Longitude (ºE)	Altitude (m)	Data Recovery			
				Temperature	Rainfall	Humidity	Wind
Robben Island	-33.7980	18.3740	2	97%	97%	97%	95%

Figure 4-1: Robben Island meteorological station

4.1 TEMPERATURE, HUMIDITY AND RAINFALL

Ambient air temperature influences plume buoyancy as the higher the plume temperature is above the ambient air temperature, the higher the plume will rise. Further, the rate of change of atmospheric temperature with height influences vertical stability (i.e. formation of mixing or inversion layers). Rainfall is an effective removal mechanism of atmospheric pollutants and thus also relevant in the assessment of pollution potential.

Figure 4-2 presents the average monthly temperature, humidity and rainfall as recorded by the SAWS Robben Island station. Higher rainfall occurs during the cooler months (June, July and August) with drier conditions during the warmer months (December, January and February). Summer temperatures for the island average at 19.5°C while winter temperatures average at 13.5°C. Average humidity ranges between 71% in summer and 81% in winter. Robben Island received on average 370 mm of rainfall per year, with approximately 56% during winter and 5% during summer.

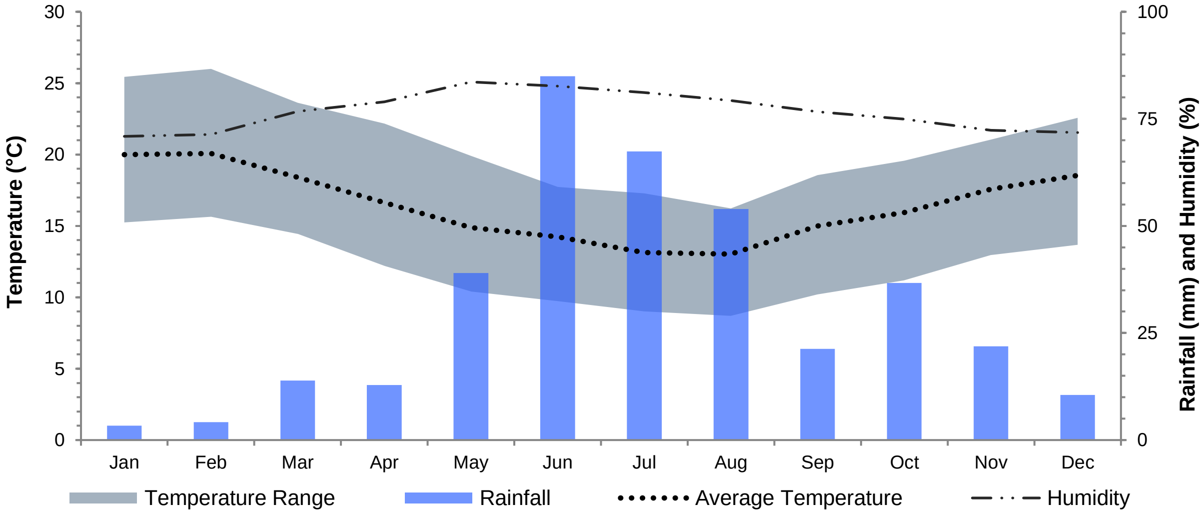

Figure 4-2: Meteorological summary for Robben Island (January 2019 - December 2021)

4.2 WIND FIELD

Wind roses (**Figure 4-3**) display wind speed and directional frequency. Each directional branch on a wind rose represents wind originating from that direction. Each directional branch is divided into segments of colour, representative of different wind speeds. Calm conditions are defined as wind speeds less than 1.0 m/s (i.e. based on the typical sensitivity of the wind sensor installed at SAWS stations).

Wind roses were created using Lakes Environmental WRPlot Freeware (Version 7.0.0) for the full period (January 2019 – December 2021); diurnally for early morning (00h00 – 06h00), morning (06h00 – 12h00), afternoon (12h00 – 18h00) and night (18h00 – 00h00); and seasonally for summer (December, January and February), autumn (March, April and May), winter (June, July and August) and spring (September, October and November). The analysis of the measured winds showed the following:

— For the assessment period, calm conditions (wind speeds <1 m/s) occurred 4.70% of the time.

— Wind speeds ranged from light (1 – 1.5 m/s) to moderate gale force (13.9 – 17.1 m/s) along a prevailing southeasterly / north-northwesterly trajectory.

— Peak (17.0 m/s) wind speeds occurred from the east-southeast and highest average (5.7 m/s) wind speeds occurred from the southeast.

— Winds from the east-southeast and southeast prevailed during the early morning (00h00 – 06h00), morning (06h00 – 12h00) and night (18h00 – 00h00).

— Southerly and southeasterly winds prevailed during the afternoon (12h00 – 18h00).

— Diurnal peak (14.4 m/s) and highest average (4.0 m/s) wind speeds occurred during the afternoon hours.

- Prevailing southeasterly and east-southeasterly winds with less frequent southerly components are noted during the summer, autumn and spring months.
- Winds from the north-northwesterly quadrant prevailed during winter months. Highest directional variability in the wind field is observed during winter.
- Seasonal peak (13.2 m/s) and highest average (3.8 m/s) wind speeds occur during spring.

