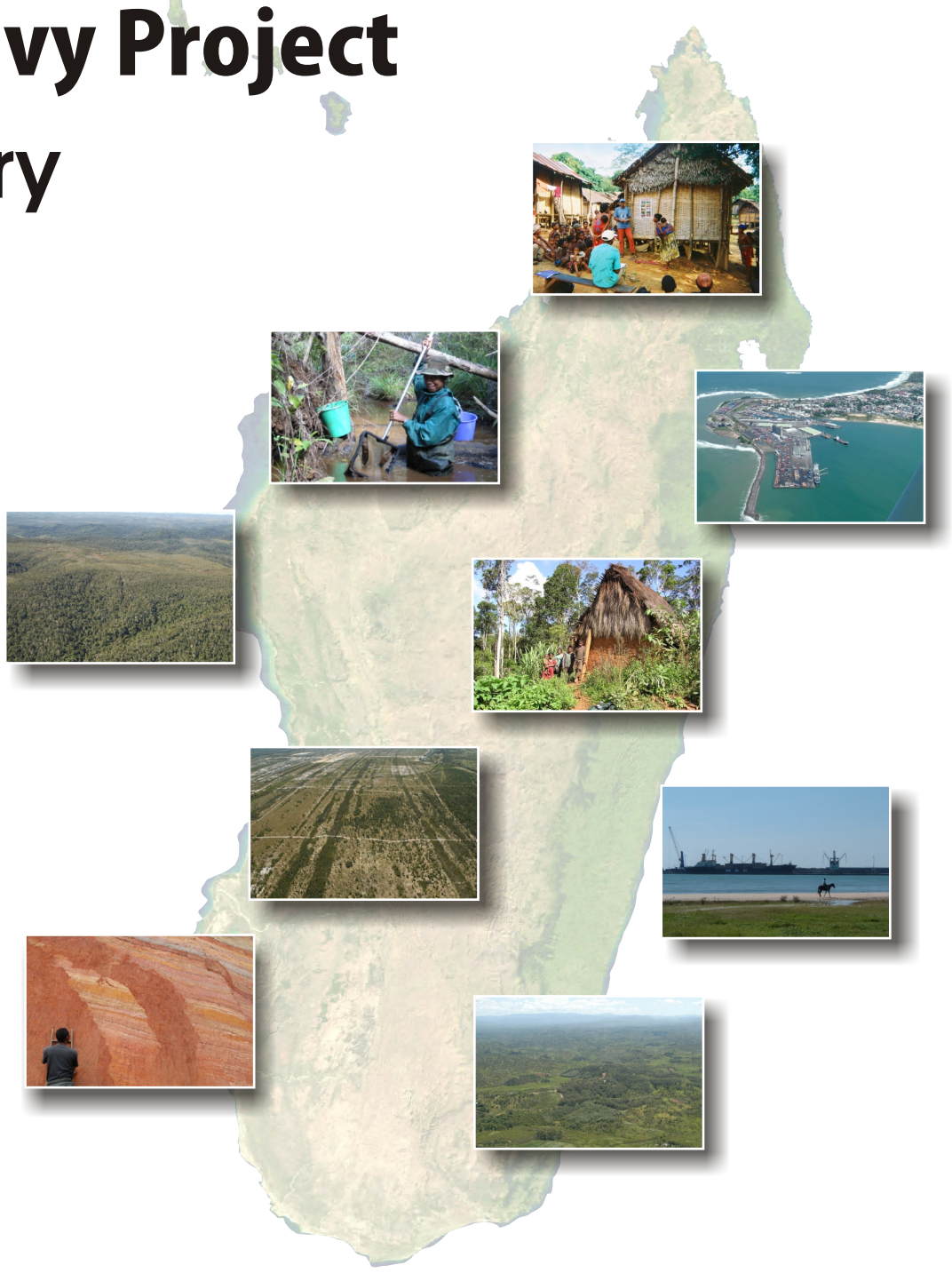
# Environmental Assessment Ambatovy Project

## Summary



**Submitted by Dynatec Corporation of Canada on behalf of the Ambatovy Project**

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Golder Associates

# INTRODUCTION


Location of the Ambatovy Project in Madagascar

In 1960, the Malagasy Geologic Service first mapped the Ambatovy and Analamay nickel / cobalt ore bodies north of Moramanga in central Madagascar. Since then several companies have conducted exploration drilling to evaluate the mineral deposits, including most recently Dynatec Corporation of Canada (Dynatec). Now a joint venture including Dynatec is proposing the development of both ore bodies through the Ambatovy Project (the project). For the purpose of the Environmental Assessment (EA), the project is divided into five sites:

- mine site;
- slurry pipeline;
- process plant;
- tailings facility; and
- port expansion.

