# DRAFT ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT

## VOLUME 2: EIE MINE SITE

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**NOVEMBER 2013**

# *CES Report Revision and Tracking Schedule*

| | |
|---|---|
| ***Document Title*** | *Draft Environmental and Social Impact Assessment Ranobe Mine Project, Southwest Region, Madagascar* |
| ***Client Name & Address*** | *World Titanium Resources*<br>*15 Lovegrove Close,*<br>*Mount Claremont*<br>*Western Australia, 6010* |
| ***Document Reference*** | |
| ***Status*** | *Draft* |
| ***Issue Date*** | *November 2013* |
| ***Lead Authors*** | *Dr Chantel Bezuidenhout* |
| ***Reviewer*** | |
| ***Study Leader or Registered Environmental Assessment Practitioner Approval*** | |

| ***Report Distribution*** | ***Circulated to*** | ***No. of hard copies*** | ***No. electronic copies*** |
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# 1. LEGAL FRAMEWORK, INTERNATION CONVENTIONS, STANDARDS AND CODE OF GOOD PRACTICE

## *1.1* The Legislated EIA Process in Madagascar

The requirements of Malagasy environmental legislation have been translated from the French and Malagasy text of the Compatibility of Investments with the Environment (MECIE) Decree, the purpose of which is to lay down the rules and procedures to be followed to ensure the compatibility of investments with the environment. The EIA process is depicted in Figure 5.1 below.

Article 3 requires that, pursuant to the provisions of Article 10 of Law No 90-033 of December 21, 1990 on the Charter of the Environment, any public or private investment project, whether submitted or not for the authorization or approval of an administrative authority, or likely to cause impacts on the environment, must be the subject of an impact study. These impact studies take the form of either an Environmental Impact Assessment (EIA), or an Environmental Commitment Program (ECP), according to the provisions of Articles 4 or 5.

As per Article 4, the Ranobe Mine Project is an investment that needs to be governed by laws of authorization, approval or agreement, and so triggers an environmental impact assessment (EIA). This results in the need to obtain an environmental permit which is issued after the satisfactory review of the EIA and the submission of a Project Environmental Management Plan (PEMP), which constitutes the environmental specifications of the project concerned. These regulations govern the types of investments listed in Appendix 1 to Decree No 99-954 of December 15, 1999, into which the Ranobe Mine Project falls, as it includes projects involving any installations, works and activities which have potential detrimental effects on the environment due to their technical nature, their scope and the sensitivity of the site. In particular, the following activities, which may be carried out during this project, trigger the environmental process:

- Excavation and earth moving of over 20 000 cubic metres.
- Pumping of water (surface water or groundwater) exceeding 30 cubic metres per hour.
- All mechanized mining activity.
- Any physical or chemical processing of mine substances on the site of exploitation.

Article 7 defines the scope of the EIA process, which consists of the pre-examination of the foreseeable potential impacts of a given activity on the environment; requires the use of all scientific knowledge to anticipate these impacts, and to reduce them to an acceptable level in order to ensure the integrity of the environment, within the limits of best technologies available and at an economically viable cost. The level of acceptability is appreciated in particular on the basis of national environmental policies, legal standards, rejection trigger values, social, cultural and economic costs, and losses of heritage.

Under Article 11 of Chapter II, applicable rules and procedures for the MECIE, Section I, methods of assessment of impacts: the EIA, pursuant to Articles 3 and 7, is carried out at the cost and under the responsibility of the proponent, and its contents depend on the importance of works and installations to be undertaken and on their potential impacts on the environment.

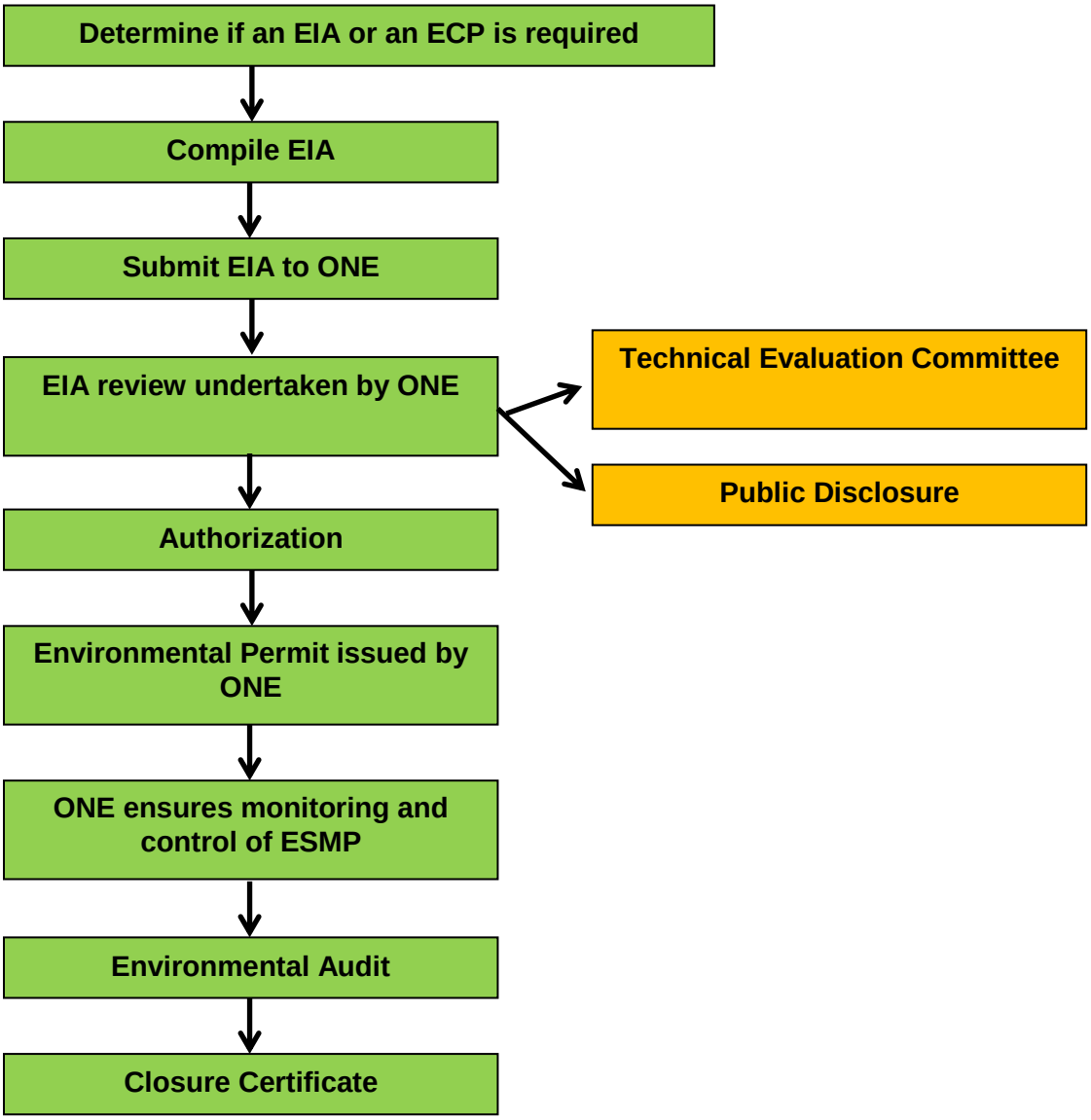


**Figure 1.1: The legislated EIA process in Madagascar**

According to the Compatibility of Investments with the Environment (MECIE) the contents of the EIA (in terms of Chapter II, Section I, Article 11 of the MECIE) must at least include:

1. A document certifying the legal status of the proposed project site;
2. A description of the investment project;
3. An analysis of the environmental system affected or potentially affected by the project. This analysis must lead to a schematic model emphasizing the main aspects (static or dynamic, local or regional) of the environmental system, in particular those on which the proposed investment is likely to have an impact;
4. A prospective analysis of the potential impacts of the proposed investment on the system described previously;
5. A Project Environmental Management Plan (PEMP);
6. A non-technical summary, written in Malagasy and in French, in order to facilitate public awareness of the information contained in the study, to be attached to the study. The summary must indicate, in substance and in layman's language, the baseline conditions of the site and its environment, the modifications made by the project and the proposed mitigation measures for the negative consequences of the investment for the environment.

Within fifteen working days from the receipt of the EIA report, the report of public review and the technical opinion of the Technical Evaluation Committee (CTE) is released by the authorities, according to Article 27 of Section III (Environmental Review), Number C – "Granting of the Environmental Permit", the Minister responsible for the environment must pronounce in favour of, or against, the granting of the environmental permit. This permit shall accompany each request for authorization of a listed activity.

## *1.2* The Equator Principles

The Equator Principles (Box 5.1) are a financial industry benchmark for determining, assessing and managing social and environmental risks to projects. There is close alignment between the Equator Principles and the IFC Performance Standards and Environmental, Health and Safety (EHS) Guidelines, and many financial institutions have committed themselves to the Equator Principles. The Principles represent a voluntary set of environmental and social guidelines for project finance lending. These principles are outlined below and are adhered to in this report.

**Box 5.1: The Equator Principles**

**THE EQUATOR PRINCIPLES** (adapted from www.equator-principles.com)

**PRINCIPLE 1 – REVIEW AND CATEGORISATION:**
The EPFI, as part of its internal social and environmental review and due diligence, must categorise a project based on the magnitude of its potential impacts and risks in accordance with the environmental and social screening criteria of the International Finance Corporation.

**PRINCIPLE 2 – SOCIAL AND ENVIRONMENTAL ASSESSMENT**:
The borrower has conducted a Social and Environmental Assessment process to address the relevant social and environmental impacts and risks of the proposed project. The Assessment should also propose mitigation and management measures relevant and appropriate to the nature and scale of the proposed project.

**PRINCIPLE 3 – APPLICABLE SOCIAL AND ENVIRONMENTAL STANDARDS:**
The Assessment will refer to the applicable IFC Performance Standards, and establish the project's overall compliance with, or justified deviation from, the respective Performance Standards and Environmental Health and Safety (EHS) Guidelines. The EPFI will require that the Assessment process evaluates compliance with the applicable standards as follows:
For Projects located in Non-Designated Countries, the Assessment process evaluates compliance with the then applicable IFC Performance Standards on Environmental and Social Sustainability (Performance Standards) and the IFC / World Bank Group Environmental, Health and Safety Guidelines (EHS Guidelines) (Exhibit III [2]).
For Projects located in Designated Countries, the Assessment process evaluates compliance with relevant host country laws, regulations and permits that pertain to environmental and social issues. Host country laws meet the requirements of environmental and/or social assessments (Principle 2), management systems and plans (Principle 4), Stakeholder Engagement (Principle 5) and, grievance mechanisms (Principle 6).

**PRINCIPLE 4 – ENVIRONMENTAL AND SOCIAL MANAGEMENT SYSTEM AND EQUATOR PRINCIPLES ACTION PLAN:**
The developer must prepare and maintain an Environmental and Social Management System, an Environmental and Social Management Plan and an Equator Principles Action Plan to address issues raised in the Assessment process and incorporate actions required to comply with the applicable standards.

**PRINCIPLE 5 – STAKEHOLDER ENGAGEMENT:**
The developer must demonstrate effective Stakeholder Engagement as an on-going process in a structured and culturally appropriate manner with Affected Communities and, where relevant, other stakeholders.
**PRINCIPLE 6 – GRIEVANCE MECHANISM:**
The borrower should, scaled to the risks and adverse impacts of the project, establish a grievance mechanism as part of the management system. This will allow the borrower to receive and facilitate resolution of concerns and grievances about the project's social and environmental performance raised by

individuals or groups from among project-affected communities.

**PRINCIPLE 7 – INDEPENDENT REVIEW:**
An independent social or environmental expert, not directly associated with the borrower, will review the Assessment, action plans and consultation process documentation.

**PRINCIPLE 8 – COVENANTS:**
An important strength of the Principles is the incorporation of covenants linked to compliance with all relevant host country laws, accepted action plans and relevant standards.

**PRINCIPLE 9 – INDEPENDENT MONITORING AND REPORTING:**
Ensure on-going monitoring and reporting over the life of the loan. The proponent will require the appointment of an independent environmental and/or social expert, or retain qualified and experienced external experts to verify its monitoring information, which would be shared with the funding agency.

**PRINCIPLE 10 – REPORTING AND TRANSPARENCY:**
Each funding agency adopting the Equator Principles commits to report publicly at least annually about its Equator Principles implementation processes and experience, taking into account appropriate confidentiality considerations.

## 1.3 International Finance Corporation Performance Standards

The IFC have developed eight performance standards that can be used to identify and manage risk in proposed developments. Box 5.2 below outlines these standards.

**Box 5.2: The IFC Performance Standards**

| | |
|---|---|
| Performance Standard 1: | Social and Environmental Assessment and Management Systems |
| Performance Standard 2: | Labour and Working Conditions |
| Performance Standard 3: | Pollution Prevention and Abatement |
| Performance Standard 4: | Community Health, Safety and Security |
| Performance Standard 5: | Land Acquisition and Involuntary Resettlement |
| Performance Standard 6: | Biodiversity Conservation and Sustainable Natural Resource Management |
| Performance Standard 7: | Indigenous Peoples |
| Performance Standard 8: | Cultural Heritage |

This ESIA have been structured to meet the requirements outlined in the IFC's Guidance Notes on performance standards on social and environmental sustainability (IFC, 2007), as well as the latest amendments to the Performance Standards which came into effect on the 1st of January 2012. The main objectives of the Performance Standards as listed in Box 5.2 above are briefly discussed below:

### *1.3.1 Performance Standard 1 (PS1): Social and Environmental Assessment and Management Systems*

The primary objectives of PS1 are to:

- Identify and assess social and environmental impacts, both adverse and beneficial, in the project's area of influence.
- To avoid, or where avoidance is not possible, minimise, mitigate or compensate for adverse impacts on workers, affected communities, and the environment.
- To ensure that affected communities are appropriately engaged on issues that could potentially affect them.
- To promote improved social and environmental performance of companies through the effective use of management systems.

The main requirement of this standard is an environmental and social management programme for the duration of the project. From a social perspective the management plans must, at a minimum, address health and safety, security, human resources, community engagement, and labour, and must address social management issues.

All environmental, social and health impacts must be determined and ranked in terms of the risks they pose to the project. All impacts must be avoided and, if this is not possible, they must be minimised. Once the ESIA has been completed a management programme must be compiled which outlines what mitigation measures are to be used, how they are to be implemented and how they will be monitored and evaluated. The management programme must outline the roles and responsibilities associated with implementation and the monitoring requirements. The management programme should identify communication strategies to ensure community engagement throughout the project lifecycle.

Monitoring plans must be periodically reviewed by internal and external parties to ensure compliance and for evaluation purposes.

Because this project will, in addition to adhering to the requirements of Malagasy environmental legislation, be guided by the IFC performance standards, the PEMP required by Malagasy law will be replaced with a more comprehensive Social and Environmental Management Programme (SEMP) in line with the IFC requirements. This will ensure that the requirements of both national and international standards and laws are adhered to.

### *1.3.2 Performance Standard 2 (PS2): Labour and Working Conditions*

The primary objectives of PS2 are to:

- Establish, maintain, and improve the worker-management relationship.
- Promote the fair treatment, non-discrimination and equal opportunity of workers, and compliance with national labour and employment laws.
- Protect the workforce by addressing child labour and forced labour.
- Promote safe and healthy working conditions.
- Protect and promote the health of workers.

Most of these issues will be dealt with in the management plans required in PS1. However, PS2 outlines in detail what working conditions are acceptable and how worker relationships should be managed, and also deals with occupational health and safety for the project (addressed in various management plans).

### *1.3.3 Performance Standard 3 (PS3): Pollution Prevention and Abatement*

The primary objectives of PS3 are to:

- Avoid or minimise adverse impacts on human health and the environment by avoiding or minimising pollution from project activities.
- Promote the reduction of emissions that contribute to climate change.

The primary requirement of PS3 is that technologies and practices which avoid or minimise detrimental impacts of pollution are applied throughout the lifecycle of the project. In addition to the EHS General Health and Safety Guidelines, the IFC has sector-specific guidelines which deal with pollution and human health issues associated with mining (IFC Environmental Health and Safety Guidelines for Mining, (30 April 2007)). These guidelines will be used for this project and will be included in the management plans.

### *1.3.4 Performance Standard 4 (PS4): Community Health, Safety and Security*

The primary objectives of PS4 are to:

- Avoid or minimise risks to and impacts on the health and safety of the local community during the project lifecycle from both routine and non-routine circumstances.
- Ensure that the safeguarding of personnel and property is carried out in a legitimate manner that avoids or minimises risks to the community's safety and security.

The major requirement in terms of PS4 is that all risks and impacts to the surrounding community are assessed and managed appropriately. This includes issues such as infrastructure and equipment safety, hazardous material storage and handling, hazards associated with the natural environment (such as floods and landslides), community exposure to disease, and emergency preparedness and response.

### *1.3.5 Performance Standard 5 (PS5): Land Acquisition and Involuntary Resettlement*

The primary objectives of PS5 are to:

- Avoid or at least minimise involuntary resettlement wherever feasible by exploring alternative project designs and layouts.
- Mitigate adverse social and economic impacts from land requisition or restrictions on affected persons' use of land by (i) providing compensation for loss of assets at replacement cost; and (ii) ensuring that resettlement activities are implemented with appropriate disclosure of information, consultation and the informed participation of those affected.
- Improve or at least restore the livelihoods and standards of living of displaced persons.
- Improve living conditions among displaced persons through provision of adequate housing with security of tenure at resettlement sites.

Physical resettlement is limited within the proposed project area, but the mining activities will result in extensive economic displacement (i.e. agricultural land, grazing land, tombs, use of natural resources etc.). Compliance with this performance standard will require ensuring that people are fairly compensated for loss of access to this area. A Resettlement Action Plan will be completed prior to any resettlement and/or compensation taking place. This is will done upon completion of the ESIA.

### *1.3.6 Performance Standard 6 (PS6): Biodiversity Conservation and Sustainable Natural Resource Management*

The primary objectives of PS 6 are to:

- Protect and conserve biodiversity.
- Promote the sustainable management and use of natural resources through the adoption of practices that integrate conservation needs and development priorities.