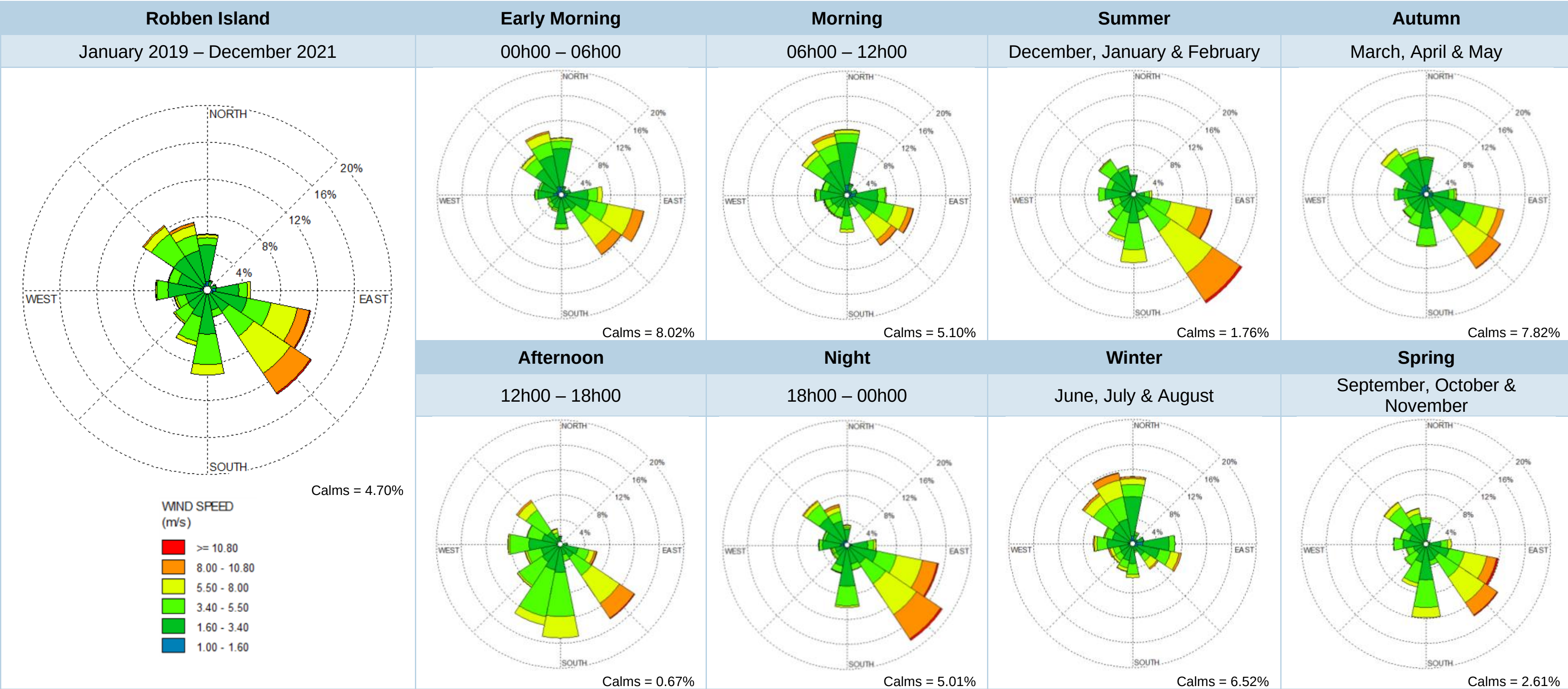

Figure 4-3: Local wind conditions at Robben Island

5 EMISSIONS CHARACTERISATION

5.1 ODOUR AND WASTEWATER TREATMENT

Volatile organic compounds (VOCs), H_2S and NH_3 are emitted from wastewater treatment, collection, and storage systems, through the evaporation of compound molecules at the liquid surface (Department of Agriculture, Water and Environment, 2011). Sources of atmospheric emissions from WWTW include aeration during primary treatment, aerobic digestion, mechanical thickening of sludge, anaerobic digestion, sludge drying and flaring (as applicable). Odour problems associated with WWTW can be complex with odour originating from several components in the plant area which are commonly located outside.

According to Márquez, *et al* (2022), biological treatment is an environmentally friendly method of transforming organic material into harmless by-products (e.g. carbon dioxide or mineral salts such as sulphates) and is also considered the most influential component of the wastewater treatment process in the elimination of soluble pollutants. The biodegradation of organic matter results in the generation of sewage sludge, liquid effluent, and malodorous gases. Volatile sulphur compounds (such as H_2S) are primarily responsible for the unpleasant odours associated with wastewater treatment and can account for up to 90% of the malodorous gas emissions (Márquez, et al., 2022). The odour impact caused by WWTW on surrounding areas is closely related to the organic load of the wastewater influent as well as the quantity of sludge produced. Intrinsically, impacts can vary widely between individual facilities. Different chemical and biological processes and processing conditions, such as pH[4], temperature and retention time, also have a great effect on the odour character. Long retention times and low oxygen levels or even complete anaerobic conditions favour the generation of malodorous sulphur compounds (Belgiorno, Naddeo, & Zarra, 2013).

Márquez, *et al* (2022) noted that odour emissions tend to decrease as the wastewater moves through the treatment process and the biological stability of the material increases; however, also highlighted sludge handling activities (which occur toward the end of the treatment process) as the major source of odour, regardless of the biological treatment process utilised.

5.2 EMISSIONS INVENTORY

An emissions inventory is a list of air pollution sources, including their physical and chemical parameters. An emission factor is a representative value that attempts to relate the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant. These factors are usually expressed as the weight of pollutant divided by a unit weight, volume, distance or duration of the activity emitting the pollutant.

Emission factors are used to estimate emissions when actual emission data is not available. In most cases, these factors are averages of available data of acceptable quality and are generally assumed to be representative of long-term averages for all facilities in the source category. The general equation used for the estimation of emissions is:

$$E = A \times EF \times \left(1 - \frac{ER}{100}\right)$$

Where:
E = emission rate
A = activity rate
EF = emission factor
ER = overall emission reduction efficiency (%)

South Africa's *Modelling Regulations* recommend the use of published emission factors for national consistency. (e.g. United States Environmental Protection Agency (USEPA) Compilation of Air Pollutant Emission Factors (AP-42) emission factors). The US EPA has developed a wastewater treatment model known as WATER9, for estimating air emissions from typical WWTW systems. WATER9 is however, limited in this case as it does not

[4] Acidity or basicity of the wastewater.

provide for RBC based biological treatment nor does it simulate odour independently of its constituent gases (odour nuisance is commonly caused by a mixture of malodorous gases). The focus of this study is to assess odour impact based on odour concentrations within the ambient environment rather than compound specific concentrations for comparison with recognised odour detection or annoyance thresholds. As such, documented odour-based emission factors were applied in this assessment as the main assessment methodology which aligns with international best practice. H_2S and NH_3 as standalone constituent gases, were assessed for comparison and additional context.