The open pit mine will produce nickel and cobalt ore over at least 27 years. A slurry of ore and water will be sent by pipeline from the mine to a process plant near Toamasina on the east coast. A tailings facility will be constructed southwest of Toamasina, to receive tailings solids from the process plant. In Toamasina, the existing port will be expanded to allow for import of raw materials such as limestone, coal and sulphur, and export of a mixed metal sulphide. The exported product will be refined to pure nickel and cobalt at an off-shore refinery. The schedule for the project is subject to Environmental Assessment (EA) review, permitting and detailed engineering design, but proposes construction from 2007 to 2009, with production beginning in 2010.

Over the 30 year lifetime of the project, average direct employment of Malagasy labour is estimated at between 1,400 and 2,000 jobs annually. Money spent in Madagascar is estimated to be over US$100 million annually. In addition, an estimated annual average of US$25 million will be paid to the Malagasy government (duties, tax and royalties). Many additional indirect and induced economic benefits will also be realized and will be described later in this summary.

In developing the Ambatovy Project, including preparing the EA, the proponents have strived at all times to maintain high social and environmental standards. The EA explains proposed mitigations that will be implemented to ensure that beneficial project effects are optimized and negative impacts minimized. The proponents are committed to

teaming with communities, government and other stakeholder groups, to integrate the project regionally as a contribution to sustainable development.

## The National and Regional Context

Madagascar, located off southeast Africa in the Indian Ocean, is the fourth largest island in the world. Madagascar has a total land area of 587,040 $km^2$ and is rich in natural resources and ecosystems, including some of the world's most unique biodiversity. Despite its diverse resource base however, the country's 18 million people represent one of the world's least economically developed nations, with over 70% of the population living below the national poverty line.

Rural poverty and the environment are closely linked. Environmental degradation along with associated soil erosion is reducing agricultural productivity and increasing rural poverty. Madagascar has lost about 50% of its forest cover since 1960, with about 12 million hectares cleared. Forest clearance, practiced in the 1970s and early 1980s to produce more rice to feed the growing urban population, accounted for a large proportion of the lost forest cover. However, since the launch of the Government's National Environmental Action Plan in the late 1980s, deforestation rates have declined.

Special reserve near Andasibe

Madagascar has 53 protected areas, with a total surface area of just under 2 million hectares, or 3% of total land area. This network of protected areas is overseen by the National Association for the Management of Protected Areas (ANGAP). A commitment known as the Durban Vision was made by the President of Madagascar to triple the area under protection (including terrestrial and aquatic/marine protected areas) to six million hectares by 2009.

Recently, the government has aggressively pursued reforms, particularly oriented towards gaining the confidence of private investors. Public sector, tariff and customs reform, concessioning of major public enterprises and infrastructure and a concerted effort to battle corruption, create an improved climate for foreign investors. Regulatory reform has focussed on the mining sector, as the rich natural resource base is considered a potential source of economic growth and development. The determination of the government to reform in the interest of national economic and social development has resulted in support from international financial institutions and bilateral development assistance agencies.

The country is politically divided into six faritany or provinces, 22 regions, 110 prefectures, and over 1,500 communes, which are the smallest formal administrative units. All components of the Ambatovy Project are located in Toamasina Province. Early efforts in the mid 1990s at decentralization legislated responsibilities of commune governments,

including responsibilities for social services and development planning. However, the process of strengthening the capacity of rural communes has been difficult and is ongoing.

Fokontany and fokonolona are kinship-based units, composed of extended families and are traditionally governed by elder representatives of principal families. These units are no longer recognized by the new legislation on decentralization, but still have real value in practical terms. These have been the basic units of social organization.