In order to conform to PS6 the study has to consider ecosystem goods and services afforded by the natural environment in the study area. This assessment has to include an investigation into provisioning services, regulating services and cultural services. A biodiversity monitoring plan will be produced at a later stage to demonstrate how the project will monitor the plant and animal biodiversity in the study area to ensure it is properly managed and conserved within designated ecological corridors. This plan will outline the monitoring and evaluation required to manage the designated ecological corridors. Biological offsets will be considered as a primary means to mitigate negative impacts on the biological environment.

### *1.3.7 Performance Standard 7 (PS7): Indigenous Peoples*

Indigenous peoples are recognised by the IFC as social groups with identities that are distinct from dominant groups in national societies and are amongst the most marginalised and vulnerable segments of the population. The population in the Project's area of influence does not fall into this category, and therefore PS7 does not apply to the Project.

### *1.3.8 Performance Standard 8 (PS8): Cultural Heritage*

The primary objectives of PS8 are to:

- Protect cultural heritage from adverse impacts of project activities and support its preservation.
- Promote the equitable sharing of benefits from the use of cultural heritage in business activities.

PS8 defines cultural heritage broadly to include tangible forms of cultural heritage (property and sites having archaeological (prehistoric), paleontological, historical, cultural, artistic, and religious values, as well as unique natural environmental features that embody cultural values, such as sacred groves), and intangible forms (cultural knowledge, innovations and practices of communities embodying traditional lifestyles).

The value of cultural heritage will be respected throughout the project's life. Care will be taken to ensure that all the cultural practices in which the communities participate are not impacted negatively as a result of the project.

## *1.4* IFC Sector Specific Guidelines

The IFC EHS Guidelines for Mining (30 April 2007) are applicable to this project. The guidelines detail industry-specific impacts and ways in which to manage them. They cover environmental, occupational health and safety, community health and safety, and performance indicators and monitoring.

## 1.5 Other Applicable Madagascar Laws

### *1.5.1 Introduction*

This legal summary presents the relevant Malagasy environmental legislation that the Ranobe Mine Project must adhere to as provided by the Ranobe Mine Project team. Large sections of the laws do not apply to the project and are thus not discussed (for example laws governing hydroelectric projects). In addition large sections of the law are not relevant to the impact assessment (although they may apply to other aspects of the project) and have therefore also not been included.

### *1.5.2 Ordinance number 62-165 dated 11 October 1962 regarding permitting for the construction of buildings and allotments.*

This ordinance deals with ensuring that urban areas develop in a harmonious and organised manner. The law deals with building authorisations and permissions for allotments. It is applicable to urban areas with more than 2 000 inhabitants. All construction activities require a permit, including public works programmes. Certain small projects may be exempted from this requirement by the Ministry for Public Works.
The ordinance describes the right to inspection of various government departments, fines for inhibiting inspections, and the interruption to works as a result of non-compliance with the building permit. Building contractors, architects and other professionals in charge of the construction work will be held liable for non-compliance with the permit conditions. The competent authority may order that non-compliant buildings are taken down or amended to ensure compliance with the permit. Fines may be imposed for every day that the building remains

non-compliant and should corrective actions not be taken within stipulated timeframes, the Department of Public Works can undertake the work on behalf of the proponent at their risk and cost. All housing estates must comply with the ordinance. Decrees will state the conditions to which certain authorisations are granted, notably the financial responsibility of the proponent for certain public works required as a result of the existence of the building.

### *1.5.3 Law number 98-029 date 20th January 1999 – the Water Law*

The water law recognises the scarcity and importance of water as a national resource that must be conserved, improved, and managed sustainably, carefully and rationally. Water is recognised as part of the national communal heritage of Madagascar. The lack of water in the south and west of Madagascar is acknowledged, and the role of the State in policing and managing water resources throughout the country is stated.

Surface water is defined in article 6 as all pluvial water, all above ground flowing water, all water contained in canals, rivers, navigation channels, canalised rivers, certain irrigation channels, saline lakes linked to the sea, lakes, bogs, and wetlands. Surface water is considered to form part of public land.

Groundwater is defined in article 8 as all water contained in aquifers and below ground wells. Any springs are also considered as part of the groundwater.

Surface and groundwater abstraction are covered in articles 10 and 11. No changes to a water course may be undertaken without prior permission from the National Authority for Water and Sanitation (Autorite Nationale de L'Eau et de L'assainissement - ANDEA). Groundwater abstraction is limited to personal use up to a specific volume and as long as that use poses no pollution threats to the resource. Groundwater abstraction is managed by ANDEA.

Pollution is discussed in articles 12 and 13. Pollution of surface and groundwater must be avoided at all times. In cases where pollution takes place the polluter pays principle will be applied. Pollution is defined as all runoff, effluent, direct or indirect introduction of all types and more generally any action which could provoke or result in the degradation of water by modifying its physical, chemical, biological, bacteriological or radioactive characteristics in the ground or surface water.

Waste is discussed in articles 14-18. Article 15 states that any person who produces or stores wastes that could have a negative impact on soils, flora and fauna, air or water, human health or the environment is required to ensure its proper treatment and elimination.

Article 16 states that any industrial waste that is released into circulation must be treated and this treatment must guarantee that it does not pose a threat to the environment. All costs associated with the transport, treatment and elimination of the waste are to be covered by the industry producing the waste.

All industries that produce, import or treat wastes are required to provide the authorities with information concerning the origin, nature, characteristics, quantities, destinations and state of wastes produced, treated or passed on to a third party.

Article 18 states that decrees outline the conditions under which wastes can and cannot be discharged into water, or more generally to alter the quality of surface or groundwater.

Sanitation regulations are presented between article 19 and 22. Article 20 states that all companies must ensure the treatment of all waste water, and this treatment must ensure that the receiving water quality is maintained or improved. Article 21 states that all discharges into public sewers must have prior approval from the authorities. The characteristics of the effluent will need to be determined by an accredited laboratory. Article 22 states that all water containing industrial effluents must be kept separate from storm water runoff. However if it can be demonstrated

through the analyses obtained from accredited laboratories that mixing storm water and industrial effluents ensures sufficient treatment so that no harm is caused to the receiving environment, mixing may be permitted.

Articles 23 to 27 discuss the conservation and protection of natural water resources and the environment. Article 24 states that it is forbidden to dispose of insalubrious material into water that could affect the quality or quantity of that receiving water. Article 25 states that forest or herbaceous cover must be maintained where these exist to minimise impacts of erosion and siltation on existing infrastructure. Specific measures must be implemented to ensure that erosion and siltation are minimised when clearing takes place to protect water quality, hydraulic regimes and to prevent major flooding.

Articles 32 and 33 deal with industrial water uses. This states that all possible measures must be taken to minimise the water requirements of the industrial activity and to preserve the environment.

### *1.5.4 Decree number 64-291 dated July 1964 which states the regulations regarding the delineation, use of, conservation and policing of public property*

This decree describes the delineation, classification and alignment of public property. Possible uses of public property include temporary uses (for example during construction), which are permissible but prior approval must be obtained from the ministry in charge of public property. All requests for such a use must include a description of the activity to be undertaken and the length of time the activity will require. If the land is located near a military land, the Ministry of Defence must be consulted regarding using the land.

The decree further describes the processes to be followed for declassifying public property and how public property is policed.

### *1.5.5 Decree number 310 dated 2nd February 1964 regarding alignment methods*

This decree states that any person wishing to construct a building or fence along a public access road is required to request a survey of the public access road prior to requesting permission for construction. The decree contains two examples of how to apply for the survey and outlines the process that must be followed by all parties.

### *1.5.6 The urbanisation and housing law, dated 1963, 1265 pages*

The law details the roles of the Minister of Public Works, how services are organised and what consultative organisations are included in consultations regarding urbanisation and housing. It outlines the processes and different categories which different building types fall into. In the case of the Ranobe Mine Project, all the major construction associated with the project (in other words, the primary and secondary concentrators, mineral separation plant, haul road and marine loading facilities) will all require special permission for construction. The law contains many details regarding the safety and sanitary requirements for various types of buildings which will need to be conformed with. The permits for these activities will need to be obtained by the building contractors after the EIA phase is complete. The annex to the law describes what needs to be included in the application for a construction permit.

Decree no. 180 dated January 1964 states that any staff related housing plans must be approved by the Ministry for Public Works prior to obtaining a construction permit.

### *1.5.7 Law number 99-021 dated 19th August 1999 regarding the management and control of industrial pollution*

This law outlines that it is the State's aim to ensure the protection of the environment and the conservation of biological ecosystems and natural resources from all causes of degradation or

alteration by pollutants.

Polluting substances may, as a result of their nature and concentration, result in an imbalance in the receiving environment (for example water, air and soil) and create dangers or inconveniences, impacts of all kinds on either the surrounding area, or on health, security, sanitation and public health, agriculture, places of national heritage including monuments and sites.

Industrial pollution is deemed to have taken place when the quantitative and qualitative changes to the environment as a result of the presence of a polluting substance resulting from an industrial activity are detected. Industrial pollution includes all wastes, emanations and nuisances of all kinds that are generated either directly or indirectly by industrial activities.

All industrial activities must safeguard the environment through cleaner technologies and technologies that result in a reduction, treatment and elimination process of any wastes produced.

Liquid wastes must be managed in accordance with the licence provided by the competent authority which will ensure that effluent discharge is limited as far as possible and that it is properly treated prior to release. Solid wastes are divided into non-hazardous wastes and hazardous (special) wastes. Non-hazardous wastes should be minimised, recovered, recycled, incinerated, buried or composted. Hazardous wastes must be dealt with in accordance with the licence provided by the competent authority.

The proponent is obliged to take the environmental impact that the industrial operation may have into account in the economic planning stage. The proponent is required to:

- Participate in local environmental protection;
- Hold a valid waste licence for the operation;
- Be aware and incorporate technical advances into the operation to reduce wastes produced by the industrial activity;
- Continually adjust to and conform with changes in the national environmental legislation and good management practices; and
- Allow the competent authority access to relevant information that demonstrates the operation is using good management practice to minimise wastes.

All proponents are required to monitor their waste management. An inter-ministerial decree will detail the nature of the requirements of each industrial operation.

Environmental guidelines will be developed to be applied to the receiving environment in due course but while these are being developed, the norms and standards recommended by international organisations that are affiliated with the United Nations are to be used as a standard reference.

### *1.5.8 Inter-ministerial decree number 12 032/2000 regarding the regulation of the mining section with respect to the protection of the environment*

The Minister of Environment decides whether or not to award an environmental licence based on the findings of the technical evaluation committee (Comite technique d'evaluation CTE), and issues the Quitus Environnemental[1]. The National Office for the Environment (Office National pour L'Environnement ONE) ensures cohesion between sectors regarding the technical contents of analyses, standards, and the efficacy of attenuation and rehabilitation methods in the elaboration and assessment of EIAs and environmental management plans (Plan de Gestion

[1] The Quitus Environnemental is the administrative acceptance and recognition that the permit holder has completed all rehabilitation to the required standard and restores the environmental responsibility for the permit area to the state.

Environnemental du Projet PGEP). The ONE, together with the branch in charge of environment in the Ministry of Mines (known as the 'cellule', cell), compile an individual list of management, mitigation and rehabilitation measures for each mining project depending on the type of mining project. In addition, the ONE forms part of the CTE, which provides technical comments on whether to award the Quitus Environmental.

The Decree de MECIE[2] and other subsequent directives contain details of the methodologies to be followed during an EIA. The ultimate objective of the rehabilitation plan which is submitted as part of the EIA, is to ensure that the mine footprint is left in a healthy, stable condition and that the environment has been restored to a level that allows the land to be used for other activities that is compatible with all other forms of life and activities in the region. The mitigation measures and rehabilitation plan must aim to:

- Ensure the safety of the mine locations during and after mining operations have been completed.
- Reduce negative effects of the mining operation on the atmosphere and water sources and courses to an acceptable level.
- Integrate the mine and associated infrastructure into the area by using development approaches that are appropriate to the flora and fauna of the area.
- Reduce erosion, water leaks, chemical leaks and other mining accidents, and negative impacts on faunal habitats.
- Reduce negative impacts of the operation (shocks, noise, dust etc.) on the local human populations and animal populations that live nearby to the operation.
- Avoid the introduction of parasites and alien vegetation.
- Support rapid re-colonisation of cleared areas using indigenous species or species that are compatible with the rehabilitation area.

A budget for the rehabilitation must be submitted as part of the EIA, and sufficient funds to cover the rehabilitation must be kept in a Malagasy bank account as a guarantee of the rehabilitation.

The PGEP of the project must outline the monitoring and surveillance mechanisms to be used to monitor the effectiveness of the rehabilitation and mitigation measures.

The terms of reference for the environmental audit at the end of the project will be assessed as part of the evaluation of the EIA. These will be annexed to the environmental permit for the project and will enable the Quitus Environnemental to be obtained at the end of the project, once the audit has been completed to the satisfaction of the authorities.

The Ranobe Mine Project must adhere to the specific conventions outlined in the law because of the size of investment into the project. The convention shall specify:

- The terms of reference for the EIA;
- The manner in which the proponent will contribute to the cost of the evaluation of the EIA;
- The methods and timeframes for the evaluation of the EIA in parallel with its completion; and
- The practical details regarding the type and timing of the public participation in the EIA.

The means by which a request for a specific convention can be applied for are detailed between article 46 and 49.

Article 50 states that seven hard copies of the EIA must be lodged with the Cadastral section of the Ministry of Mines. The cadastral section will determine whether the EIA is acceptable (complete) within 2 working days and notify the proponent. If accepted, the cadastral section will distribute the copies of the EIA within the Ministry of Mines and the ONE. The submission must be accompanied by:

[2] Decree no. 99- 945 dated 15 December 1999 regarding the compatibility of Investments and the Environment.

- Proof of payment of the required contribution to the evaluation of the EIA by the proponent; and
- Proof of the size and sum of the investment.

The PGEP including all plans for rehabilitation, as well as the financial guarantee for the rehabilitation must be implemented within 60 days of approval of the EIA and PGEP. Oversight and monitoring of the implementation of the PGEP is undertaken by the ministry for environment, the environmental branch in the Ministry for Mines and the ONE.

### *1.5.9 Decree number 200-107 stating the conditions of application of law number 99-022 dated 19 October 1999 regarding the Mining Law.*

Article 5 of the mining law states that the permit holder must, where qualifications between two candidates are the same, prioritise employing Malagasy people over other nationalities. It also states that the proponent must put in place theoretical and practical training courses for the Malagasy employees at their cost. The proponent must favour the advancement of Malagasy workers in the company at all levels, in relation to the individual's capacity.

The mining environment is administered by the following organisations:

- The branch in charge of the environment within the Ministry of Mines (the cell);
- The Ministry of Environment and all organisations attached to it, including the competent environmental authorities delegated to deal with protected environments; and
- The Autonomous Provinces and the Communes.

The environment branch within the Ministry of Mines has the coordinating role between proponent and above listed bodies.

The Environmental Impact Assessment (Etude d'Impact Environnementale (EIE)) must be submitted to the Ministry of Mines. The timeframes for obtaining a decision on an EIA are detailed in the environmental legislation dealing with mining. The environmental authorisations and protection measures required are listed under heading X, first chapter of the Mining law. In addition to producing the EIE (and this being approved), the proponent must ensure that all environmental legislation is respected, specifically:

- While undertaking mining activities the proponent is obliged to define, evaluate and implement appropriate measures aimed at minimising and repairing all foreseeable damages that the mining activity is likely to have on the environment;
- The proponent is only permitted to undertake those activities that were approved in the PEE and EIE. Permission and authorisation to undertake any activities not included in these documents must be obtained prior to commencing any such activities;
- Rehabilitation work can either be undertaken as the project progresses or at the end of the mining activities; and
- The proponent is obliged to have a rehabilitation plan in place.

Methods for environmental protection and rehabilitation are described in the inter-ministerial decrees.

The proponent is required to ensure adequate closure of the mine, even if mining is terminated prior to the expiry date of the lease for whatever reason.

The protection of workers is discussed in chapter IV of the mine law. The proponent must ensure the safety of workers as outlined in their permits and any other applicable labour law. This includes proper organisation of the workforce, emergency drills, regular inspections, maintenance, registers and training courses for workers, compilation of work related accidents which must be submitted to the authorities. Workers are required to abide by the safety regulations imposed by the mine, use all protective gear and follow security instructions,

immediately inform management in cases of unusual circumstances or broken equipment. The health and hygiene of the workers will be maintained through a set of methods to be determined by the Ministry of Labour and the Ministry of Mines for each mine. In addition to these, the proponent must ensure that the sanitation requirements of the workforce are met and that sufficient medical care systems are in place, put in place hygiene and health regulations that are periodically reviewed, install appropriate medical centres, ensure that the equipment and medicines are available, perform medical examinations on workers and provide them with the reports, and generate individual health files on workers. Workers are required to adhere to hygiene and health systems in place, voluntarily allow themselves to be examined, and immediately alert the mine in case of illness or unusual symptoms.

Heading XI discusses the relationship between mining right holders and landowners. This section discusses the obligations of the rights holder regarding obtaining permission from land owners, singing contracts for the use of the land, agreeing on compensation with the land owners. In addition the law recognises the rights of two other types of land users: traditional occupants - defined as people belonging to a local community who through customary rights recognised by the administration in charge of estates, occupies sections of land on a permanent and peaceful basis without having a title deed to that land – and usufructuaries – defined as people who only harvest fruit, wood, and practice other similar activities in land located within the permit boundary without holding a title deed or forming part of the traditional occupants. The rights holder is required to enter into a lease agreement with land owners and land users of the land that falls within the permit area. The rights holder must obtain permission from the land owners and land users to use or remove wood or water from the area within the permit area. The permit holder can engage in similar accords with land owners and land users that fall outside the permit area for activities that are required by the project, such as the erection of power lines or haul roads, for example. The land owner has the right to negotiate in good faith a lease with the rights holder for his land. He can be compensated for assets on the land that he will lose as a result of his exclusion from the land. The land owner is required to make himself known as soon as he hears of the official procedure being undertaken to rent his land. Failure to do so within four months of the official procedure commencing results in him losing the right to lease his land and compensation for any assets on the land. Traditional occupants and people in possession of usufructuary status have the same rights as land owners, but must organise themselves into representative groups and elect a community representative. Failure to make themselves known once they hear of the official process within four months of the start of the process results in a loss of these rights.