QUANTIFIED EMISSION SOURCES

Activity data (i.e. WWTW component specifications, layout thereof, throughputs, etc.) required to calculate emissions was provided by RIM. Any errors, limitations, or assumptions inherent in this data therefore also extend to this study.

Many of the components of the proposed Robben Island WWTW will be enclosed or covered to aid with odour containment. No documented odour control efficiency statistics for covering or enclosing wastewater treatment operations were found in the available literature. This study therefore assumes that the vapour space of enclosed or covered components will reach a state of equilibrium (i.e. where molecules in the liquid evaporate into the vapour space above the liquid surface, the vapour space becomes saturated due to containment, and those molecules condense and return to the liquid at the same rate) and in principle, enclosed or covered components will not be a source of odour. It is understood that component covers will only be removed for maintenance purposes, which is not considered to be normal operations. Nonetheless, emission rates for covered/enclosed components are still provided in the sections that follow; however, it is highlighted that covered/enclosed components were not used as input to the dispersion modelling simulation of normal operations.

WWTW components (some of which have multiple subsections) quantified for this assessment are shown in **Figure 5-1** and listed as follows:

- Inlet structure (2)
- Primary settling (3), comprising of both anaerobic (a) and anoxic reactors (b)
- Biological treatment (4) – RBC
- Secondary settling (5) – clarifier
- Disinfection (6) – chlorine contact channels
- Sludge management (7) – drying beds

Figure 5-1: Emission sources

ODOUR

The odour emission factors used for this assessment were developed by Márquez, *et al* (2022) and are based on odour measurements using dynamic olfactometry. Where the Márquez, *et al* (2022) study does not account for facility components incorporated into the Robben Island WWTW design, emission factors developed by Capelli, *et al* (2009) were substituted to ensure all potential emission sources are accounted for. The Márquez, *et al* (2022) emission factors apply to each component's uncovered surface area, whereas the Capelli, *et al* (2009) emission factors are based on total influent throughput (200 m^3/day in this case). Odour emission factors are presented in **Table 5-1**.

CONSTITUENT GASES

A comparative assessment of NH_3 and H_2S is offered for additional context. The generic emission factor (2.2 g/m^3) provided by the Australian National Pollution Inventory (NPI) (Department of Agriculture, Water and Environment, 2011) for facility wide NH_3 emissions was used, with emission rates apportioned between the individual WWTW components based on the surface area of each source.

In the absence of an established emission factor for H_2S for wastewater treatment, emission rates were back calculated using quantified odour emission rates and an H_2S odour detection threshold (ODT) of 0.2 $\mu g/m^3$ (i.e. the lower range value documented by WHO (2000). This approach conservatively assumes that 1 OU_E is equivalent to an H_2S concentration of 0.2 $\mu g/m^3$ and that the odorous emission mixture comprises 100% H_2S.

Component dimensions and operational specifications are provided in **Table 5-2** and the quantified emission rates are presented in **Table 5-3**.

Table 5-1: Odour emission factors considered for this assessment

Component Number	Robben Island Design Component Description	Emission Factor Reference	Reference Component Description	Emission Rate Unit	Emission Factor
2	Inlet structure	Capelli, *et al* (2009)	Wastewater arrival	OU_E/m^3	10 900
3a	Septic tank - anaerobic reactor chamber	Márquez, *et al* (2022)	Biological treatment (aerobic reactor)	$OU_E/m^2/s$	0.16
		Capelli, *et al* (2009)	Primary sedimentation	OU_E/m^3	190 000
3b	Septic tank - anoxic reactor chamber	Márquez, *et al* (2022)	Biological treatment (anoxic reactor)	$OU_E/m^2/s$	0.19
		Capelli, *et al* (2009)	Nitrification	OU_E/m^3	7 350
4	Rotating Biological Contactor - aerobic reactor	Márquez, *et al* (2022)	Rotating Biological Contactor	$OU_E/m^2/s$	0.09
5	Secondary clarifier - humus tank	Márquez, *et al* (2022)	Secondary settling (ASP)	$OU_E/m^2/s$	0.27
		Capelli, *et al* (2009)	Secondary sedimentation	OU_E/m^3	13 100
6	Chlorine contact channel	Capelli, *et al* (2009)	Chemical-physical treatments	OU_E/m^3	8 250
7	Sludge drying beds	Márquez, *et al* (2022)	Sludge dewatering	$OU_E/m^2/s$	452.66
		Capelli, *et al* (2009)	Sludge storage	OU_E/m^3	8 260

Notes:
Red – selected as the most appropriate emission factor for the relevant component

Table 5-2: WWTW component specifications

Component Number	Robben Island Design Component Description	Covered or enclosed?	Number of component subsections	Subsection dimensions				Component surface area (m^2)	Proportion of emission surface area
				Length (m)	Width (m)	Radius (m)	Area (m^2)		
2	Inlet structure	Yes	1	6.30	0.60	-	3.78	3.78	2.3%
3a	Septic tank - anaerobic reactor chamber	Yes	2	5.50	3.00	-	16.50	33.00	20.0%
3b	Septic tank - anoxic reactor chamber	Yes	2	3.00	3.00	-	9.00	18.00	10.9%
4	Rotating Biological Contactor - aerobic reactor	Yes	6	3.50	2.13	-	7.44	44.63	27.0%
5	Secondary clarifier - humus tank	No	1	-	-	1.75	9.62	9.62	5.8%
6	Chlorine contact channel	No	3	2.50	0.80	-	2.00	6.00	3.6%
7	Sludge drying beds	No	2	5.00	5.00	-	25.00	50.00	30.3%