## Regional Planning

Lake Alaotra

A number of important government planning initiatives relevant to the development of the Ambatovy Project also take place at a regional level. Madagascar has been split into 22 regions for the purpose of aiding decentralisation of economic development, with each region producing a regional development plan focused on sustainable development and poverty reduction. The regions are not only planning units, but also decentralized territorial collectives and administrative areas (Article 4, law no. 2004-001). Alaotra–Mangoro and Atsinanana are the main regions in the project area. At a smaller scale, Toamasina Province is split into three regions, with each developing a regional development plan. The project is located within the Mangoro and Toamasina economic zones. Lastly, within a large central part of Toamasina Province, a planning structure has been created for the Ankeniheny–Zahamena Corridor. (This corridor was previously called the Mantadia–Zahamena Corridor, and is so named within most of the EA.) The planning region comprises much remaining tropical forest and the initiative aims to harmonise development with natural resource conservation needs.

## The Environmental Assessment Process

The Ambatovy Project requires an EA approval to commence mining, as described in Madagascar's Environmental Charter of 1990 with subsequent modifications. This EA follows the Terms of Reference (ToR) issued in 2004 by the Malagasy National Office for the Environment (ONE). The ONE therefore appointed a Technical Evaluation Committee (CTE) in 2004 to review the EA.

Community consultation

Work on the EA started in January 2004, and benefited from studies during 1996 - 1998 for the Phelps Dodge mine project at Ambatovy. As required by the ToR and international guidelines, ongoing consultation has been, and continues to be, an important part of the EA process. Over 150 disclosure and consultation meetings took place in 2004 and 2005, with a variety of stakeholders: the public, NGOs, special interest groups, and regional and national government. Some meetings were large and involved many stakeholder groups at once, while others were small, such as meetings with village members living near the project. Along with professional expertise, consultation provided a solid basis for

focusing mitigation planning and impact analyses on issues of concern. The CTE also participated in consultation during 2004 when the focus was on project disclosure and identification of issues, and late 2005 when the emphasis changed to discussing proposed mitigation.

CTE workshop 2005

Many issues were raised during consultation and these have been discussed throughout the EA. Some key issues include:

- the need to optimize employment and economic benefits for Malagasy people;
- concern over the need to re-settle people, especially from the tailings area;
- concern over possible health and safety effects on people, including from HIV/AIDS linked to migrant workers;
- concern that changes to water quantity and quality downstream of the mine and tailings area could damage the environment and affect people and agriculture;
- concern over the level of impact the mine will have on biodiversity; and
- concern that the slurry pipeline will further fragment primary forest in the Ankeniheny–Zahamena forest corridor.

Public consultation will continue during construction and operations.

The preparation of the EA also involved collaboration within the project's EA team, which comprised Dynatec staff, international consultants and many specialists based in Madagascar. The EA considered baseline conditions, construction, operations and closure phases for the project. As required by the ToR, the EA process included the following steps:

- identify the environmental and socio-economic resources potentially affected by the project;
- predict positive and negative effects and the extent to which positive effects can be enhanced and negative effects mitigated;
- quantify and assess the significance of effects where possible;
- consider the need to compensate for any high residual negative effects; and
- identify methods to monitor resources that may be affected by the project.

The above steps suggest a linear flow of activities. However, in many instances, results of initial impact analyses were provided to the engineering design team, so that negative impacts could be minimized through improved design. The EA provides the basis for the development of an environmental and social management plan for construction, operation and closure.

As reflected in this summary, the EA considers each of the five project sites in turn. This approach allows for a focused assessment that considers each spatially separated site in detail. However, the Ambatovy Project is a single project, composed of all project sites. Combined effects of the project as a whole are assessed after each site is considered in turn. Further details on the structure of the EA report are provided at the end of this summary.

## Project Policies

Project-specific policies on environment, health and safety, re-settlement and biodiversity have been developed for the Ambatovy Project. It is the policy of the project to maximize Malagasy employment to the extent feasible given skill requirements. It is also project policy that training programs be put in place to enhance the skill level of local residents, enabling increased employment over time. The human resources policy also promotes project programs to enable local companies to participate in the project, with a focus on Small and Medium Enterprises (SMEs). The Project has also endorsed the Equator Principles developed by financial institutions to assess and manage environmental and social risk in project financing.

# MINE SITE

## Social Context

The mine site is about 14 km northeast of the regional centre of Moramanga, and near the communes of Morarano Gare, Ambohibary (also called the Suburban Moramanga Commune), Ampasipotsy and Andasibe. The sub-villages of Berano, Behontsa, Andranovery and Ampangadiantandraka are closest to the mine site. The total population in the mine social study area approached 80,000 people in 2003, with less than half of these in the town of Moramanga.