Heading XII chapter 2 states that special permits are required to transport mined product on national roads.

### *1.5.10 Law number 98-026 dated January 1999 regarding the revision of the roads charter*

This law states that all investments in roads requiring rehabilitation construction work or requiring the use of nearby materials are required to undergo an EIA in accordance with the Mecie Decree.

### *1.5.11 Law number 90-033 regarding the Malagasy environmental charter*

Article 10 of this law states that any public or private project likely to affect the environment must be assessed by an EIA. The EIA must consider the scale of the development the technical aspects of the project and the sensitivity of the environment in which the project will take place.

The charter recognises the inseparable relationship between conservation of the environment and sustainable economic development of the local population. In order to ensure that the needs of these two objectives are harmoniously met, an environmental action plan has been developed and will be put into action through several sectorial strategies including:

- Developing tools to educate, sensitise and train people in environmental management and protection;
- Water basin management with a particular focus on avoiding erosion;

- Land tenure and land rights, with emphasis on ownership and responsibility for land;
- Biodiversity protection and management;
- Development of ecological tourism;
- Improvement of living standards in rural and urban areas;
- Putting in place tools for environmental management, protection and ongoing monitoring; and
- Developing institutional framework for the environment.

In order to ensure that this takes place, strategies have been developed per region, including the southern region. The main restorative actions required for the southern region are listed as:

- Restoration of security;
- Preservation of vegetation and enhancement of useful species;
- Re-vegetation of areas affected by erosion through native species with the ultimate aim of increasing water infiltration into soils and groundwater resources;
- Increasing the occurrence of wind breaking hedges such as those used in valamahafaty to create a hedged farmland landscape;
- Introduction or selection of drought resistant species (sorghum, millet, niebe); and
- Intensification of animal husbandry using locally adapted species.

The law outlines the roles and responsibilities of various organs of state and bodies in rolling out the environmental charter over various time periods through three sets of programmes (I-III).

### *1.5.12 Law no. 97-107 date 8th august 1997 detailing the revision of the forestry legislation*

The first article of the law defines a forest as all areas with the following attributes:

- Areas covered in trees or woody vegetation other than those planted to produce fruit, fodder or for decoration;
- Areas covered in trees and bushes along water courses and lakes and eroded areas; and
- Lands used to produce fruit as the principle product. Forest products are defined as all natural products obtained from forests.

The second article details types of land that are considered to form part of the forest including:

- Non-forested areas such as forest clearings, or areas that have been cleared for forest management purposes such as roads and other infrastructure;
- Lands that have been cleared for forestry purposes such as clearing for soil rehabilitation and conservation, biodiversity conservation, water course management;
- Lands that have been cleared of forest within the past five years without permission;
- Marshlands and aloe habitats;
- Natural and pure habitats for fruit producing trees such as mango trees; and
- Mangroves, sacred woods and raphieres (heart of Ravinala palm).

Article 4 states that the following are not considered forests:

- Reforestation in non-forestry areas;
- Woody gardens, avenues and urban parks, nurseries not located on forestry lands;
- Tree cultivation that is aimed at short term harvesting, not located on forestry land, registered as such with the forestry administration;
- All lands used to produce agricultural produce, except if the land is covered in naturally grown trees or reforestation; and
- Grazing lands as defined by law.

The law states that all forests can become forestry areas. This is determined by a forestry commission. Thus most forests (particularly forests in national parks, forest reserves, state owned land etc.) fall under the law. Some forests may be exploited in a sustainable manner once a suitable harvesting plan has been developed for it by the forestry authority and once a permit has been issued to do so.

Article 48 recognises that certain forestry corridors may need to be under special management for specific management outcomes. These include soil and water conservation, soil rehabilitation, ecological, social, or cultural corridors, sacred forests, buffer borders to protection global heritage areas or biospheres, and protective corridors for industries such as mines. These corridors are formed by the state either through its initiative or as a result of a request.

The creation of special management corridors can result in the expropriation of land or through the creation of a convention passed by the forestry administration.

## 1.6 International Environmental Conventions

| International Environmental Conventions | Ratified |
|---|---|
| Convention on International Trade and Endangered Species of Wild Fauna and Flora (CITES) | 1975 |
| Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (Basal Convention) | 1999 |
| Convention on Biological Diversity (CBD) | 1996 |
| United Nations Framework Convention on Climate Change (UNFCCC) | 1999 |
| Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNCCD) | 2003 |
| United Nations Convention to Combat Desertification | 1997 |
| Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar Convention) | 9 Proclaimed RAMSAR sites (1998-2012) |
| Protocol for the Protection of the Ozone Layer (Montreal Protocol) | 1996 (Accession) |
| African Convention on the Conservation of Nature and Natural Resources | |
| Convention concerning Safety and Health in Mines | Member since 1960 |
| Stockholm Convention on Persistent Organic Pollutants | 2005 |
| Cartagena Protocol on Bio-safety to the Convention on Biological Diversity | 2003 |
| Vienna Convention for the Protection of the Ozone Layer | 1996 |
| Convention of the Law of the Sea | 2001 |
| International Convention for the Prevention of Pollution of the Sea by Oil,1954, as amended in 1962 and 1969 | 1965 |
| Convention on Fishing and Conservation of the Living Resources of the High Seas | 1966 |
| Convention on the High Seas | 1962 |
| Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space and under Water | 1965 |
| African Convention on the Conservation of Nature and Natural Resources | 1971 |
| Convention on the Conservation of Migratory Species of Wild Animals | 1979 |
| Convention concerning the Protection of the World Cultural and Natural Heritage | 1983 |
| Protocol concerning Protected Areas and Wild Fauna and Flora in the Eastern African Region | 1985 |
| Convention for the Protection, Management and Development of the Marine and Coastal Environment of the Eastern African Region | 1985 |
| Protocol concerning Co-operation in Combating Marine Pollution in cases of Emergency in the Eastern African Region | 1985 |
| Framework Convention on Climate Change | 1996 |
| Agreement establishing the African Development Bank | 1976 |
| Amendment to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (art.XI) | 1987 |
| Agreement for the Establishment of the Indian Ocean Tuna Commission | 1996 |

# 2. DESCRIPTION OF THE PROJECT (PRECONSTRUCTION, CONSTRUCTION, EXPLOITATION PHASE)

## *2.1* Planning and design phase of the Ranobe Mine Project

Processing test work has been carried out at pilot scale to develop the flow sheets for the Primary Concentrator Plant (PCP) and the Mineral Separation Plant (MSP). Over 5 000 tonnes of sand were tested using conventional mineral sands processing equipment, therefore there is a high degree of confidence in the scale up for the commercial plant.

The sand is characterised by low slimes and very little oversize material, therefore the concentrator plant does not have some of the complexities required at other mineral sands projects.

Test work on hundreds of tonnes of HMC produced consistently good results for the ilmenite production, as well as final rutile and zircon products. The simplified process flow sheet to be installed for Stage 1 has been tested using HMC from the pilot plant.

Two ilmenite products are recovered, with about 80% being suitable for direct use in the sulphate pigment process. This ilmenite is also suitable for smelting to make slag that can be used in both chloride and sulphate pigment processes. The slag would also be very good for making titanium metal sponge. The remaining 20% of the ilmenite is a higher $TiO_2$ product that has been tested by Australian synthetic rutile producers, and is also suitable for direct chlorination to make either pigment or titanium metal sponge.

A mixed rutile/zircon concentrate suitable for shipment to overseas processing plants will also be recovered. The recovery of the rutile/zircon concentrate is accompanied by rejection of monazite and other waste minerals for return to the mined areas.

Data from the resource models was used to facilitate the formulation of the optimum mining sequence and identification of the high grade areas to be mined first. The models were limited to the Upper Sand Unit for the northern portion of the Ranobe deposit.

The project area was divided into adjacent blocks, representing the area to be mined, for each year, commencing in the higher grade areas. The optimised plan is depicted in Figure 2.1 where each year of mining shown as outlined blocks.

It should be noted that a separate EIA was undertaken for exploration prior to drilling occurring in 2003-2005 and the construction and operation of the pilot plant in 2006-2012, and thus the planning and design phase for mining do not apply to this environmental permit application.

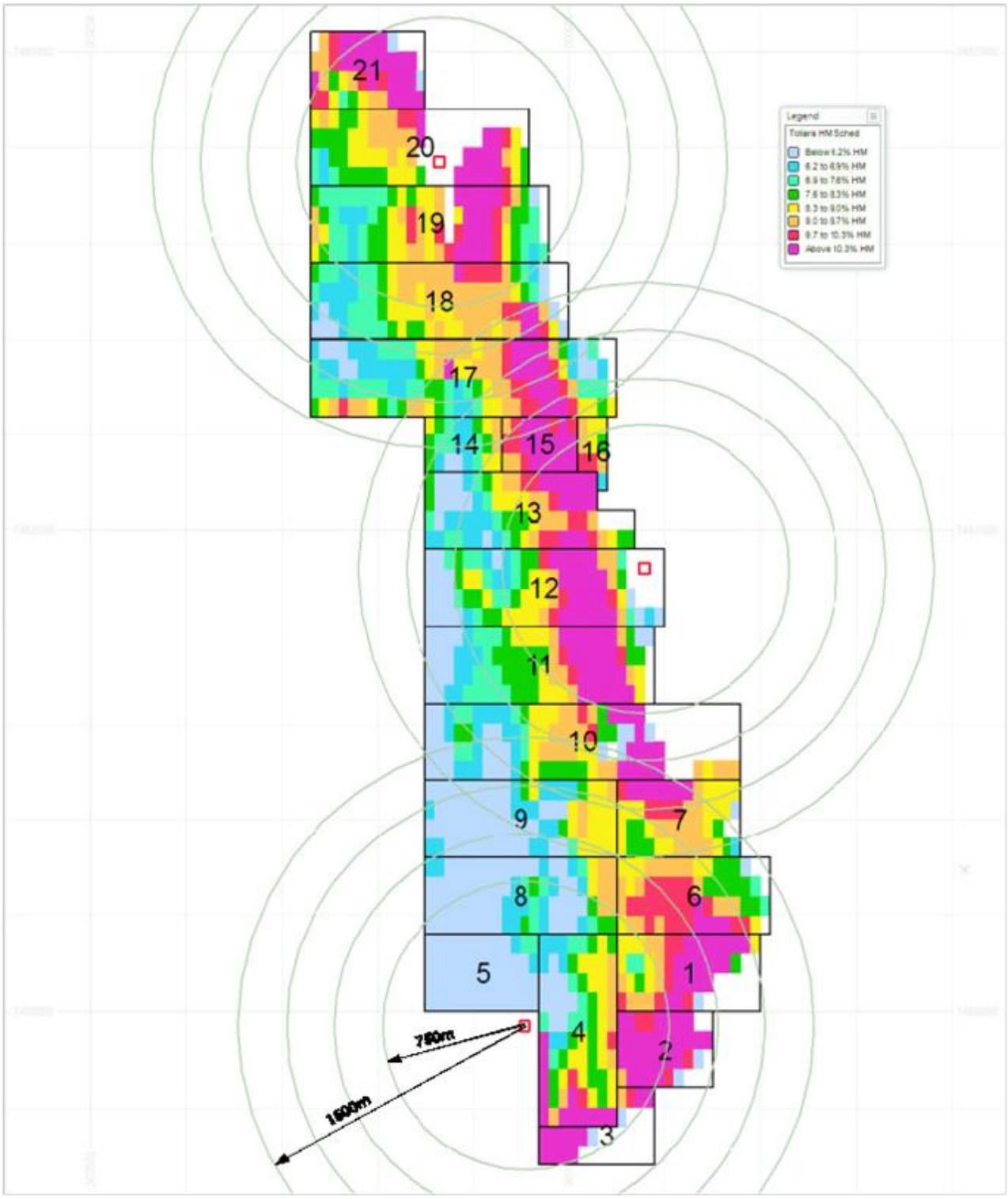


**Figure 2.1: Ranobe Project Area mine plan within the Ranobe Permit Area**
*(Source TZMI)*

## 2.2 Construction Phase

### *2.2.1 Mining area*

Because the mining operation moves from area to area there will be no permanent structures constructed in the mining areas. The largest piece of equipment, the hopper, primary concentrator and slurry pump, will be skid-mounted. Mobile offices, store workshop, canteen and toilet / washing facilities will be provided at the sites. Construction activity in the mining areas comprises clearing existing vegetation, stripping and stockpiling topsoil ahead of the mine path

for later replacement during rehabilitation, and clearing the routes of temporary unpaved access roadways. Pipelines between the mining areas and the mineral processing plant will be laid on the surface, along the routes of access roads, and will therefore require minimal excavation.

### *2.2.2 Mineral processing plant*

The mineral processing plant is a series of large steel-framed structures, the components of which are pre-fabricated off site, transported to and erected on site. Some of the structures will be clad with sheet steel sheeting, while parts will be left unclad. Construction activities comprise topsoil stripping and site levelling where necessary, excavating for foundations, and casting *in-situ* reinforced concrete foundations and floor slabs on which the structures are erected. Because of the size of the structures the foundations and slans will be substantial to ensure structural stability.

### *2.2.3 Mining camp*

Facilities at the mining camp are described in section 2.3.3.2 following, and a preliminary site layout is shown in Figure 2.4. Construction activities will involve topsoil stripping and site levelling where necessary, excavating for and concreting foundations for the structures, most if which will be permanent, single-storey domestic-type structures comprising brick walls and steel-sheet roofing. It may be necessary to provide temporary accommodation for construction workers, which will be steel units set on concrete foiundations. In-camp roads will be unpaved. The camp wastewater treatment works will be a series of prefabricated units (see Figure 2.5), which will be set on concrete foundations.

## 2.3 Operational Phase

### *2.3.1 Description of mining and processing operations*

The operations at the Ranobe Mine Project can be divided into four key steps:

1. Mining (dry mining);
2. Heavy mineral concentration at the primary concentrator plant (PCP) and
3. Heavy mineral concentrate processing at the mineral separation plant (MSP) located adjacent to the PCP; and
4. Product export.

The process flowsheet comprises a PCP where heavy minerals present in the ore are concentrated to produce a heavy mineral concentrate (HMC). The HMC is further processed at the MSP to produce the final products; Primary Ilmenite, Secondary Ilmenite as well as Non-Magnetic concentrate containing zircon and rutile.

Figure 2.2 gives a high level overview of the operational steps.

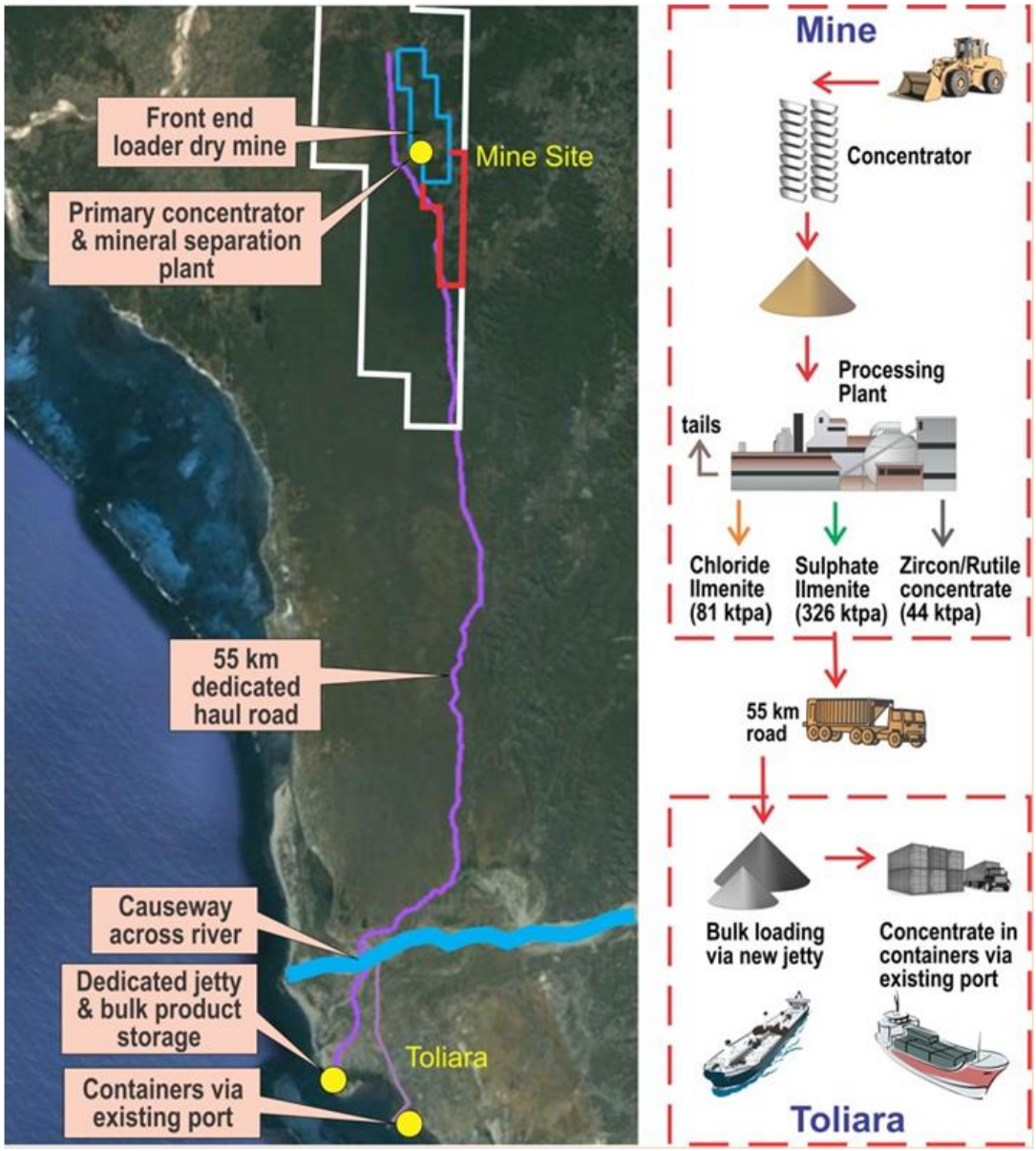


**Figure 2.2: Simplified process flow diagram of the Ranobe Mine Project operations**
*(Source: TZMI)*

The mining operation has been sized to provide a steady feed rate of mine material at an economic scale, whilst ensuring that the project financial return is satisfactory.