Table 5-3: Quantified emission rates

Component Number	Robben Island Design Component Description	Component emission rate		
		Odour (OU_E/s)	NH_3 (g/s)	H_2S (g/s)
2	Inlet structure	25.23	0.42	5.05
3a	Septic tank - anaerobic reactor chamber	5.28	3.67	0.53
3b	Septic tank - anoxic reactor chamber	3.42	2.00	0.34
4	Rotating Biological Contactor - aerobic reactor	4.02	4.96	0.13
5	Secondary clarifier - humus tank	2.60	1.07	0.52
6	Chlorine contact channel	19.10	0.67	1.27
7	Sludge drying beds	19.12	5.55	1.91

6 MODELLING PROCEDURES

Atmospheric dispersion models mathematically simulate the transport and fate of pollutants emitted from a source to the atmosphere. The model algorithms incorporate source criteria, surface topography, land use and meteorology to predict the downwind concentrations of these pollutants. Atmospheric dispersion models provide a useful tool to predict the spatial and temporal patterns of ground level pollutant concentrations arising from various point, line, area and volume sources. These outputs are primarily used in environmental and health impact assessments, exposure risk assessments and to determine monitoring requirements.

6.1 ASSESSMENT LEVEL

As per the *Modelling Regulations* the level of assessment is dependent on technical factors such as geophysical and meteorological context and the complexity of the emissions inventory. The temporal and spatial resolution and accuracy required from a model must also be considered.

A Level 2 assessment was used for this assessment. Level 2 assessments are appliable in generic assessments where:

— The distribution of pollutant concentrations and deposition are required in time and space.

— Pollutant dispersion can be reasonably treated by a straight-line, steady-state, Gaussian plume model with first order chemical transformation.

— Emissions are from sources where the greatest impacts are in the order of a few kilometres (less than 50 km) downwind.

A Level 3 assessment is applicable in the assessment of long-range (greater than 50 km) impacts from large scale, multi-source industrial developments in environmentally sensitive situations and where it is important to account for complex meteorology. A Level 3 assessment is generally preferred for assessments situated in close proximity to a coastline; however, is not considered appropriate in this case. Since the proposed Robben Island WWTW is small, and emissions are released at ground-level, shoreline fumigation effects are not a concern and impacts from low level sources can be expected to peak nearfield (less than 1 km).

6.2 MODELLING INTERFACE

AERMOD is an air dispersion model designed for short-range dispersion of airborne pollutants in steady state plumes that uses hourly sequential meteorological files from pre-processors to generate flow and stability regimes for each hour. The model outputs can be used to produce maps of plume spread with key isopleths for visual interpretation and statistical outputs allowing for comparison with national and international ambient air quality guidelines and standards. AERMOD is a prescribed Level 2 model in the *Modelling Regulations*.

The AERMOD atmospheric dispersion modelling system is an integrated system that includes three modules:

— A steady-state dispersion model designed for short-range (up to 50 km) dispersion of air pollutant emissions from stationary sources.

— A meteorological data pre-processor (AERMET) that accepts surface meteorological data, upper air soundings, and optionally, data from onsite instrument towers. It calculates the atmospheric parameters needed by the dispersion model, such as atmospheric turbulence characteristics, mixing heights, friction velocity, Obukhov length (often referred to a Monin-Obukhov length) and surface heat flux.

— A terrain pre-processor (AERMAP) which generates location and height data for each receptor location. It provides information that allows the dispersion model to simulate the effects of air flowing over hills or splitting to flow around hills.

6.3 MODEL INPUTS

A description of model input variables is provided below. A summary of key input variables is given in **Table 6-1**.

TERRAIN AND LAND USE

Terrain influences dispersion of pollutants, especially during periods of stable conditions. The NASA Shuttle Radar Topographic Mission (SRTM) digital elevation model (DEM) data was extracted for the modelling domain to account for terrain influences on dispersion. Local topography is considered flat. The model's overall land use classification was set to '*Rural*' and accounted for proximate water bodies.

METEOROLOGY

Meteorological conditions affect how pollutants emitted into the air are directed, diluted, and dispersed within the atmosphere, and therefore incorporation of reliable data to an air quality assessment is of the utmost importance. To represent meteorological conditions at the site, Weather Research and Forecasting (WRF) data was purchased from Lakes Environmental as recommended in the *Modelling Regulations*. For the purposes of this study, an AERMET-ready dataset for the years January 2019 – December 2021 and centred at 33.804642°S, 18.376894°E (i.e. the approximate centre of the proposed development site) was used.

DOMAIN AND GRID RESOLUTION

According to the *Modelling Regulations*, the selected size and extent of the model domain is influenced by factors such as source buoyancy, terrain features (i.e. mountains) and the location of contributing sources. Larger domains are recommended for elevated, buoyant sources (e.g. stacks) while smaller domains are considered sufficient for small-scale facilities comprising of sources with lower release heights. The modelling domain for this study is 5 km by 5 km centred over the proposed development site. The *Modelling Regulations* specify the use of a multi-tier grid and recommend specific tier resolutions. In line with these requirements, the grid resolution is 50 m up to 1 km from the centre of the site and 100 m thereafter. A receptor distance of 25 m was used along the development site boundary.

DISCRETE RECEPTORS

Discrete receptors selected for the assessment included the sensitive receptors listed in **Table 2-2**. These were selected based on proximity to the study site. They are places where sensitive individuals may be impacted, such as residences or places where the public might gather (i.e. tourist attractions, or churches). Their proximity to the proposed WWTW is shown in **Figure 2-2**.