Moramanga

The economy has both rural and urban aspects. Rural livelihoods are based largely on subsistence agriculture, predominantly rice and manioc, and to a lesser extent livestock. People depend on the nearby markets of Moramanga to sell agricultural and artisanal products. They also exploit forest resources for additional subsistence and work in the wage economy. The town's economy was based primarily on forestry, including production of lumber but also manufacturing of wood products. This industry is in decline.

Valley with the sub-village of Berano near mine site

## Culture

The rural population is very young, with well over half under the age of 16. Overall, the rural economy is characterized by multiple cash income and subsistence sources, of which agriculture is the chief component although accounting for only about one quarter of income. This is despite the fact that according to focus groups, about 95% of the population works in the agricultural sector. At present, land use by people in the general mine area is gradually transforming the vegetation cover of the landscape. It is estimated that the current national rate of deforestation is about 1% per year.

Belief in tradition and in the accumulated wisdom of the ancestors has shaped Malagasy culture. Beliefs and customs remain a key part of Malagasy life today. The table below lists the main types of cultural sites that occur in the region of the Ambatovy Project.

### Main Types of Cultural Sites in the Project Area

| *Site Category* | *Sub-Categories* | *Cultural Relevance* |
|---|---|---|
| tombs | Fasana | considered ancestral residences, their displacement requires careful attention to proper ritual |
| | Tranomanara | |
| | Feraomby | |
| cemeteries | -- | as above |
| ceremonial sites | Jiro | family prayer altar |
| | Fisokona | communal prayer altar |
| nefarious places | Tany Mahery | bad luck area |
| sacred waterfalls | Riana | symbolize purity; place for offerings |
| other cultural / archaeological sites | Vatolahy | large raised stone commemorating an important person or event of the past |
| | Tsangambato | small raised stones symbolizing a tomb |
| | Tanana Taloha | ancient abandoned villages |

During surveys of the mine site, three sacred waterfalls, three ceremonial centres, two symbolic tombs, and several ancient villages were found. Of these cultural resources, however, only one sacred waterfall is located within the actual mine footprint. In addition, about eight kilometres east of the Ambatovy ore body, a hill named Ambavahadivohitra has been identified as being a principal communal prayer area (fisokona) used by the regional population as a whole. Overall, there is a relative scarcity of cultural sites in the mine area. Also, people have not been dependent on the generally stunted azonal forest (see description below), but have focused on the thicker forests farther away from the proposed mine area.

# Environmental Context

The project proponents recognize that Madagascar has a unique biological diversity within a sensitive tropical environment. Because of this, a very experienced group of over 50 local specialists joined the EA team and conducted extensive soils, water, flora and fauna baseline surveys in the mine area. This allowed the EA team to be in a good position to assess potential impacts and design mitigation.

The mine area includes the eroded remnants of a plateau located at about 1,100 metres above sea level (masl). Temperatures in the area of the proposed mine have ranged from 8°C to 31°C with an annual average of 17°C. The plateau is flanked to the west by the broad alluvial plain of the Mangoro River and to the east by the Torotorofotsy Wetlands and forested hills.

The plateau surface is fairly uneven with numerous depressions that form ephemeral pools. Small headwater streams originate in the mine area and flow away in all directions as part of six basins. The mean annual rainfall is estimated to be 1,700 mm. Based on the Madagascar classification system for surface waters, most watercourses and water bodies near the mine site are assigned to “Class A” (i.e., water is suitable for multiples uses). In a few samples, baseline concentrations of lead, nickel and arsenic were higher than the World Health Organization drinking water quality guideline values.

Aerial view of mine site at Analamay

The mine site is covered with natural forests. The surrounding area includes intact and degraded forests and scrublands, areas dominated by grasses, eucalyptus plantations, woodlots and rice paddies. The soils in the mine region are generically known as laterites, which are highly weathered iron-rich tropical soils. The ore bodies are characterized by ferricrete soils with a hard, rock-like surface. This has resulted in the forests on the ore bodies being different (azonal) from the surrounding primary forest (zonal).