#### *2.3.1.1 Dry Mining*

The ore depth averages about 20 m and will be mined by three front end loaders (FELs) at an average combined mining rate of 1 000 tph. In areas where the height of the ore zone exceeds the reach of the FEL, a stepped mining approach will be taken to ensure that mining can be carried out safely with no risk of overhang of the mining face.

Dry mining significantly reduces the risk associated with the variable depth at which the limestone basement occurs, which in places directly underlies the Upper Sand Unit. The dry mining methods are significantly more flexible than the large scale dredging operation originally considered, and can effectively adjust for local variations in the level of the limestone basement.

Dry mining also provides good flexibility to selectively sequence and mine the higher grade parts of the deposit.

Ore mined by the FELs will be fed to the mining unit (MU) consisting of a dump hopper, scalping screens and a surge bin. Each mining unit will be mounted on "skids" which will allow easy movement of the mining to follow the advancing mining face.

Recirculated water will be added to the ore in the surge bin to create a slurry that will be pumped to the primary concentrator plant, located up to 1.5 km from the mining face.

The mining process will comprise the following stages (see Figure 2.3):

- Clearing existing remnant vegetation and removing and stockpiling topsoil ahead of the mine path for later replacement during rehabilitation;
- Excavating the mineralised sand using a front end loader and transferring the mined material into a hopper from which it will be slurried and pumped to the primary concentrator plant;
- Back filling the mined areas with sand tailings (> 90% of the sand mined);
- Rehabilitating the back filled areas by replacing topsoil and replanting with trees/crops.

The large majority of the sand mined will be returned to the mining void as sand tailings and deposited into the mine void behind the mining operation through a dewatering cyclone allowing most of the water to be reused (similar to the stacker arrangement used for HMC stockpiling at the concentrator).

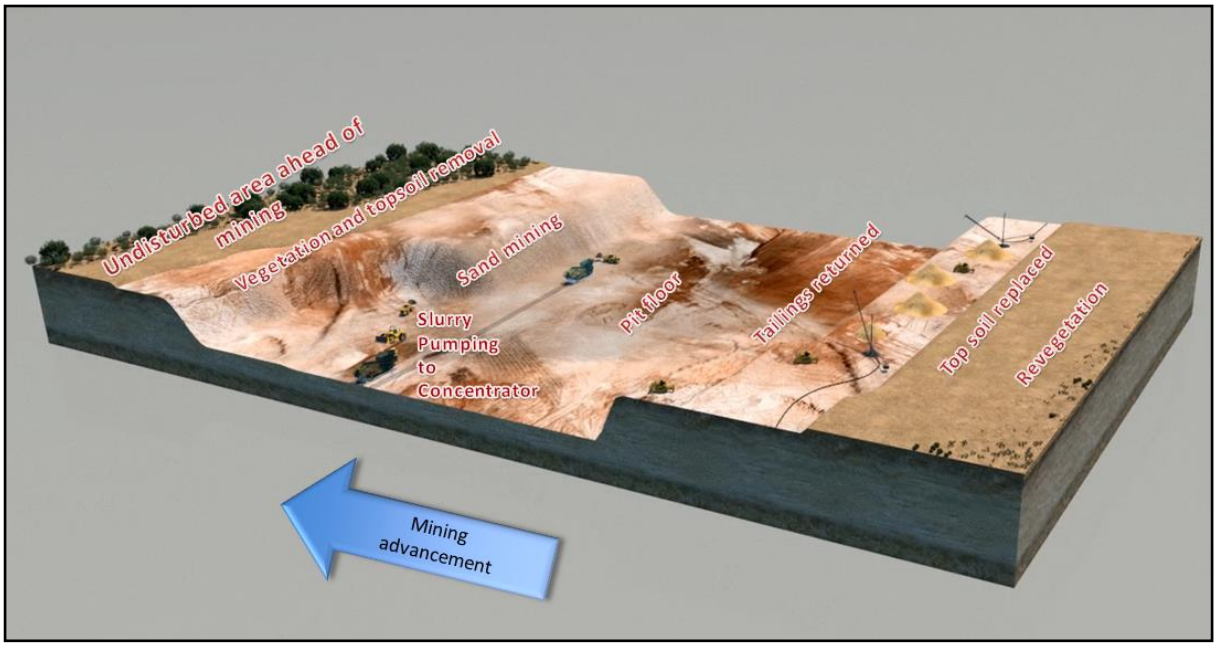


**Figure 2.3: Schematic of the mining sequence**
*(Source TZMI)*

The Stage 1 mining operation will take 21 years to complete and will cover a total area of approximately 455 hectares. However, at any one time only a small part, around 10 - 35 ha of the deposit will be exposed.

### *2.3.1.2 Heavy Mineral Concentration using the PCP*

The Primary Concentrator Plant will be located in close proximity to the mining excavation. From the mine, a pipe line conveying the ore in the form of a slurry feeds into the PCP where the contained heavy minerals (HM) are concentrated to produce a heavy mineral concentrate (HMC). The incoming ore slurry is passed through a feed screen with the undersize fed into a surge bin. From the surge bin the sand is pumped to a gravity concentration circuit comprising spirals and an up current classifier. These circuits separate most of the quartz from the ore concentrating the

heavy minerals. The HMC undergoes water attritioning to remove any contaminants that may be present on the surface of the minerals.

The flowsheet adopted makes use of conventional mineral sands separation equipment and comprises a standard configuration of spirals with an intermediate classification stage to reject fine quartz minerals. The process water is recirculated via a thickener and from hydrocyclones which remove a small amount of fine particles present in the ore. The attritioning stage has been included to assist in further downstream processing by removing surface coatings from the minerals. The PCP circuit provides for the recovery of heavy minerals present in the ore producing a heavy mineral concentrate with a grade of approximately 92% heavy minerals.

The separation processes at the PCP generate both a concentrate (HMC product) as well as coarse and fine sand tailings. The sand tailings are pumped to the mine area and are deposited back into the mine void. The fine clay tailings (also known as slimes) are separated from the sand tailings, mixed with flocculant and allowed to settle under the influence of gravity in a thickener to form a slurry which is pumped back to the mine void. The clear water which overflows the top of the thickener is recycled. The fine particles are concentrated and removed to prevent a build up of solids content in the process water and disposal after thickening reduces water loss.

The HMC produced by the PCP is pumped to a hydrocyclone where it is dewatered and stockpiled for transfer to the MSP where it is further processed to produce the final products for export to international markets.

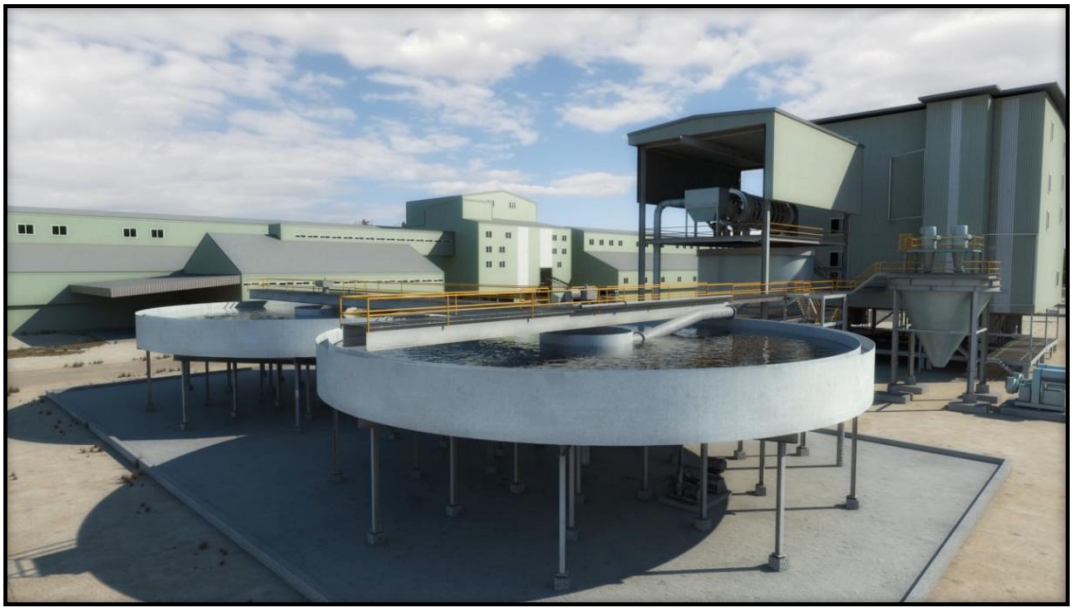

**Plate 2.1: 3D representation of the processing plants (WCP in the foreground and MSP and storage sheds in the background)**
*(Source TZMI)*

It is important to note that the primary concentration process does not involve any changes to the chemical composition of the ore. The HMC is separated from the ore by gravity using standard spirals, with the waste sand tailings back filled into the mined area.

A pilot plant established at the mine site by Exxaro processed several thousand tonnes of ore to produce HMC. The trials using ores from different parts of the orebody conclusively demonstrated that HMC production is a simple and robust process, with no sophisticated equipment or operating techniques required.

Once the HMC has been upgraded to 92% total heavy minerals it will be transferred from the PCP to the MSP.

### *2.3.1.3 Mineral Separation Process (MSP)*

The mineral separation plant (MSP) uses conventional mineral sands separation equipment to produce final products consisting of primary ilmenite, secondary ilmenite and a valuable non-magnetic product comprising rutile and zircon. A combination of magnetic separators and high tension rolls are used to achieve the required separation and a small gravity circuit is incorporated to reject the remaining light gangue.

The proposed MSP is a land based plant and will be located at the mine site.

***Feed preparation***

The HMC will be attritioned at the primary concentrator plant to improve the efficiency of the upgrading processes at the MSP. The attritioning process also removes surface impurities on the minerals which may impact on final product quality.

The HMC is stockpiled and allowed to drain before being transferred into the MSP. The stockpiled HMC will contain approximately 5% residual moisture and will be fed via front end loader from the stockpile into the MSP where it will be dried in a diesel fired fluid bed dryer (FBD) where the remaining surface moisture is driven off.

The dryer will be controlled to maintain a product exit temperature of between 100°C and 110°C. The dried material is screened with the bulk of the material reporting to the undersize being fed dry into the ilmenite circuit.

***Ilmenite circuit***

The dried concentrate is passed through a series of magnets to produce magnetic and non-magnetic streams containing predominantly ilmenite and non-magnetic minerals. The more magnetic, primary ilmenite is diverted to final product while the less magnetic secondary ilmenite stream is further upgraded by additional electrostatic and magnetic cleaning stages. The low magnetic susceptibility minerals are passed through a rare earth roll magnet where the magnetic stream containing ilmenite is upgraded by removing non-conductor mineral contaminants via an electrostatic process producing a high $TiO_2$ secondary ilmenite product stream. No chemicals are added to the process and no chemical wastes will be produced in this circuit.

The ilmenite circuit results in the production of two types of ilmenite:

- Primary ilmenite containing approximately 49% $TiO_2$
- Secondary ilmenite containing approximately 57% $TiO_2$

This results in an overall ilmenite product yield of 65-70% per tonne of HMC.

***Non-magnetics circuit***

The non-magnetic stream from the ilmenite circuit, which contains rutile and zircon and various other impurities, is further upgraded in the non-magnetics section of the plant. The non-magnetic stream is upgraded by rejecting light minerals through a series of gravity and magnetic separation stages.

Approximately 600 000 tpa of heavy mineral concentrate will be treated in the MSP to produce saleable products of primary ilmenite (320 000 tpa), secondary ilmenite (80 000 tpa) and a rutile/zircon concentrate (43 000 tpa).

The simplified flow sheet for the revised project concept has been tested and subsequently revalidated by an independent laboratory (Allied Mineral Laboratory) in Perth, Australia, using concentrate produced at the Ranobe pilot plant.

### *2.3.2 Tailings Disposal*

Mining, concentration and tailings disposal will occur as a continuous process. The composition of the sand tailings from the PCP, which amount to > 90% of the mined material, will be unchanged by the process and will be immediately returned to the mining void as backfill material, as practised in all mineral sand mining operations around the world.

Fine particles, referred to as slimes, collected at the PCP's thickener will be mixed with the top layer of sand to create a fertile growing zone in the mined area, with the original landform returned to its current state. Slimes is composed of fine clay and silt particles, which are present in the sand mined, but have now become concentrated through the mining process. By incorporating this material in the top of the rehabilitated area the water holding capacity of the soil is increased, resulting in a better soil type for agricultural purposes.

The concentrate produced by the PCP, known as HMC, represents approximately 5 per cent by weight of the total sand mined, is transferred (either pumped or trucked) to the MSP where it is stockpiled prior to further processing. HMC, is a mixture of the valuable minerals ilmenite, rutile and zircon as well as non-valuable heavy minerals and remaining silica. The tailings from the MSP will be blended with those from the PCP prior to stockpiling or back filling.

It is important to note that as part of the start-up procedure a stockpile area will be set aside for the initial tailings produced by the operation prior to the mining face advancing sufficiently to allow for tailings to be safely returned to the mining void. Two alternative locations have been assessed for the disposal of initial tailings (one to the west and one to the east of the year 1 position of the PCP as indicated on Figure 2.6 below). Currently the preferred option is to have the initial tailings storage facility to the east of the PCP (for full details see Chapter 3). This area will accommodate the sand tailings and slimes which will be generated in the first 6 months of operation while the mine is being established.

### *2.3.3 Ancillary Infrastructure*

#### *2.3.3.1 Landfill Site*

The landfill site will encompass an area of < 1 ha which will be sufficient to meet the mine and processing site waste requirements. The landfill site will cater for non-hazardous waste streams only (i.e. litter, domestic waste, building rubble etc.). No hazardous waste will be deposited at the landfill site. Three options have been proposed for the location of the landfill site (depicted in Figure 2.6). The preferred option is currently landfill site 3 (for full details refer to Chapter 3).

#### *2.3.3.2 Construction and Operation Accommodation*

During the construction phase of the Ranobe Mine facilities, temporary site based accommodation will be required for construction employees. Two alternative locations for this accommodation are shown in Figure 2.6 below and both lie to the south-west of the main processing facilities.

On completion of the construction phase, the construction accommodation will be maintained for non-routine operational requirements on a "as needs basis". Toliara Sands currently envisages a workforce of approximately 250-400 employees who will be employed at the Ranobe Mine during the commercial production stage of the mine. Rather than using a high proportion of migrant labour, sourced from regional centres, Toliara Sands envision utilizing labour sourced from the 5 communes affected directly by the mine. For this reason it is expected that the majority of workers will live and commute from home.

The construction phase accommodation will comprise of the following infrastructure (Figure 2.4):

- Recreation Centre/ Wet mess
- BBQ and Shelter Areas
- Gym and Change Room
- Dining Room and Kitchen
- Maintenance and Linen Store
- Shop
- Ablution facilities
- Office (Recreation)
- Administration Building
- Project Office
- First Aid Building
- Accommodation Units
- Laundry Facility
- Lockers
- Swimming pool
- Sports Field
- Car park
- Bus Stop

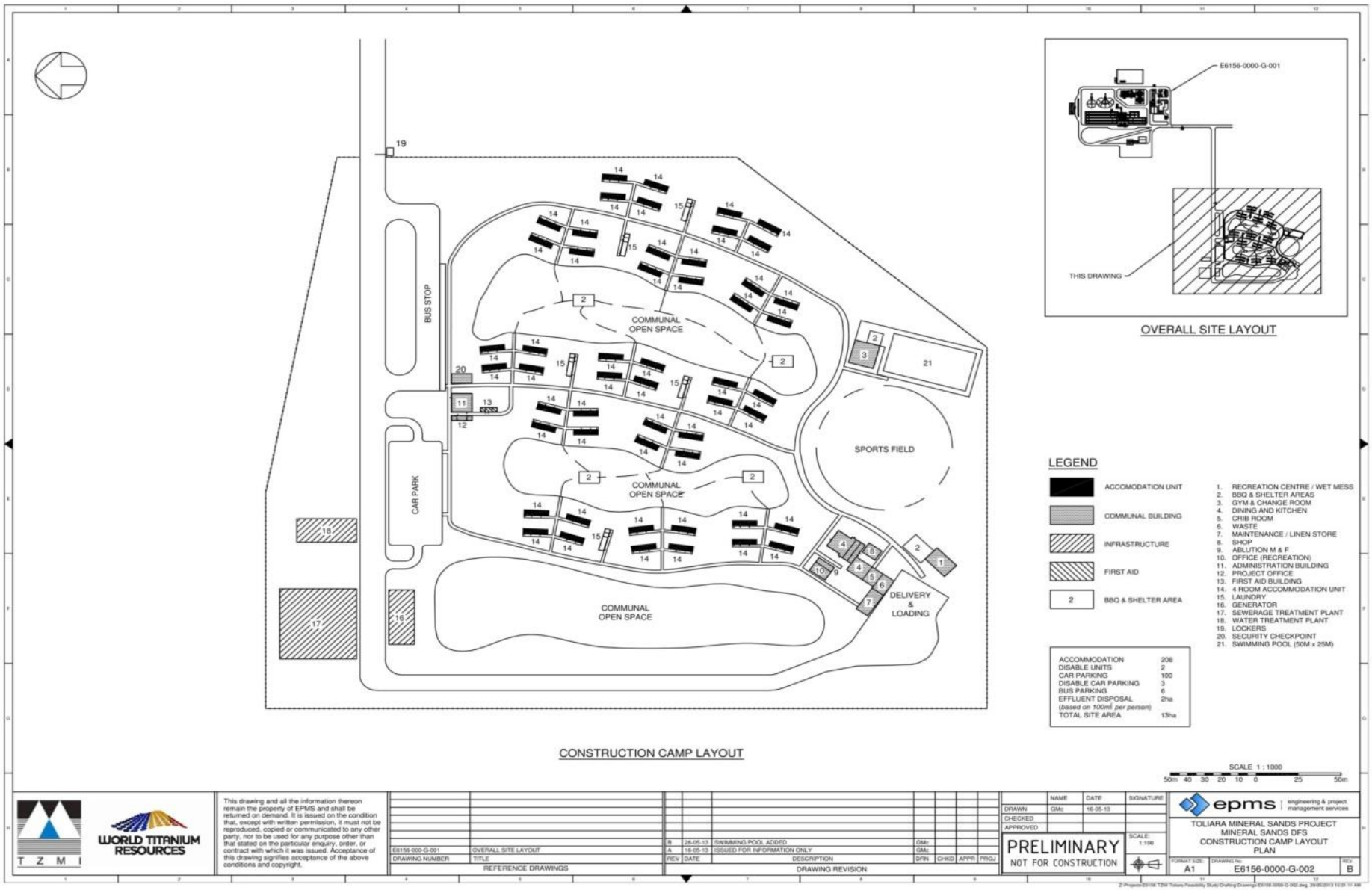


**Figure 2.4: Construction phase accommodation**

#### *2.3.3.3 Sewerage Treatment Works*

Domestic sewage is characterised by a high concentration of nutrients, organic matter and a variety of pathogens. As such, it must be properly treated prior to discharge to avoid negative impacts to human health and the environment. During the life of the mine, the proposed facility will not have access to a municipal sewage reticulation network and will thus have to rely on the use of a packaged sewage treatment plant to cater for the sewage emanating from the facilities.