Table 6-1: Summary of key model input variables

Parameter		Model input
Model		
Dispersion model interface		AERMOD View v 10.2.1
Dispersion model executable		AERMOD US EPA 21112 released on 11 May 11 2021
Supporting models		AERMET and AERMAP
Emission scenarios		
Pollutants modelled		Odour, NH_3 and H_2S
Operational scenarios		Normal operations
Chemical transformations		N/A
Exponential decay		N/A
Terrain settings		
Terrain type		Flat
Terrain data		STRM1
Terrain data resolution (m)		30
Land classification		Rural
Receptor grid		
Domain extent		5 km x 5 km
Domain centre	Latitude (°S)	33.804642
	Longitude (°E)	18.376894
Receptor flagpole height		0.0 m
Receptor grid type		Multi-tier
Grid resolution	Tier I	50 m (within 1 000 m of site)
	Tier II	100 m (within 2 500 m of site)
Plant boundary resolution		25 m
Sensitive receptors		5 (as per **Table 2-2**)

6.4 MODEL OUTPUTS

Dispersion modelling simulations of odour, NH_3 and H_2S were undertaken for normal operating conditions only. Simulated ground-level concentrations are compared with relevant international guidelines (in the absence of local standards) to assess impact.

For the purposes of this investigation, the following statistical outputs were be generated:

- 98th percentile (P98) concentrations are calculated for the comparison of short-term term (i.e. 1-hour) odour concentrations with the UK odour impact criteria guideline. P98 hourly outputs are specified by the selected guideline for assessing impact.
- 100th percentile (P100) concentrations are calculated for the comparison of short-term (i.e. 1-hour) NH_3 and H_2S concentrations with the relevant international odour annoyance threshold guidelines. These guidelines do not specify a percentile threshold and therefore the P100 value was used as a worst-case scenario.

7 IMPACT ASSESSMENT

7.1 MODEL RESULTS

Model simulated concentrations at sensitive receptors are presented in **Table 7-1**. Isopleth maps showing the dispersion of odour, NH_3 and H_2S are presented in **Figure 7-1** to **Figure 7-3**. Predicted concentrations are evaluated against applicable international guidelines (refer to **Section 3.3**). Key findings are as follows:

ODOUR

— P98 1-hour odour concentrations at sensitive receptors fall below the 1-hour UK odour criteria limit of 1.5OU_E/m^3. In line with the UK IAQM guidance (**Table 3-3**), the impact significance for sensitive receptors is determined to be 'negligible'.

— Peak odour concentrations are predicted to occur along the southwestern fenceline of the proposed WWTW development site.

— Offsite exceedances of the UK odour criteria limit (1.5 OU_E/m^3) are predicted up to 20 m to the southwest, northwest and northeast of the proposed WWTW boundary.

NH_3

— P100 1-hour NH_3 concentrations at sensitive receptors fall below the TCEQ NH_3 1-hour odour-based guideline of 3 600 $\mu g/m^3$.

— Peak NH_3 concentrations are predicted to occur along the northeastern fenceline of the proposed WWTW development site however these are not predicted to exceed the TCEQ NH_3 1-hour odour-based guideline and are thus not expected to result in odour nuisance.

H_2S

— P100 1-hour H_2S concentrations at sensitive receptors fall below the WHO H_2S 30-minute odour nuisance guideline of 7 $\mu g/m^3$ (applied in the absence of a 1-hr average criterion).

— Peak H_2S concentrations are predicted to occur along the northwestern and northeastern fencelines of the proposed WWTW development site.

— Offsite exceedances of the WHO odour nuisance guideline (7 $\mu g/m^3$) are predicted up to 15 m southwest, northwest and northeast of the proposed WWTW boundary.

— It must be noted that the WHO H_2S odour nuisance guideline is applicable to a 30-minute averaging period and the comparison of the worst-case 1-hour model output to this shorter-term threshold is considered environmentally conservative.

Based on the above findings, odour is anticipated along the unpaved roads that run adjacent to the proposed WWTW development site. These roads are used by maintenance staff only and are not roads used by the Island's residents or tourists.

Table 7-1: Simulated concentrations for sensitive receptors

Pollutant		Odour	NH_3	H_2S
Averaging period		1-hour	1-hour	1-hour
Standard / Guideline		1.5	3 600	7[(a)]
Reference		United Kingdom	TCEQ ESL	WHO
Percentile		P98	P100	P100
Unit		OU_E/m^3	$\mu g/m^3$	$\mu g/m^3$
Domain peak		3.48	25.45	9.65
Boundary peak		3.48	25.45	9.65
Sensitive receptor	SR1	0.004	0.074	0.042
	SR2	0.154	1.116	0.631
	SR3	0.007	0.694	0.413
	SR4	0.002	0.122	0.070
	SR5	0.001	0.065	0.038

Note:
(a) – Applicable to a 30-minute averaging period
Red – exceeds the applicable guideline limit value