The project plans to utilise a MBBR Maxi SewaPak sewage treatment facility. Sewerage from the proposed development is anticipated to be approximately 36 $m^3$/day. This will be fed into a constructed equalization tank that hosts a Pre Screen area. The sewage is then pumped from the equalization tank into a treatment plant, in series with the equalization tank area. The final discharge water will be used for irrigation purposes or utilised within the operations (e.g. watering areas for dust suppression).

The MAXI plant consists of (Figure 2.5):

- Raw sewage pump
  - Placed in the equalization tank and plumbed to the Maxi SewaPak.

- Two moving bed bioreactors in series.
  - A sludge return pump feeds a small quantity of sludge back to the first reactor tank on a periodic basis.
  - The reactor is filled with a large surface area plastic biomedia and has an overflow screen at the upper liquid level and into the second reactor.

- A clarifier
  - The inclined plate clarifier receives effluent from the second bioreactor and separates the sludge from the clear water.
  - The sludge accumulates at the bottom of the inner cone and the clear water flows over the launder channel and out to a relay tank.
  - The clarifier is drained via a valve at the base, and pumped via solids separation cyclone on a timer basis to an outside sludge tank on a pre-set time basis.

- An optional sterilising system
  - Using chlorine kills any bacteria in the effluent as it passes through on the discharge pipe. Ultra Violet sterilisation is available.

- Normally the settled water is then filtered through a tertiary filtration process for further quality improvement.

#### *2.3.3.4 Air Strip*

It is proposed to construct an airstrip within the exploration area in close proximity to the mining activities. Two alternative locations were assessed (see Chapter 3). The proposed airstrip will be constructed in a straight section of the haul road. The airstrip will be approximately 1 200 m in length and 24 m in width and will be utilised for emergency purposes only.

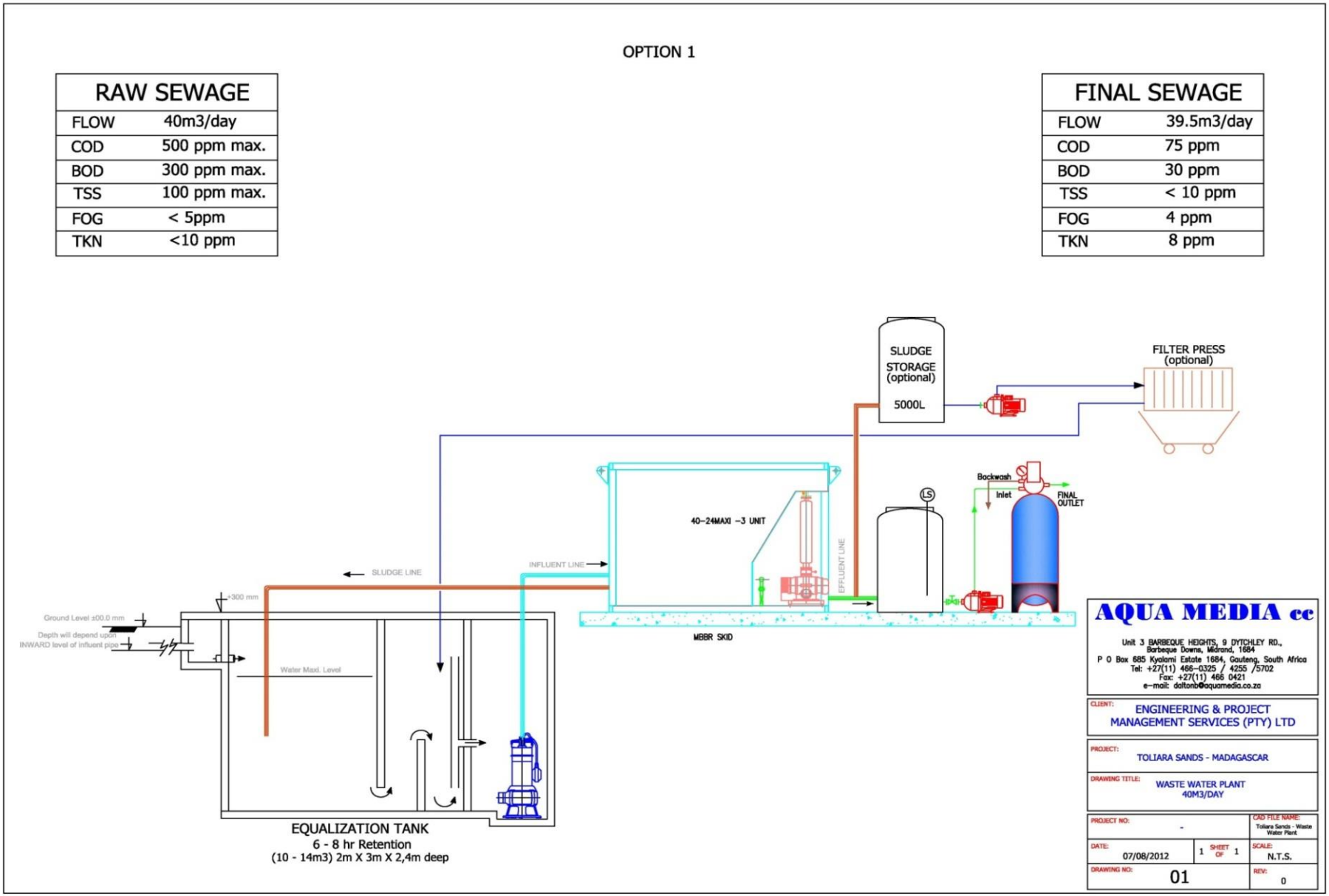


**Figure 2.5: Proposed sewerage treatment facility**

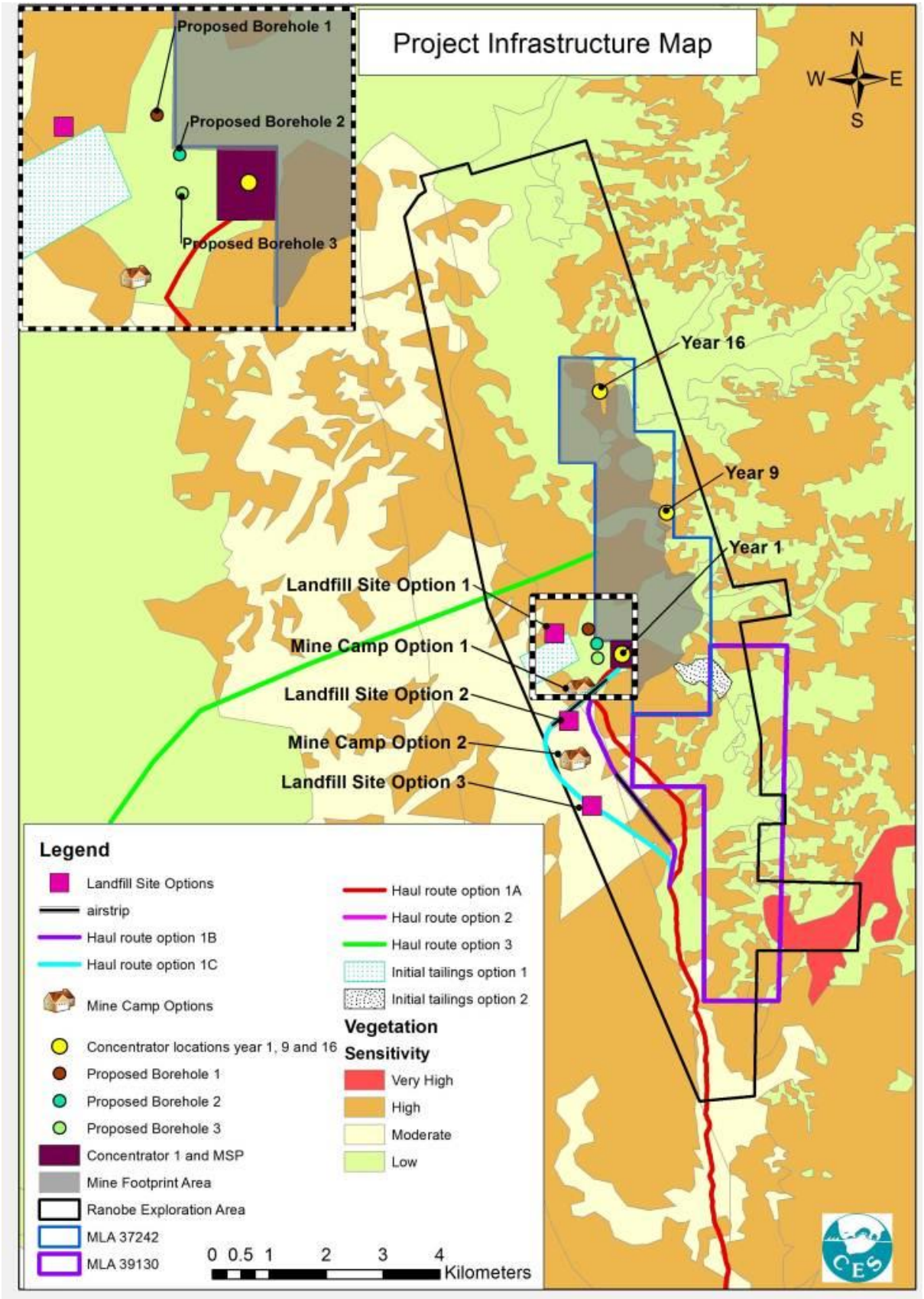


**Figure 2.6: Ancillary infrastructure**

### *2.3.4 Infrastructure*

While the project has been designed to minimise overall infrastructure requirements, mineral sands mining and processing plants require water and energy (both in the form of fuel and electricity) to operate. Given the low level of economic activity taking place in Madagascar and the remote location of the deposit, most of the infrastructure requirements will need to be developed and operated by the mineral sands operation.

During the early stages of the project Thomson & Van Eck were appointed to undertake a study to evaluate the infrastructural elements that need to be considered for the establishment of a mining operation in the Ranobe Permit Area. Further investigations were carried out by a variety of specialists for Exxaro relating mainly to water, infrastructure (roads, port) and power.

For the revised project the main issues that need to be addressed that have not been discussed in the sections above relate to: water and power.

#### *2.3.4.1 Water*

Water requirements for the dry mining and processing operations are estimated to be 560 $m^3$/hr (a little less than 13 500$m^3$/day), of which about 90% will be abstracted from boreholes and 10% recovered - recycled - from the mined ore. Approximately 90% of the water demand will be returned to the environment through the placement of tailings from the wet processing plant, thereby artificially recharging the underlying Eocene limestone aquifer. The processing plants make significant use of recycled process water, and in the long term the ratio of process water to external freshwater inputs is about 6.5 to 1. Water requirements will remain essentially constant during the 21-year operational lifetime of the mine.

Extensive research and modelling of the hydrology of the area has been carried out since 2003 with several studies being completed. The results of previous work by Hydromad (2004), GCS (2004) and SRK (2007) concluded that the reliable yield of the limestone aquifer was sufficient to supply the previously planned large-scale, 30-year Exxaro dredge mining operation, for which the water requirements were estimated to be 45 000$m^3$/day (about 1 900$m^3$/hr) for the first 11 years of mining, and 68 000$m^3$/day (about 2 900$m^3$/hr) for a 50% increase in production during years 12 to 30. The impacts of dredge (wet) mining on the ground and surface water resources of the coastal plain between Toliara and the Manombo River were investigated by Rison Consulting (Pty) Ltd in 2008 (Rison 2008) using a two-layer numerical groundwater model. The results of previous studies were summarised in a report prepared by Aquaterre in February 2013 (Aquaterre, 2013).

Since the water requirements for dry mining are only 30% of the years 1 to 11 requirements for dredge mining it is clear that there will be sufficient water for the smaller scale Stage 1 dry mining and processing operations without the resource being over-exploited. This water can readily be accessed via a carefully designed system of well-spaced boreholes. There will be no need to consider accessing the surface water resources of the Manombo River to the north of the mining area.

#### *2.3.4.2 Power*

The existing Toliara power station is old, dating from the 1950s, and does not have sufficient capacity to provide the mine or processing plants with power, even at the lower offtake required in the revised project.

Self-generated diesel power is considered to be the only practical option for the project, with capital and operating costs factored into the overall project economics.

Electrical power for the mining operation will therefore be generated through diesel generators. An economic power reticulation system will be developed to decide on the number and size of

diesel powered generators, the placement thereof and the distribution of power. The total installed power requirements of the operation once it is at full capacity are estimated to be approximately 5.6 MW with actual consumption estimated to be 80% of installed power.

### *2.3.5 Markets*

Under currently foreseen market conditions, and in the absence of major new entrants to the titanium feedstock supply industry, adequate market opportunities exist for the sale of the total output from the Ranobe project.

#### *2.3.5.1 Sulphate ilmenite*

For the major product from the Ranobe Project, sulphate ilmenite, the supply / demand outlook is positive.

Forecasts indicate that, without considering likely supply from potential new projects that have yet to receive formal approval to proceed, there will be a tight market for sulphate ilmenite in the medium to long term as demand for the product increases at a much faster rate than supply.

Global sulphate ilmenite demand is forecast to grow over the next decade, while supply is expected to remain flat over the period to 2015, before declining steadily thereafter due to the continued depletion of existing resources. Based on forecasts, additional supply from new projects will be required from 2013 onwards to avoid the market moving into supply deficits. As such, it is expected that the planned 320 000 tpa of sulphate ilmenite from the Ranobe Project, which compares favourably to most other competing products, can be absorbed by the market.

#### *2.3.5.2 Chloride ilmenite*

Supply/demand forecasts show increasing supply deficits for chloride ilmenite, influenced by demand growth outpacing supply from existing producers. From 2013, the supply gap will grow into progressively larger deficits without the development of new projects. Even with additional supply from new projects, there remains a significant long-term supply gap unless additional new (unapproved) projects are developed and there will be a growing supply deficit from 2014. This primarily brought about by the anticipated depletion of existing resources over this period.

#### *2.3.5.3 Zircon*

For the other major product from the Ranobe Project, zircon in the form of a zircon rich concentrate, the supply/demand outlook is also positive. The overall market dynamics for zircon are very similar to those being observed for titanium feed stocks. Due to resource depletion the production from existing producers is expected to decline significantly from the peak seen in 2007. New discoveries will certainly be required if supply levels are to be sustained anywhere near anticipated levels of global demand.

If zircon supply does not increase significantly later in the decade then a fundamental change in end-use must occur, which could see some zircon end-use applications disappearing. It is therefore anticipated that the planned 30 000 tpa of zircon from the Ranobe Project can be readily absorbed by the market.

# 3. ANALYSIS AND CHOICE OF THE ALTERNATIVES

## 3.1 Extent of the mining footprint

The mineralised zone in the Ranobe Permit Area is of an appreciable size, being around 16 km long and between 1 and 2 km wide. It comprises three mineralised sand units, which together contain approximately 1 200 to 1 400 million tonnes of sand at an average grade of 4 to 5% total heavy minerals (THM) (see Figure 3.1).

The original Exxaro project was based on the key requirement to produce 460 000 tonnes of smelter-grade ilmenite to feed two furnaces at Ticor South Africa's Empangeni smelter. Only about 80% of the ilmenite produced from the Ranobe Mineral Separation Plant (MSP) was primary ilmenite with a titanium dioxide ($TiO_2$) grade suitable for smelter feed. The remaining 20% was altered ilmenite, which can be sold as chloride feedstock. As a result, the total ilmenite production requirement of the original project was 575 000 tonnes of ilmenite. This translated into a large-scale dredge mining operation with a capacity to mine over 10 million tonnes of ore in the first year.

The major impediment to advancing such a large-scale project is the absence of developed infrastructure, and in particular the need to consume large quantities of water and electrical power in producing the heavy mineral concentrate (HMC) at the mine using a dredge mining operation.

Subsequently, World Titanium Resources reviewed the mine plan and schedule and has now focussed initial activity around a high-value area (the project area) capable of sustaining a sizeable dry mining operation for 21 years. The project has now been redesigned to allow progressively larger tracts of the Ranobe resource to be brought into production over time. Stage 1 is centred on the higher grade part of the deposit, where 161 million tonnes of ore containing 9 million tonnes of ilmenite for which a mining licence has been granted. The balance of the deposit remains within the Ranobe Permit Area, and will support further stages of development.

It is important to note that due to the smaller area proposed to be mined, and due to the dry mining approach, the amount of water required to sustain the operation is significantly less than the dredge option originally envisaged for this deposit. The electrical power requirement, while still being generated by diesel engines, is now at a realistically low level when compared to the option originally envisaged for the dredge mining operation.

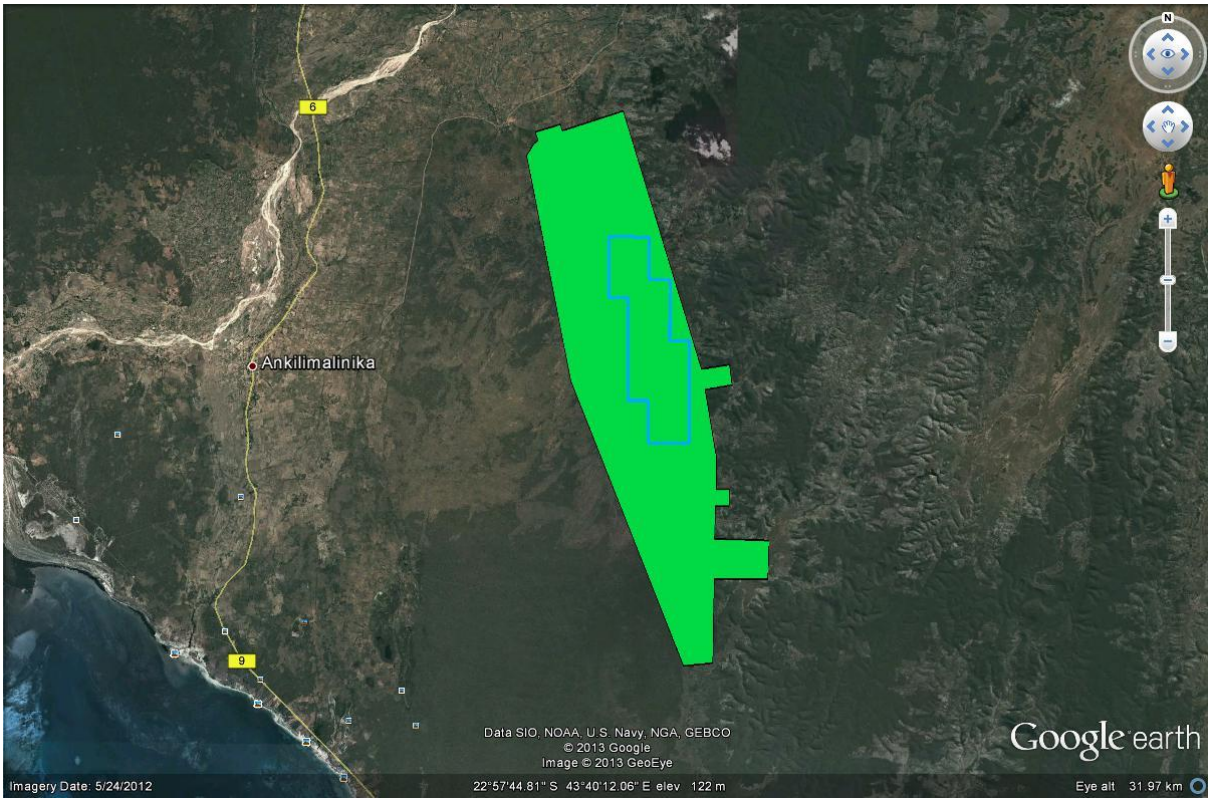


**Figure 3.1: The proposed mining area (outlined in blue) in relation to the Ranobe Deposit (shaded in green)**

## 3.2 Location of the MSP

Alternative locations considered for the Mineral Separation Plant (MSP) included placing it near the quay at the Port of Toliara; and locating the MSP at the mine site.

### *3.2.1 MSP located at the Port of Toliara:*

This would necessitate the transport of wet HMC from the mine site to the MSP, and transport of final products from the MSP to ships for export. The transportation of HMC and final product would entail the following:

- The HMC from the PCP at the mine would be trucked to a transfer station (not required if MSP is located at mine site) on the northern bank of the Fiheranana River near Belalanda;
- HMC from the mine would be stockpiled at the transfer station and pumped via a high pressure slurry line (not required if MSP is located at mine site) approximately 14 kilometres to the MSP located at the Port of Toliara;
- From the MSP the rutile/zircon concentrate will be loaded into containers and trucked to the existing quay at the Port of Toliara; and
- The ilmenite will be transported by truck or conveyor to a ship loader at the existing quay at the Port of Toliara, where it will be loaded into barges for transhipment to large vessels anchored in the lagoon.

The MSP situated at the Port Quay is likely to result in more significant impacts for fisher communities by virtue of its proximity to existing villages and much larger volumes of pirogue traffic. It is also likely to result in more significant impacts on existing fishing grounds and general shipping activity in and around the port.

### *3.2.2 MSP located at the mine site*

Siting the MSP at the mine site will mean that all aspects of minerals processing will be located at the mine, and it will be necessary to only transport dry products to the jetty for export via ship. The transportation of the final products for export would therefore entail the following:

- The final products from the MSP at the mine would be trucked on a dedicated haul road to the northern bank of the Fiheranana River where it crosses the RN9.
- The River will be crossed by the trucks via a suitably designed causeway constructed as part of the project.
- Once across the river the haul trucks will carry the final products along the dedicated haul road to a storage facility adjacent to the new proposed jetty.
- The ilmenite products will be reclaimed from the sheds and bulk loaded, via conveyor belts, onto the vessels docked at the jetty.
- The zircon/rutile concentrate will be either loaded into containers at the new jetty and transported to the Toliara Port Quay for loading onto container vessels or loaded into bulk vessels using the same infrastructure as for ilmenite.

**Table 3.1: Comparison of the two location alternatives for the MSP**

| Impacts associated with situating the MSP at the Port of Toliara | Impacts associated with situating the MSP at the mine site |
|---|---|
| Tailings from MSP, located at the port, will be pumped back to the transfer station, dewatered and then back-hauled by truck to the mine site to be deposited in the mining void for co-disposal with the PCP tailings. This option would result in a higher significance rating of impacts, since it is located in close proximity to Toliara Town. These impacts will include the following:<br>• Deterioration of air quality and subsequent impacts to human and environmental health<br>• Impacts to surface and ground water due to run-off from stockpiles; and<br>• Impacts associated with radionuclides in the tailings. | Tailings from MSP will be mixed with the PCP tailings and returned to the mining void as backfill.<br><br>This option would result in a lower significance rating of the discussed impacts, since the storage and transfer of tails are limited and there will be no households in close proximity to the mine. |
| Increasing traffic along new Haul Road | |
| Although highly unlikely, the abstraction of ground water from the alluvial aquifer associated with the Fiherenana River for the MSP (if located near Toliara) could theoretically lower the water table in the adjacent locality in the dry season when there is no surface flow in the river reach near the existing road bridge. | |
| Impact on local fishing communities as well as fishing grounds | |
| Requires the construction two high pressure 10-14 km pipelines | Requires the construction of a single low pressure pipeline with a maximum length of 2 km |

### *3.2.3 Water Consumption*

The proposed study site occurs within the driest region of Madagascar and therefore concerns about the amount of water utilised by the project have been raised by various I&APs. Dredge or dry mining has a strong influence on the amount of water consumed. In a dredge mining operation pond make-up water is required, as the dredge and concentrator float in a large, man-made pond. Extensive research and modelling of the hydrology of the area has been carried out since 2003 with several studies being completed. Given the results of previous work by Hydromad and SRK, which concluded that there was sufficient water in the area to supply the planned Exxaro dredge mining operation (which required approximately 2 000 to 3 000 $m^3$/h), it

follows that there will be sufficient water for the smaller scale Stage 1 dry mining and primary concentration operations without the resource being over-exploited. This water can readily be accessed through a system of well-spaced boreholes. Water requirements for the mining operation and PCP are estimated to be 500 cubic metres per hour ($m^3$/hr), of which approximately 80% will be returned to the environment through the placement of tailings from the MSP. The water requirements for the MSP will be largely satisfied by the water arriving with the slurried ore from the PCP: Additional water requirements are estimated to be 20 $m^3$/h.

## 3.3 Alternatives associated with ancillary infrastructure

### *3.3.1 Location of the Landfill Site*

A landfill site is required for the disposal of non-hazardous wastes and will therefore be constructed within the Ranobe Exploration Area. Three possible sites have been identified (Figure 3.2).

- Option 1 is located to the north west of the MSP and is in an area of high sensitivity.
- Option 2 is located to the south west of the MSP and is in an area of medium sensitivity.
- Option 3 is located further south of option two and also occurs in an area of medium sensitivity.

According to the botanical impact assessment Option 1 is in an area of high sensitivity. In addition, the site is approximately 1.3 km from the proposed haul road, which will result in additional access routes having to be developed within the overall project area and may result in further fragmentation of habitat within the overall project area and new fragmentation within an area of high sensitivity.

Options 2 and 3 are both relatively close to the proposed new haul road (< 500 m) and therefore relatively easily accessible. In addition, according to the botanical impact assessment, both of these options are within areas of moderate sensitivity. It is important to note that the prevailing wind direction in the area is south-west. Since both options for the construction and operation accommodation are downwind from Option 3 it is suggested that Option 2 is the preferred option, as the landfill site should be situated downwind from any living areas to prevent the impact of odour and wind-blown pollution. However, Option 2 is in close proximity to the preferred location for the airstrip. As landfill sites are notorious for attracting birdlife this may result in safety risks associated with the use of the airstrip.

Even though landfill site Option 3 is downwind from the preferred site for the construction and operation accommodation it is approximately 800 m away. According to the International Solid Waste Association (Guidelines for Design and Operation of Municipal Solid Waste Landfills in Tropical Climates, 2013) no landfill site should be established within 500 m of a residential area. Option 3 is therefore outside the suggested buffer zone and it is unlikely to have a significant impact on the proposed location for the mine accommodation. Option 3 becomes the preferred option.

### *3.3.2 Initial Tailings Storage Facility*

As part of the start-up procedure a stockpile area will be set aside for the initial tailings produced by the operation prior to the mining face advancing sufficiently to allow for tailings to be safely returned to the mining void. Two alternative locations have been identified for consideration:

- Option 1 is located to the north-west of the MSP as indicated in Figure 3.2.
- Option 2 is located to the east of the MSP.

According to the Botanical Impact Assessment Option 1 traverses an area of high sensitivity for one third of its coverage. The proposed site is situated approximately 1.3 km from and downwind

of the proposed preferred site for the construction and operation accommodation and it is therefore unlikely to result in any health and safety related issues.

Option 2 is situated in an area of low sensitivity as defined by the Botanical Impact Assessment. In addition it is situated more than 2 km from and downwind of the construction and operation accommodation and it is therefore even less likely to result in any health and safety related issues. Furthermore, this proposed site is situated adjacent to the mine path and the majority of the footprint is situated within the mining license area. Even though this option may result in additional operations cost (as tails need to be pumped uphill) it is the preferred location for the proposed initial tailings storage facility from an environmental point of view.

### *3.3.3 Construction and Operation Accommodation*

During the construction phase of the Ranobe Mine facilities a temporary site based accommodation will be required for construction employees. Two alternative locations for this accommodation have been identified for consideration:

- Option 1 is located to the south west of the MSP in an area of high and low sensitivity.

- Option 2 occurs further south of Option 1 in an area of medium sensitivity. This option is the preferred site as it is further away from the proposed tailings area, MSP and the mine area and is in an area of medium sensitivity compared to Option 1, which is close to the initial tailings area and MSP and straddles an area of high and low sensitivity.

According to the Botanical Impact Assessment approximately half of the footprint of Option 1 is in an area of high sensitivity, whereas the remainder is in an area of low sensitivity. This option is situated approximately 500 m from the MSP and the mine site and is directly adjacent to the proposed airstrip. As a result this may pose some safety risks to potential residents and it was therefore suggested that the proposed accommodation area be moved further away from the mine.

Option 2 is situated further south from the original proposed position of the accommodation area at a distance of approximately 1.6 km from the MSP and mine site and approximately 500 m from the airstrip. Option 2 is therefore the preferred alternative.

### *3.3.4 Airstrip*

It is proposed to construct an airstrip within the exploration area in close proximity to the mining activities. As discussed in Chapter 2 of this report the proposed airstrip will be utilised for emergency purposes only. Two alternative locations for the proposed airstrip have been identified for consideration:

Option 1 is situated in close proximity to the mining area and associated infrastructure (approximately 400 m) from the MSP. Therefore in the event of injury and/or illness, travelling time is minimised. In addition to this, it is anticipated that the proposed airstrip will be constructed in a straight section of the proposed haul road, thereby minimising the overall footprint of the development. Furthermore, this Option is aligned in a SW/NE direction, and therefore with the Toliara airport runway and takes the prevailing daytime SW wind into account. This option is also in an area of moderate sensitivity.

Option 2 is situated approximately 1.6 km from the mining area and therefore in the case of injury and/or illness there may be additional travelling time if the need arises for evacuation. In addition this option is proposed in an area where no development was anticipated thereby increasing the development footprint. Furthermore, the proposed area for the development of the airstrip is in an area of high sensitivity for the majority of its footprint. Lastly, Option 2 is positioned in NW/SE direction and does not account for the prevailing daytime wind direction.

Option 1 is therefore the preferred option.

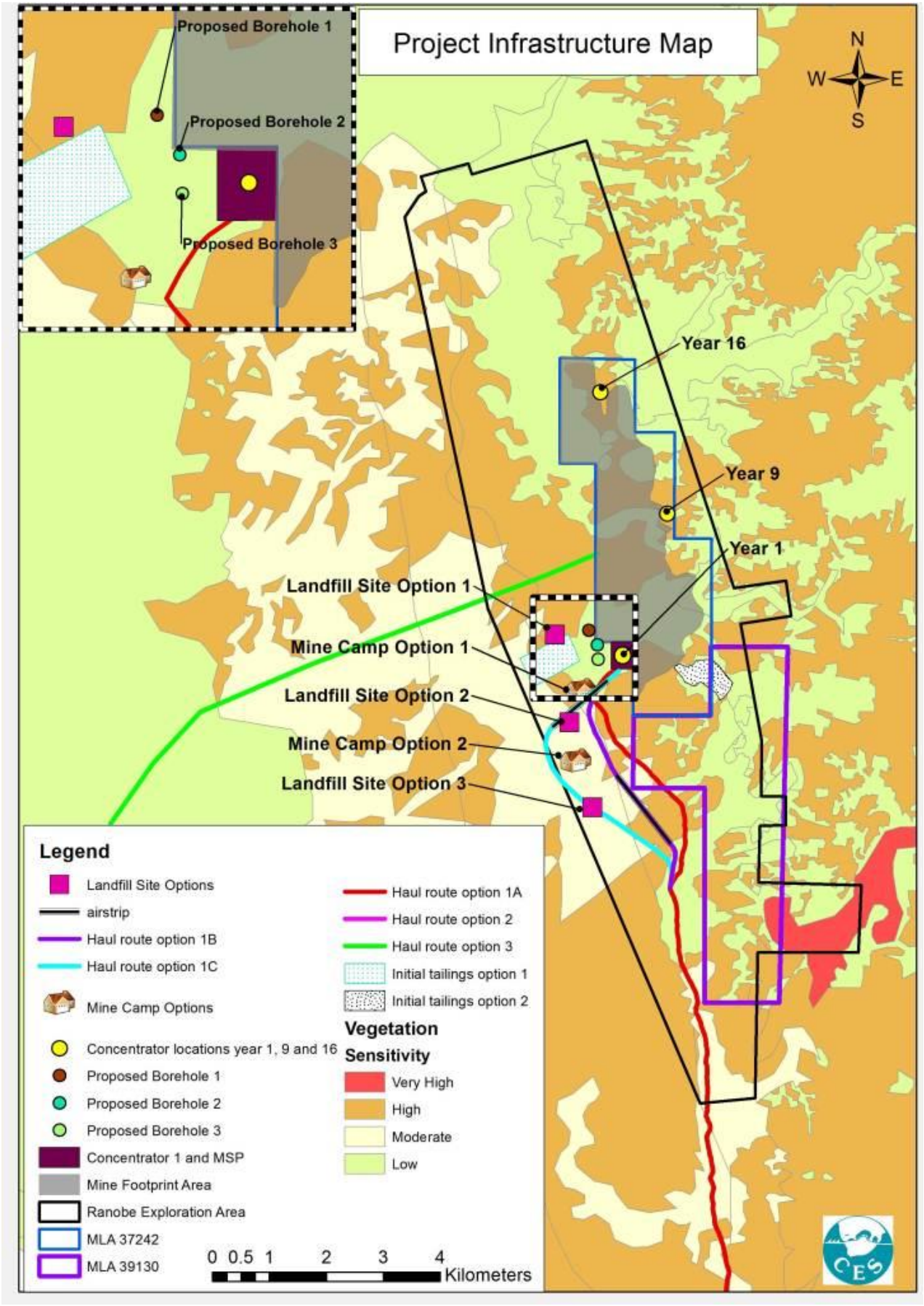


**Figure 3.2: Ancillary infrastructure alternatives**

# 4. DESCRIPTION OF THE PHYSICAL STATE OF THE ENVIRONMENT

## 4.1 Climate

### *4.1.1 Description of the study site*

#### *4.1.1.1 Wind*

Wind roses comprise 16 spokes, which represent the directions from which winds blew during a specific period. The colours used in the wind roses below (Figure 4.1), reflect the different categories of wind speeds; the red area, for example, representing winds in excess of 5 m/s. The dotted circles provide information regarding the frequency of occurrence of wind speed and direction categories. The frequency with which calms occurred, i.e. periods during which the wind speed was below 1 m/s are also indicated.

The wind field in the study area is dominated by easterly winds to south easterly winds, south westerly to west-south westerly and north westerly to north-north easterly winds. The wind blows the most frequently from the east. Calm conditions prevailed 24.08% during 2006-2009 with a period average wind speed of 1.9 m/s.