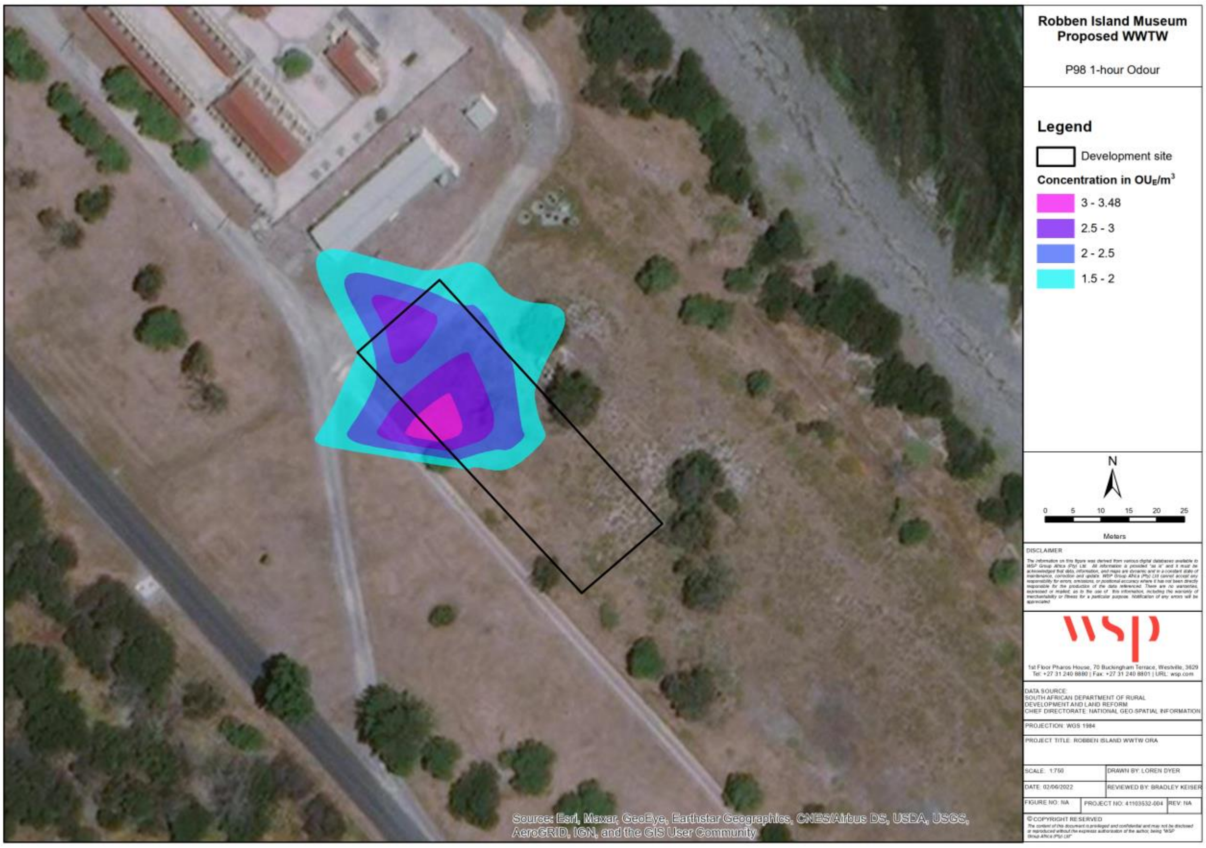

Figure 7-1: P98 1-hour odour

Figure 7-2: P100 1-hour NH_3

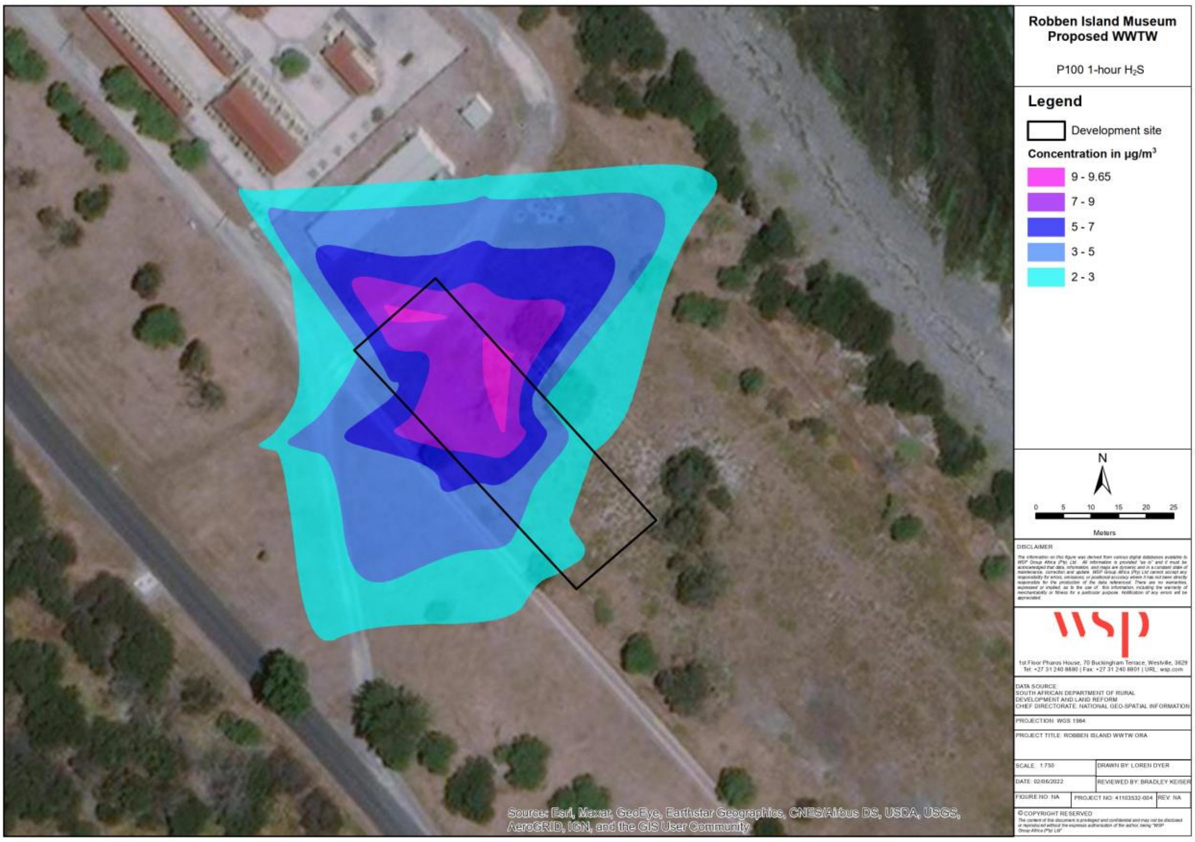

Figure 7-3: P100 1-hour H_2S

7.2 IMPACT RATINGS

From a technical, conceptual, or philosophical perspective the focus of an impact assessment ultimately narrows down to a judgment on how significant the predicted impacts are. The concept of significance is at the core of impact identification, prediction, evaluation, and decision-making (Department of Environmental Affairs and Tourism, 2002).

The determination of the significance of an impact relates to the degree of change in the environmental resource measured against some standard or threshold. Potential impacts are assessed using the calculations and rating system, as outlined below, and based on the findings of this assessment. This incorporates two aspects for assessing the environmental significance (i.e. severity and occurrence), which are further sub-divided as indicated below.