During day-time the wind field is mostly characterised by wind from the south-west to west–south-west and 11.88% calm conditions. Wind speed decreases during the night, increasing the occurrence of calm conditions to 34.06% and the dominant winds are from the east. The wind flow pattern is most probably influenced by the presence of land-sea breezes. The large heat capacity of oceans reduces water-surface temperature change to near-zero values during a diurnal cycle. The land surface, however, warms and cools more dramatically because of the small molecular conductivity and heat capacity in soil prevents the diurnal temperature signal from propagating rapidly away from the surface. As a result, the land is warmer than the water during the day and cooler at night. During the morning, when the nocturnal surface boundary layer has been eliminated, air begins to rise over the warm land near the shoreline, and cooler air from the water flows in to replace it. This is known as the sea-breeze. A return circulation (the anti-sea-breeze) brings the warmer air back out to sea where it descends toward the sea surface to close the circulation. At night, land surfaces usually cool faster than the neighbouring water bodies, reversing the temperature gradient that was present during the day. The result is a land breeze: cool air from land flows out to sea at low levels, warms, rises, and returns aloft toward land (anti-land-breeze) where it eventually descends to close the circulation.

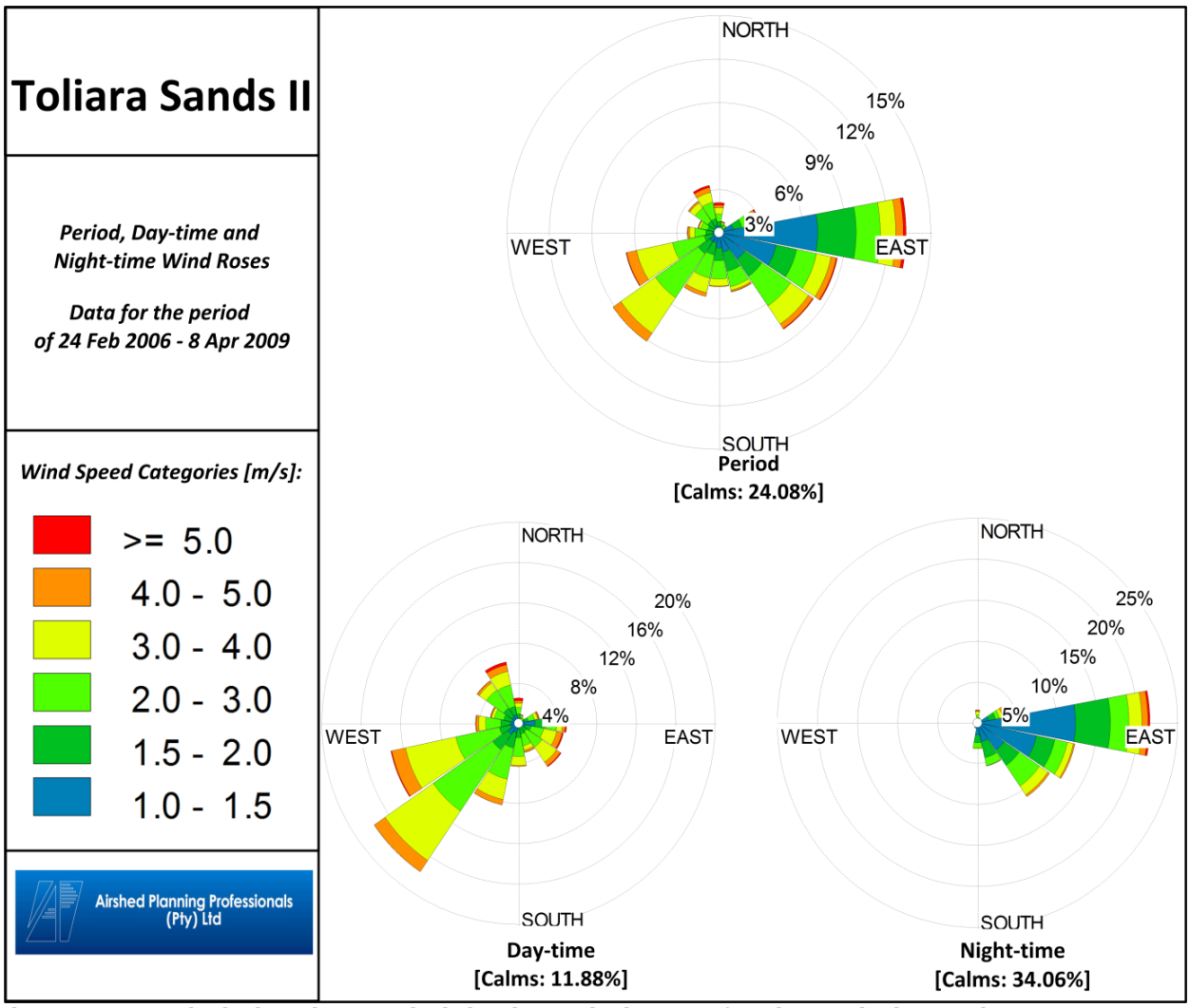


**Figure 4.1: Period, day-time and night-time wind roses for the period 24 February 2006 to 8 April 2009**
*(Source Airshed Planning Professionals)*

### *4.1.1.2 Temperature*

Temperatures within the study area ranged between 8.1 and 38°C. The highest temperatures were recorded in March and October and the lowest in June. Low minimum temperatures are mostly a result of the ocean's cooling effect. During the day, temperatures increase to reach maximum at around 12:00 in the afternoon. Ambient air temperatures decreases to reach a minimum at around 04:00 from September to March and 05:00 April to August i.e. just before sunrise.

Monthly mean and hourly maximum and minimum temperatures are given in Table 4.1. Diurnal temperature trends are presented in Figure 4.2 and Figure 4.3.

**Table 4.1: Hourly minimum, hourly maximum and monthly average temperatures**

| Hourly Minimum, Hourly Maximum and Monthly Average Temperatures (°C) for the period 24 February 2006 to 8 April 2009 | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| **Monthly Average** | 26.9 | 27.2 | 26.7 | 25.3 | 22.5 | 20.8 | 20.8 | 21.5 | 22.8 | 25.2 | 26.7 | 27.6 |
| **Hourly Minimum** | 19.2 | 18.2 | 16.4 | 14.6 | 12.3 | 8.1 | 10.1 | 10.6 | 9.7 | 13.7 | 17.8 | 18.2 |
| **Hourly Maximum** | 36.3 | 37.9 | 38.0 | 37.2 | 33.4 | 31.9 | 33.4 | 33.4 | 35.1 | 38.0 | 37.5 | 37.4 |

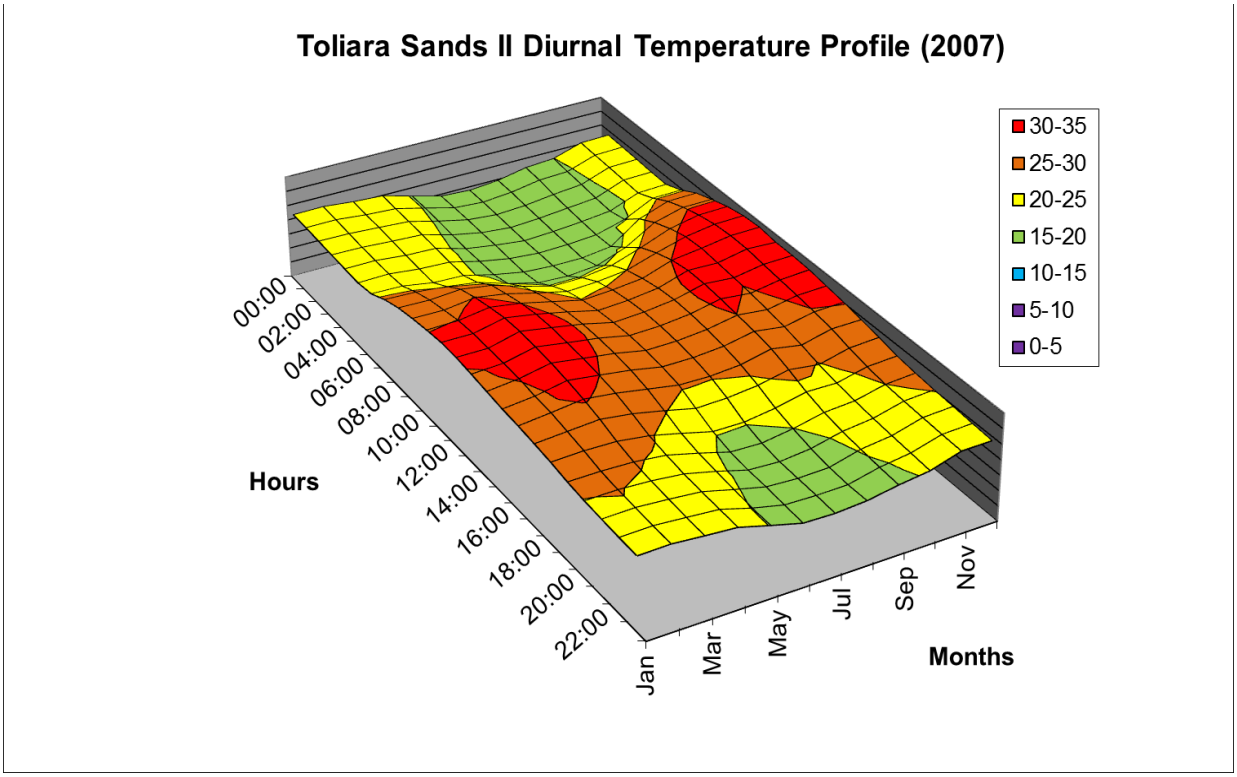


**Figure 4.2: Monthly diurnal temperature profile for the period 1 January 2007 to 31 December 2007**
*(Source Airshed Planning Professionals)*

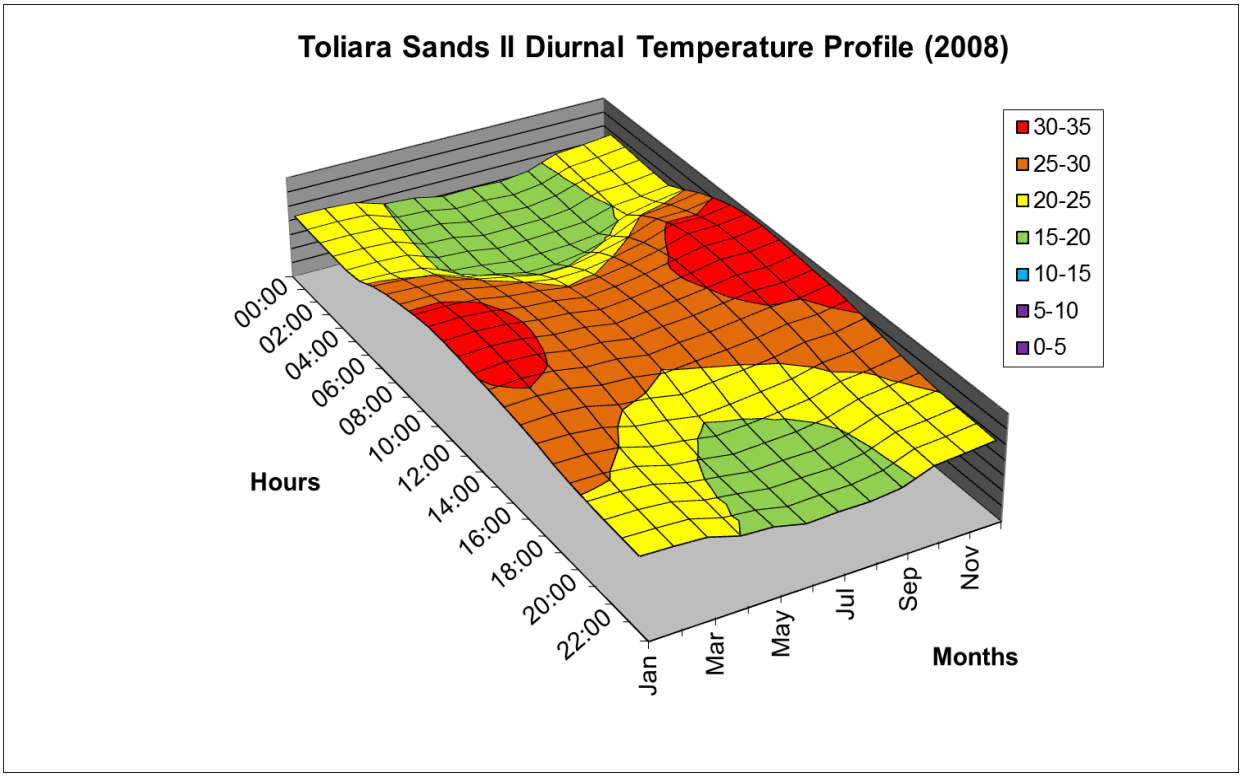


**Figure 4.3: Monthly diurnal temperature profile for the period 1 January 2008 to 31 December 2008**
*(Source Airshed Planning Professionals)*

### *4.1.1.3 Precipitation*

The Ranobe Permit Area (mine site) falls within the sub-arid region of Madagascar. According to the climate the MLA (where the weather station is located) should on average receive more than 550 mm of rain per year and most of the rainfall occur between January and March (Coastal & Environmental Services, 2012).

Average monthly rainfall recorded on-site is presented in Figure 4.4. The data used in obtaining the precipitation trends on-site was from 1 January 2007 to 31 December 2008. A reason for this is that there are many outliers in the precipitation values for the February, March and April 2006 data. A large majority of the values during this period appear to be incorrect when compared to regional climate data. Many hourly values are 2 to 5 times larger than the annual rainfall amount based on the pilot plant site rain gauge data in the scoping document (Coastal & Environmental Services, 2012). Another reason is that to compare the annual totals from the weather station to data in the scoping report and determine the months where the majority of rainfall occurs, only years with all the months data available would need to be used to produce the most accurate results. From the on-site data the total annual rainfall for 2007 and 2008 are 199.6mm and 543.3mm respectively and the majority of rainfall occurs in December, January, February and March. The highest amount of rainfall (251.2mm) occurring in February 2007.

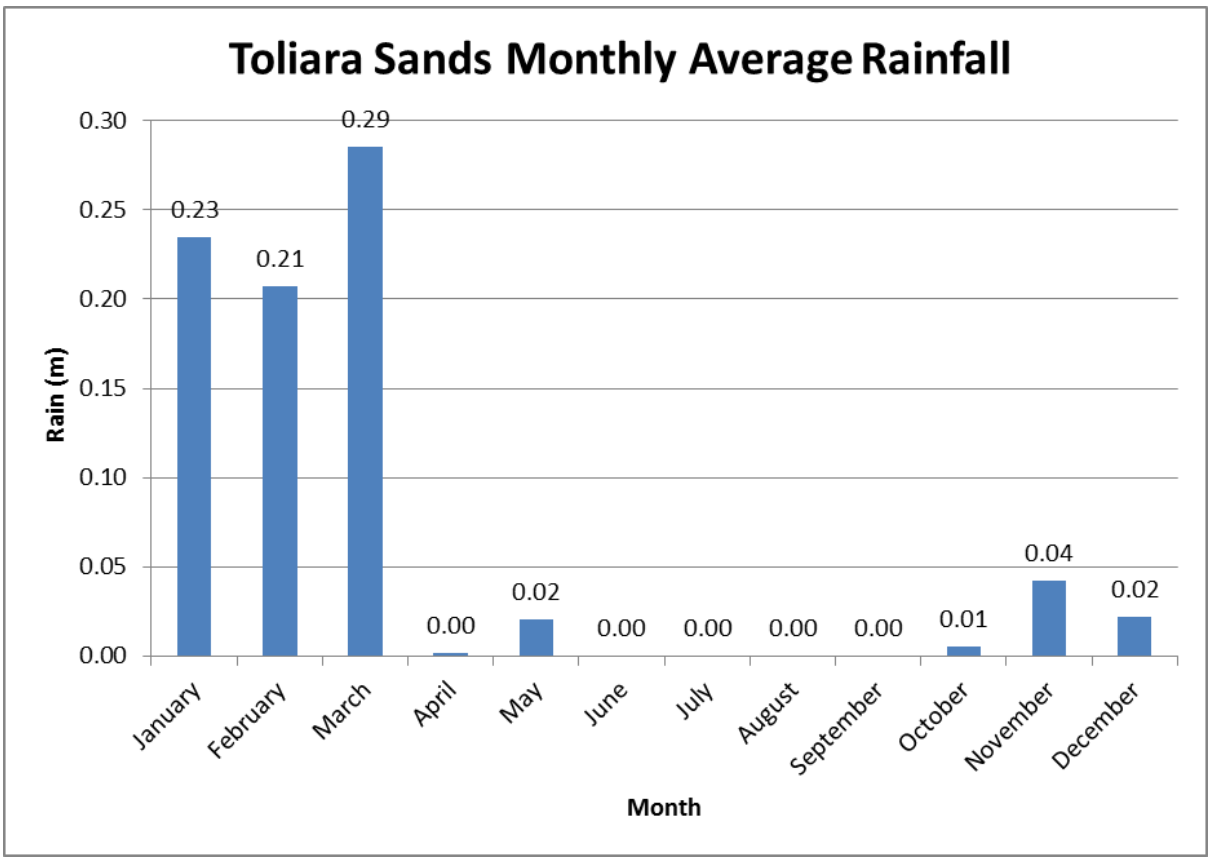


**Figure 4.4: Monthly average rainfall for the period 1 May 2006 to 8 April 2009**
*(Source Airshed Planning Professionals)*

### *4.1.2 Impacts of the Ranobe Mine Project on Climate*

#### *4.1.2.1 Introduction*

Climate change is a long-term change in the statistical distribution of weather patterns over periods of time that range from decades to millions of years. Fluctuations in the weather patterns in periods shorter than a few decades, such as El Niño, do not represent climate change. According to the Intergovernmental Panel on Climate Change (IPCC), climate change refers to any change in climate over time, whether due to natural variability or as a result of anthropogenic activity. This usage differs from that in the UN Framework Convention on Climate Change (UNFCCC), where climate change refers to a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods (IPCC Summary for Policymakers, 2007).

The change in climate is generally attributed to the change in the atmospheric gaseous composition and this could be enhanced by anthropogenic sources of greenhouse gas (GHG). The increased concentrations of GHG (including water vapour, carbon dioxide, methane, nitrous oxide, and ozone) produce global warming that affects long-term climate, with potential impacts, both negative and positive, on humanity in the foreseeable future.

Concern over the anthropogenic factors relates primarily to emissions from fossil fuel combustion and the removal of vegetation due to land use changes. Vegetation can provide an important sink for atmospheric carbon as physiological processes performed by the plants convert atmospheric carbon dioxide into plant tissue. In the case of longer-lived tree species, this process can result in large amounts of carbon being sequestered (“locked away”) for a number of years. Based on this process, protection of vegetation or afforestation can help to mitigate the potential impact of anthropogenic atmospheric releases on climate change. However, conversely, destruction of

vegetation (such as would be associated with clearing of land) could result in the release of significant quantities of carbon dioxide and, potentially, other GHG to the atmosphere.

Based on available information, climate change may influence key climate variables such as temperature, precipitation, sea level and the frequency of extreme weather events. This, in turn, may manifest as changes to rainfall patterns, increased frequency of flooding and droughts and loss of coastal land as a result of higher sea levels. Such changes may have significant ecological and socio-economic consequences.

It should be noted, however, that not all impacts of climate change will have adverse effects. While some parts of the world experience more frequent or severe droughts, floods or significant sea level rise, in other places such as the sub-arctic, which may become more habitable, crop yields may increase due to the fertilising effects of $CO_2$ and longer growing seasons. However, the likely fast rate of change will result in an increased pressure on diminishing natural resources creating problems such as substantial damage to infrastructure and extinction of indigenous life forms with slow adaptation rates.

Globally, the implementation of a low carbon economy is proposed as a means to avoid catastrophic climate change, and as a precursor to an ideal, zero carbon society.

#### *4.1.2.2 Predicted manifestations of Climate Change in Madagascar*

Madagascar is the fourth largest island in the world, covering an approximate area of 58.7 million hectares. Even though agriculture accounts for approximately 30% of the GDP and employs 75% of the workforce the country is relatively unsuitable for cultivation due to its mountainous terrain, extensive laterization and inadequate and/or irregular rainfall. For this reason, only approximately 5% of the country is cultivated at any one time. Oldeman (1988) divided Madagascar into five agro-ecological regions (Regions A-E) based on available rainfall and temperature data. Region A is regarded as the wettest region (> 255 rainy days per annum) and includes the east coast of the country, however excluding the southern Tolagnaro region. Region B is intermediate between Region A and Region C (approximately 165-255 rainy days per annum) and consists of the highest part of the Ankaratra. Region C, the medium rainfall area (110-165 rainy days per annum), covers the central highlands and their western slopes above 500 m. Region D is intermediate between Region C and Region E (approximately 75-110 rainy days per annum) and consists of the north-west region including the zone of Lac Alaotra. Region E is regarded as the driest region (< 75 rainy days per annum) and includes the south and south-west of Madagascar below a line joining Maintirano to Ambovombe. The proposed development site occurs in Region E and is therefore considered to be in the driest portion of the country.

In the south and south-west region of Madagascar the extensive dry period results in an increased difficulty of crop cultivation and this form of agriculture is only possible in close proximity to natural water resources (e.g. lakes and rivers) and by practising irrigated cultivation, although year round cultivation of dryland crops is possible.

Climate change impacts such as the decrease in soil fertility and productivity, change in rainfall, temperature and cyclone events, increases the vulnerability of agricultural based livelihoods. As food security, income, water quality and quantity become threatened, rural livelihoods dependent on natural resources are compromised resulting in possible migration to urban centres (further increasing competition over natural resources).

Despite the above, a vulnerability assessment conducted by Tom Heath (2010) from Cranfield University suggests that Madagascar's vulnerability to climate change (in terms of water resources and social impact) is low. This assessment did not account for regional variations.

The effects of the expected increase in temperature, floods, drought and change in cyclone events are listed below (Table 4.2).

**Table 4.2: Effects of climate change in Madagascar** (Source: Heath, 2010)

| | INCREASED TEMPERATURE | FLOODS | DROUGHTS | CYCLONES |
|---|---|---|---|---|
| **WATER** | • Less water for agriculture<br>• Disappearance of some water points<br>• Swamps and rivers drain in dry season | • Contamination of drinking water<br>• Ingress of groundwater into pipes | • Water shortages and rivers dry up in the south<br>• No water for irrigation<br>• Deteriorating water quality<br>• Antananarivo plains will not have sufficient water to meet demand in 2050-2100 | • Degrade water resource<br>• Flooding |
| **LIVELIHOODS** | • Cropping seasons no longer routine<br>• Reduction in soil fertility<br>• Less income from agriculture | • Soil erosion<br>• Decrease in soil fertility<br>• No access to schools<br>• Food scarcity | • Famine<br>• Locust swarms<br>• Crop failure | • Increased in soil erosion<br>• Flooding of crops<br>• Injured livestock<br>• Crop failure<br>• Sedimentation |
| **HEALTH** | • Food shortages<br>• Malaria risk | • Cholera epidemics<br>• Loss of life | • Water borne diseased increasing<br>• Less water for hygiene and cleaning | • Damage to shelter<br>• Increased risk of epidemics |
| **BIODIVERSITY** | • Loss of habitat<br>• Loss of endemic species<br>• Reduction of forest areas | • Damage to biodiversity and habitat | • Forest loss aggravated | • Biodiversity destroyed |

Temperature increase is expected to be greatest in the south of Madagascar, with less warming occurring over coastal and northern regions. Rainfall is expected to increase substantially in the tropical areas and decrease in southern and eastern parts of Madagascar. Wetlands and mangrove aquatic systems on the western coast provide important ecosystem services and will be threatened if sea levels rise.

#### *4.1.2.3 Climatic issues possibly exacerbated by the Ranobe Mine Project*

Climate change issues are of global concern and all anthropogenic activities contribute to climate change. Due to the global nature of climate change, it is not possible to describe climate change impacts in the same way as other impacts described in the sections that follow . The purpose of this section is therefore to discuss the potential impacts of global climate change on the study area, and how the proposed Ranobe Mine Project could contribute to climate change as well as exacerbate or mitigate expected manifestations thereof. Where possible, mitigation measures to counter negative impacts or enhance positive impacts are suggested.

### *4.1.3 Construction Phase Impacts*

Even though there will be a large number of heavy vehicles present during the construction phase of the project and subsequently a significant increase in vehicle emissions, the carbon emissions produced during the construction phase is nominal to that produced during the operational phase (using diesel generators for providing power to the MSP and PCP as well as increased vehicle emissions). For this reason the impacts of the project on climate change is considered to be mainly associated with the operational phase (as discussed below).

### *4.1.4 Operational Phase Impacts*

#### *4.1.4.1 Issue 1: Reduced availability of water*

Drought as well as flood episodes may be exacerbated by climate change. This will impact on the availability of potable water. Flooding can contaminate the water supply, and drought will reduce

the quantity of water for agriculture as well as human requirements (Heath 2010). The dry mining operation will abstract approximately 504 $m^3$/hr from boreholes (Aquaterre 2012). Although, specialist studies determined that this abstraction is both environmentally and socially sustainable under prevailing climatic conditions (Aquaterre 2012), the sustainability of water abstraction by the mine with respect to community needs and maintenance of ecological function during severe drought events is uncertain.

The mining operation may also lead to contamination of underground water supply through washing of machinery (including vehicles) and, possibly, dust suppression activities. As this water migrates across the site it has the potential to pick up various pollutants such as hydrocarbons and small solid particles. Furthermore, the run-off from machine washing activities is also likely to contain hydrocarbons. If this water is discharged without treatment, chemicals (hydrocarbons, pesticides etc.) and sediment could be transported into surface and sub-surface water bodies, resulting in ecological disruption. Contamination of water resources by the operation could therefore exacerbate the effects of climate change-related reduction in water availability, increasing pressure on the social as well as the natural environment. Mitigation measures as mentioned in Section 4.2 of this report (as well as the Water Assessment Specialist Study and Waste Specialist study) should be followed.

#### *4.1.4.2 Issue 2: Loss of ecosystem goods and services*

The Ranobe Project will result in the temporary loss of approximately 455 ha of natural vegetation. This includes forested areas, as well as degraded forested areas which have subsequently been used for agriculture (both crop cultivation and grazing land for zebu). The biophysical environment, of which various vegetation types are a key component, has been shown to be of great importance to local human and animal communities. It provides ecosystem goods and services including but not limited to the provision of food, water, fuel and building materials on which local communities rely. The loss of vegetation as well as ecosystem services currently provided within the 455 ha project area is likely to increase use and pressure on the natural resources of the surrounding area to sustain local communities. Loss of vegetation types susceptible to temperature and rainfall fluctuations as a result of climate change may result, increasing the overall loss of vegetation and exacerbating pressures placed by the communities.

##### *Food Security*

The predicted change in availability and quality of water, temperature change and climate extremes (for example heat waves, floods and droughts) is expected to impact negatively on food security of the area. The vulnerability of water supplies to climate change translates to the vulnerability of growing crops and the production of food. Increased temperature as a result of global warming may affect growth and therefore yield of crops. Extreme weather conditions will also affect crop yield.

As discussed previously, manifestations of climate change may include change in availability of water and, indirectly, an increase in soil erosion and loss of valuable topsoil. These factors may result in a reduction in the yield of crops and food security which may be further exacerbated by a direct loss of cropland, consumption of water and diversion of natural water flow as a result of the proposed development. In addition, the loss of large tracts of vegetation may result in reduced abundance of faunal food species.

##### *Loss of Carbon Stock*

In addition to its direct importance for the maintenance of ecological systems and provision of food, material for housing, medicine and energy, vegetation can act as an important carbon sink. If cleared vegetation is either burned or allowed to decompose, the carbon stored within the plant material will be released as carbon dioxide, thereby eliminating any future carbon storage potential of these plants while at the same time, releasing additional carbon dioxide to the atmosphere.

The primary actions required to mitigate for the disruption of the natural habitat have been described in detail in Chapter 5 of this report. Regarding the loss of carbon stock and offset of $CO_2$ emissions, it is advised that the developer implements best practice training programmes. These programmes should be designed to teach farmers how to farm more efficiently and thus reduce reliance on the slash and burn farming technique practiced in the project area as well as the ability to live off smaller pieces of land. The techniques to be improvised could adopt carbon capture and storage techniques as part of the soil conservation practice and soil improvement programmes.

In addition, the following mitigation measures should be implemented by the Ranobe Mine Project to mitigate against the climate change impacts of the loss of habitat:

- As far as possible, minimise clearing of woodlands which are in a mature or climax state;
- As an offset, consider facilitating alternatives to the charcoal industry in the local economy to reduce reliance on harvesting of woodlands for energy;
- Where feasible, implement carbon emissions offsets elsewhere. This may include long-term preservation of mature forest and other vegetation types with high carbon stock;
- Educate employees about conservation of vegetation resources (in the hope that unsustainable harvesting is decreased);
- Maintain vegetation in drainage lines to reduce loss of soil by erosion in the event of increased rainfall;
- Minimise vegetation clearing ahead of the mine path so as to minimise erosion and pressure on vegetation and related resources; and
- Prepare a detailed rehabilitation strategy that takes into consideration the likely impacts of climate change. This could include selection of more drought-tolerant species.

#### *4.1.4.3 Issue 3: Energy Consumption*

In addition to the potential climate change-related impacts associated with the clearing of vegetation, the consumption of fossil fuels, whether directly as fuel or indirectly through the use of electricity from non-renewable sources, will also contribute to climate change.

According to the IFC's Performance Standard 3 (2012), the production of more than 25 000 tonnes of $CO_2$-equivalents annually by a development should be regarded as significant. Based on an estimated diesel consumption of 14 million liters/annum during the operational phase and an emissions factor of 2.63 kg $CO_2$ e/L diesel, fuel consumption alone is therefore likely to equate to 36 820 tonnes of $CO_2$-equivalents per annum and would thus exceed the IFC threshold and be regarded as a significant contribution to $CO_2$ emissions. As such, it is recommended that a carbon footprint be established for the facility within the first year of operation. This must take into consideration the loss of vegetation. Thereafter it will be necessary to develop a greenhouse gas management plan for the operation with the specific intention of reducing GHG emissions as far as practicable.

Potential mitigation measures could include:

- Quantification of GHG emissions must be conducted annually in accordance with internationally recognized methodologies and good practice;
- Committing to efficient use of energy through the environmental policy;
- Correctly sizing motors and pumps and use of adjustable speed drives in applications with highly variable load requirements;
- Actively considering and, where practical, implementing measures to reduce energy consumption of the development. This may include the installation of solar water heaters;
- Ensuring that all machinery, including vehicles, are well maintained;
- An Operating procedure for carbon management, including key performance targets, should be designed and implemented. This should include the management of re-vegetated areas (as carbon sink) for carbon offsetting measures;

- Development and implementation of an Energy Management Plan for the facility; and
- Consideration of carbon sequestration potential when developing the rehabilitation strategy for the facility.

#### *4.1.4.4 Issue 4: Health Impacts*

It has been predicted that climate change will influence the prevalence of certain diseases and susceptibility of local communities to disease may be increased as a result of reduced food availability and subsequent reduction in immunity as well as a loss of access to medicinal plants. Certain vectors may be able to extend their ranges and changes to climate may influence vector populations. Change to rainfall patterns (such as shorter periods of more intense rainfall) may provide additional breeding areas (such as temporary puddles / ponds) for vectors such as mosquitos (which transmit malaria). It is recommended that measures be taken to ensure that food security and access to medicinal plants is not compromised as a result of the project.

Potential mitigation measures could include:

- Take steps to improve awareness of vector-borne health risks amongst employees and local communities;
- Develop an integrated pest management plan for the facility that includes vectors for disease;
- Implement necessary procedures to minimise the presence of stagnant water on the site. Through consultation with local communities, establish an inventory of key ethnobotanical resources in the area of the mine and, as far as practical, develop a nursery for cultivation of these species (such as medicinal plants); and
- Take reasonable efforts to rescue key ethnobotanical species from the mine path.

#### *4.1.4.5 Issue 5: Cumulative impact on the marine environment*

The Grand Récife of Toliara is a prominent feature along the Madagascan coastline being one of the largest barrier reefs in the region at approximately 19 km in length, and incorporating reef flats approximately 33 $km^2$ in area (Harris et al. 2010). The reef system forms a protective barrier creating a sheltered deep water lagoon on the landward side in which the Port of Toliara is located. This reef system is considered one of the most diverse along the southwest coast of Madagascar with two barrier reefs (Grand Récife and Nosy Tafara), two coral banks (Mareana and Ankilibe), three lagoon reefs (Norikazo, Dimadimatse and Beloza) and a fringing reef in the south (Pichon 1978).

Rising or decreased surface sea temperatures, reduced salinity, change in nutrient availability, pollution and any other change in marine conditions which cause stress to coral reefs result in corals to release their symbiotic algae (which provides the pigmentations) and turn the corals white - a process known as coral bleaching (Conservation International & WWF 2008, NOAA 2011).

El Nino Southern Oscillation (ENSO) events cause an increase in surface sea temperatures every four years (Conservation International & WWF 2008). These events are expected to increase in frequency as well as intensity with climate change (Conservation International & WWF 2008). The largest coral bleaching associated with an ENSO event to occur in Madagascar was 1998. Whereby 80% of Madagascan coral reefs were affected (Conservation International & WWF 2008).

Once bleaching has taken place, the coral reefs are then placed under further stress and are susceptible to dying (NOAA 2011). It has been recorded in Madagascar's southwestern coast that algae have invaded partly as well as completely destroyed coral reefs. (Blue Ventures 2006). This invasion of algae reduces feeding opportunities for fish which rely on reef organisms, which

may decrease the fish population, impacting on livelihoods based on the fishing industry (WWF 2009).

Based on the above, coral reefs around the world have already experienced extensive damage due to climate-induced bleaching. As such, developments that will contribute further to climate change or pollution of the marine environment could introduce further stress to these already vulnerable marine ecosystems. While it may not be possible to accurately assess the direct impact of individual projects, such as the Ranobe mine project, on local coral reef systems, their potential contribution to cumulative impacts on marine systems, either through emissions, use of fossil fuels or direct pollution, should be acknowledged.

### *4.1.5 Decommissioning Phase Impacts*

Even though there will be a large number of heavy vehicles present during the decommissioning phase of the project and subsequently a significant increase in vehicle emissions, the carbon emissions produced during the decommissioning phase is nominal to that produced during the operational phase (using diesel generators for providing power to the MSP and PCP as well as increased vehicle emissions). For this reason the impacts of the project on climate change is considered to be mainly associated with the operational phase (as discussed above).

### *4.1.6 Risks and hazards*

| Risk | Cause and Comment | Rating without mitigation | Recommendations |
|---|---|---|---|
| Reduced water availability and quality | • Exacerbation of drought and reduced water table may impact on the availability of the 504 $m^3$/hr of water required for the mining operation. | HIGH 3C | • Long term monitoring is required to confirm the results of the model and to ensure that the project does not have any unexpected impacts upon local water users and the surrounding environment, and support corrective measures, where and if necessary.<br>• Long term monitoring (during and after project implementation) should include the following:<br>○ Weather monitoring (specifically rainfall and evapotranspiration);<br>○ Piezometric levels at observation wells located near and downward from the mine area and well fields, and also near sensitive areas (villages, Manombo River, coastal wetlands);<br>○ Water levels within the surface water bodies (Manombo River, coastal wetlands) as well as flows on the Manombo River;<br>○ Local water supplies (hand-dug wells, private (hotel) wells, irrigation channels);<br>○ Inspection of the surrounding of the well fields to insure that no sinkholes are developing;<br>○ Water chemistry (salinity) at observation wells were there could be a potential risk of salt intrusion;<br>○ Ecological monitoring of coastal wetlands;<br>○ It will be important to include monitoring sites which are not affected by the mine and water abstraction processes, as comparative sites, to assess potential background changes which are not associated with the mine development. |
| | • Mine operation may contribute to water contamination which would in turn be exacerbated by climate change and impact on the availability of potable water for the mine and neighbouring communities. | HIGH 3B | • The General landfill to be constructed onsite should be designed and operated to international standards in order to isolate the wastes and prevent environmental contamination, particularly groundwater contamination (EHS Guidelines for Waste Management Facilities 2007 and EPA 2000) and must be licenced by the developer early in the construction phase.<br>• It will be essential to implement a ground water monitoring system in the vicinity of the constructed landfill site in order to detect any changes to the quality of sub-surface water. |