All impacts are firstly assessed in terms of direction. The direction of an impact may be **positive, neutral or negative** with respect to the particular impact (e.g. improved air quality would be classed as positive, whereas a degradation of air quality would be considered negative).

SEVERITY

— **Magnitude:**

Magnitude is the degree of change of the affected environment and is classified as: **very low** - no change from current conditions; **low** - 1 to 10% change from current conditions; **medium** - 10 to 20% change from current conditions; **high** - 20 to 30% change from current conditions; and **very high** - >30% change from current conditions. The categorization of the impact magnitude may be based on a set of criteria (e.g. health risk levels, ecological concepts and/or professional judgment) pertinent to each of the discipline areas and key questions analysed. Recognised standards are generally used as a measure of the level of impact (**Table 7-2**).

Table 7-2: Criteria for the rating of impact magnitude

Magnitude Descriptor	Definition	Rating
Very low	< 1% change from current conditions / No associated consequences	1
Low	1 – 10% change from current conditions / Nuisance impact	2
Medium	10 – 20% change from current conditions / Reduction in environmental quality/loss of habitat/loss of heritage/loss of welfare amenity	3
High	20 – 30% change from current conditions / Significant impact to faunal or floral populations/loss of livelihoods/individual economic loss.	4
Very high	> 30% change from current conditions / Significant impact to human health linked to mortality/loss of a species/endemic habitat.	5

— **Geographic extent:**

Scale/Geographic extent refers to the area that could be affected by the impact and is classified as **site**: impact is limited to the boundary of the development site; **local**: effect restricted to inside the activity area; **regional**: effect extends outside the activity area; **national**: national scope or level; and international: the effect is across borders and boundaries (**Table 7-3**).

Table 7-3: Criteria for the rating of the impact extent

Extent Description	Definition	Rating
Site	Impact footprint remains within the boundary of the site.	1
Local	Impact footprint extends beyond the boundary of the site to the adjacent surrounding areas.	2
Regional	Impact footprint includes the greater surrounds and may include an entire municipal or provincial jurisdiction.	3
National	The scale of the impact is applicable to the Republic of South Africa.	4
International	The impact has transboundary implications.	5

OCCURRENCE

— **Reversibility:**

Reversibility is the ability of the environmental receptor to rehabilitate or restore after the activity has caused environmental change. The impact is described as **reversible**: recovery without rehabilitation; **recoverable**: recovery with rehabilitation; or **irreversible**: recovery is not possible despite action (**Table 7-4**).

Table 7-4: Criteria for the rating of reversibility

Extent Description	Definition	Rating
Reversible	Rehabilitation is not needed to reverse impacts.	1
Recoverable	Rehabilitation will reverse impacts.	3
Irreversible	Rehabilitation cannot reverse impacts.	5

— **Duration:**

Duration refers to the permanence of the impact or the length of time over which an environmental impact may occur: i.e. **immediate** (on impact), **short-term** (0 to 5 years e.g. construction period), **medium term** (5 to 15 years e.g. operational period), **long-term** (project life) or **permanent** (indefinite) (**Table 7-5**).

Table 7-5: Criteria for the rating of impact duration

Duration Description	Definition	Rating
Immediate	On impact	1
Short term	0 – 5 years.	2
Medium term	5 – 15 years.	3
Long term	The impact persists for the duration of the project life.	4
Permanent	The impact will continue indefinitely.	5

— **Probability:**

Probability is the likelihood of an impact occurring in the absence of pertinent environmental management measures or mitigation. Probability is described as **improbable** (less than 5% chance), **low probability** (5% to 40% chance), **probable** (40% to 60% chance), **highly probable** (most likely, 60% to 90% chance) or **definite** (> 90% chance) (**Table 7-6**).

Table 7-6: Criteria for the rating of impact probability

Probability Description	Definition	Rating
Improbable	< 5% chance of occurring	1
Low probability	10% - 40% chance of occurring	2
Probable	40% - 60% chance of occurring	3
Highly Probable	60% - 90% chance of occurring	4
Definite	> 90% chance of occurring	5

ENVIRONMENTAL SIGNIFICANCE

Environmental significance assigns values to rate impacts to provide a more quantitative description of impacts for the purposes of decision making. Significance is an expression of the risk of damage to the environment, should the proposed activity be authorised. The overall residual significance for each effect will be classified as one of: **very low**, **low**, **moderate, high or very high** (**Table 7-7**) by evaluation of the rankings for extent, duration, reversibility, magnitude and probability:

Impact Significance = (extent + duration + reversibility + magnitude) x probability

The maximum value is 100 rating points. The potential environmental impacts are then rated as very high (81 - 100), high (61 – 80), moderate (31 – 60), low (16 – 30) or very low (4 - 15) (**Table 7-7**).

Table 7-7: Categories describing environmental significance

Score	4 – 15	16 – 30	31 – 60	61 – 80	81 – 100
Category	Very low	Low	Moderate	High	Very high

The impact significance associated with RIM's proposed WWTW (as designed) is presented in **Table 7-8**. Overall impact significance for the immediate vicinity of the WWTW is conservatively assessed to be very low. It is highlighted that the UK IAQM guidance assess impact significance for sensitive receptors in this case to be 'negligible' (refer to **Table 3-3**).

Table 7-8: Impact assessment

Impact description	Scenario	Severity		Occurrence			Significance	
		Magnitude	Extent	Reversibility	Duration	Probability	Rating points	Risk Level
Nuisance in the vicinity of the WWTW due to odorous emissions	Normal operations (as designed)	2	2	1	4	1	9	Very low

7.3 RECOMMENDATIONS FOR IMPACT MITIGATION

Although odour impacts from RIM's proposed WWTW are assessed to be very low (or negligible for sensitive receptors), WSP proposes the following mitigation measures for RIM's consideration:

- Develop a vegetative environmental buffer (VEB) along the western boundary of the proposed development site. A VEB will ameliorate odours by slowing wind and allowing dilution of odour, encouraging particulate and aerosol deposition, physical interception of dust and aerosols onto which odorous compounds can adhere, and offering a sink for the chemical constituents of odour. WSP recommends the use of indigenous leafy trees that maintain their leaves throughout the year. Multiple rows of trees (with taller and shorter but bushier species alternating) will increase effectiveness of the barrier. Additional value of the VEB is protection from bioaerosols, noise mitigation and improved visual aesthetics.
- Masking agents offer an additional odour neutralisation option should complaints arise despite the above recommendation. The efficacy of commercial additives varies widely, and local options can be investigated.
- Complaints and any actions arising from a complaint must be recorded in a complaints register maintained by site management. If required, fenceline measurements of H_2S will provide a real-time indicator of odour impact.
- Warning communities to expect potential odour events during upset conditions (e.g. during desludging or when extended maintenance is scheduled) will generate increased trust and facilitate communication between parties. When possible, maintenance/desludging of the WWTW should be scheduled for times when fewer tourists are expected in the area or strategically planned so as not to coincide with proximate community events, if any.
- Maintenance/desludging should be scheduled (where possible) for periods with dry and cool conditions, particularly when prolonged repair work or sludge drying is anticipated. Drier conditions will accelerate sludge drying, shortening the duration in which peak impacts may occur. Odorous emissions are generally higher in warmer months due to increased gas volatility.

8 STUDY ASSUMPTIONS AND LIMITATIONS

Various assumptions were made in the compilation of this ORA. When possible, an environmentally conservative approach was taken to ensure emission rate calculations and model predictions represent a worst-case scenario. The assumptions and limitations underlying the study methodology are not expected to have a substantive effect on the outcomes and adequacy of the study; and are as follows:

GENERAL

- Unless otherwise stated, design and operational information was provided by RIM. Any errors, limitations, or assumptions inherent in these datasets extend to this study.
- The capacity of the proposed WWTW is 200 kl/day.

EMISSIONS INVENTORY

- WWTW component dimensions were extracted from technical drawings and the Google Earth files provided by RIM. Where component dimensions conflicted, the Google Earth imagery was assumed to be accurate as it depicts the component size within the available development space in which it is expected to fit.
- Facility wide NH_3 emission rates were apportioned between the individual WWTW components based on the proportional surface area of each component.
- H_2S emission rates were back calculated using quantified odour emission rates and an H_2S ODT of 0.2 µg/m^3. This assumes that 1 OU_E is equivalent to an H_2S concentration of 0.2 µg/m^3 and that the odorous emission mixture comprises 100% H_2S.

DISPERSION MODELLING

- Dispersion modelling simulated the dispersion of odour and constituent gases (specifically NH_3 and H_2S) under a normal operating scenario (as designed) only. This ORA does not account for upset conditions (including maintenance periods) or alternative design scenarios.
- The vapour space within covered or enclosed components of the proposed WWTW are assumed to reach a state of equilibrium and thus were not assessed as potential odour sources. Odorous gases will be released when component covers are removed for access or maintenance reasons. Although this will be transient, maintenance should be scheduled.

9 CONCLUSION

RIM, the public entity responsible for the management and maintenance of the Robben Island national estate and World Heritage Site, are proposing to establish a competent sewage management system for the treatment of domestic effluent. Environmental authorisation was secured for RIM's proposed WWTW in 2015; however, the authorised operations failed to commence within the EA validity period and a new EA application is required in terms of NEMA. Odour nuisance was identified as a potential impact of the proposed WWTW and an ORA is required as part of the EA application.

This study assessed the potential impacts associated with normal operations using a Level 2 (AERMOD) dispersion modelling assessment. An emissions inventory was developed for odour and odorous constituent gases (namely, NH_3 and H_2S) using emission factors developed by peer reviewed studies and reputable international environmental bodies (e.g. Australian NPI) for input into the dispersion model. Quantified sources include the various WWTW components; however, components that will be covered or enclosed for odour containment purposes were excluded from the model simulation. Simulated dispersion outputs were compared to international guidelines (as applicable) to assess the degree of impact. Key findings are as follows:

- Simulated concentrations at sensitive receptors fall below the relevant international nuisance guidelines.
- Peak concentrations occur along the southwestern, northwestern and southeastern fencelines of the proposed WWTW development site.
- Offsite exceedances of odour nuisance guidelines are predicted beyond the boundary of the proposed WWTW development site; however, these are limited to within 20 m of the operational fenceline. This impact area extends to the gravel roads that run adjacent to the proposed development site. These roads are only used by maintenance staff and are not roads used by the Island's residents or tourists.
- Based on odour impact rating criteria provided by the United Kingdom (UK) Institute of Air Quality Management (IAQM) guidance, the predicted impact significance for sensitive receptors is determined to be 'negligible'.
- Based on impact rating criteria guidance provided by South Africa's national department for environmental management (Department of Environmental Affairs and Tourism, 2002), the predicted impact significance for the immediate vicinity of the proposed WWTW is determined to be 'very low'.

Although impacts were determined to be negligible or very low based on the risk rating criteria, WSP proposes the following mitigation measures for RIM's consideration:

- Establishing a vegetative environmental buffer (VEB) along the western side of the proposed WWTW will create a natural barrier and chemical sink for odorous constituent gases.
- Complaints and any actions arising from a complaint should be recorded in a complaints register maintained by site management. Should a complaint necessitate follow-up investigation, fenceline measurements of H_2S will provide a real-time indicator of odour impact.
- Warning communities to expect potential odour events during upset conditions (e.g. during desludging or when extended maintenance is scheduled) will generate increased trust and facilitate communication between parties.
- Maintenance/desludging of the WWTW should be scheduled for times when fewer tourists are expected in the area, or strategically planned so as not to coincide with proximate community events, if any.
- Maintenance/desludging should be scheduled (where possible) for periods with dry and cool conditions, particularly when prolonged repair work or sludge drying is anticipated. Drier conditions will accelerate sludge drying, shortening the duration in which peak impacts may occur. Odorous emissions are generally higher in warmer months due to increased gas volatility.

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