These azonal forests and shrub lands have been found to have a high percentage of listed species (listed as at risk by conservation agencies) and locally endemic species (species only known from the local area), especially flora. Botanists from Missouri Botanical Gardens (MBG) based in Madagascar, working as part of the EA team, have been studying this area extensively and identifying the species of concern (local endemic species currently only known from the mine footprint). So far there is a total of 127 flora species of concern at the mine site. Of this total, 53 species are currently listed in one of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) appendices, five are on the International Union for the Conservation of Nature (IUCN) list, and there are 68 others currently only known to occur in the Ambatovy/Analamay area. As MBG note, most of these species likely occur at one or more sites outside the Ambatovy/Analamay area, and in many cases they are probably present

within at least one protected area. As a result, further investigations are being conducted to search for species of concern off-site in the period before construction. Until evidence has been gathered that confirms the existence of populations outside the immediate mine area, each species will be retained on the list and they will be subject to focused species-level conservation programs.

Faunal species of concern in the mine area include local and regional endemics, rare species and species restricted for trade under CITES. Five amphibian and reptile species are regionally endemic and cause for conservation concern. Three of these species are not currently officially classified. Two species are new to science and have been found only in the Ambatovy area. As in the case of flora, while discovery of individuals of these species outside the project area is likely, they must be considered locally endemic to the project area until found elsewhere. Six of the species observed in the mine area are listed by IUCN and 21 species are listed by CITES.

The slender-billed flufftail

The most significant bird species was observed outside of the immediate mine area in the Torotorofotsy Wetlands. This species is the endemic slender-billed flufftail, which is only known from one other location in Madagascar and is facing severe habitat loss. Studies for this project have added greatly to the understanding of the biology of this species. Marsh habitat is severely threatened in Madagascar due to conversion of marsh into irrigated rice. Fifteen of the bird species observed in the mine area are listed by IUCN and 16 species are listed by CITES.

An indri

For mammals, nine lemur species were found in the mine area. All lemurs are endemic to Madagascar and seven of the nine lemur species observed are listed by IUCN. All lemur species are listed in Appendix I of CITES. One of the small mammal species, a shrew tenrec, may represent a new species. Two species identified during the surveys are IUCN listed but none is listed by CITES. Six bat species and one genus were detected during the bat survey, with one species listed by IUCN. None of the bat species detected is listed by CITES.

For insects, an important discovery was the observation of colonies of the *Pilotrochus* ant near Ambatovy. This endemic genus has not been observed since 1975 near Moramanga, despite widespread surveys. The discovery in the Ambatovy area suggests that *Pilotrochus* is locally endemic. In addition, one ant species is IUCN listed as vulnerable, but none is listed by CITES. The detection of the rare *Hovala* 2 is the most significant butterfly observation. There are less than 10 known specimens of this undescribed *Hovala*, which appears localised to the Analamazaotra region. The IUCN vulnerable species, *Papilio mangoura*, a swallowtail butterfly, was recorded although this has not yet been confirmed from detailed taxonomic analysis. No butterfly species is listed by CITES.

About half of the aquatic sites surveyed in the mine area were natural and largely undisturbed. However, within the Torotorofotsy Wetlands aquatic habitats generally had significant disturbance and loss of natural ecosystem function. Fifteen fish species were collected from the mine area, of which three were endemic, eight introduced and four native (natural to Madagascar but also found elsewhere). A fourth endemic, a new species of Malagasy rainbowfish (*Rheoclès* "*Ambatovy*"), may also be present. Two fish species were IUCN listed. A total of 70 aquatic macro-invertebrate taxa were recorded in the mine area. In contrast to the fish fauna, both diversity and abundances of the macro-invertebrate fauna were high. The ephemeral ponds were fishless, but contained a unique assemblage and diversity of macro-invertebrates and plankton.

The above summary shows the high level of biodiversity in the mine area, across a wide range of taxa. A large number of species present are also of conservation concern, as judged by IUCN (54 species) and CITES (104 species). Within the mine area the azonal habitat scored the highest for most biodiversity measures, particularly for number of species, habitat rarity and numbers of locally endemic species.

### Regional conservation planning

Torotorofotsy Wetlands are the largest and most intact natural marsh in eastern Madagascar and are now a Ramsar site (wetlands of international importance). The proposed Ankeniheny–Zahamena Conservation area is also located east of the mine. The Corridor is in the process of being defined as a Conservation Site by the Government of Madagascar, with input from other interested parties.

# Project Description

Mining is planned for the first 20 years of operation and stockpiled low grade ore would subsequently be reclaimed and processed over an additional seven years. The total area to be mined progressively over the 20 year period is about 17 $km^2$.

Ore body exposure

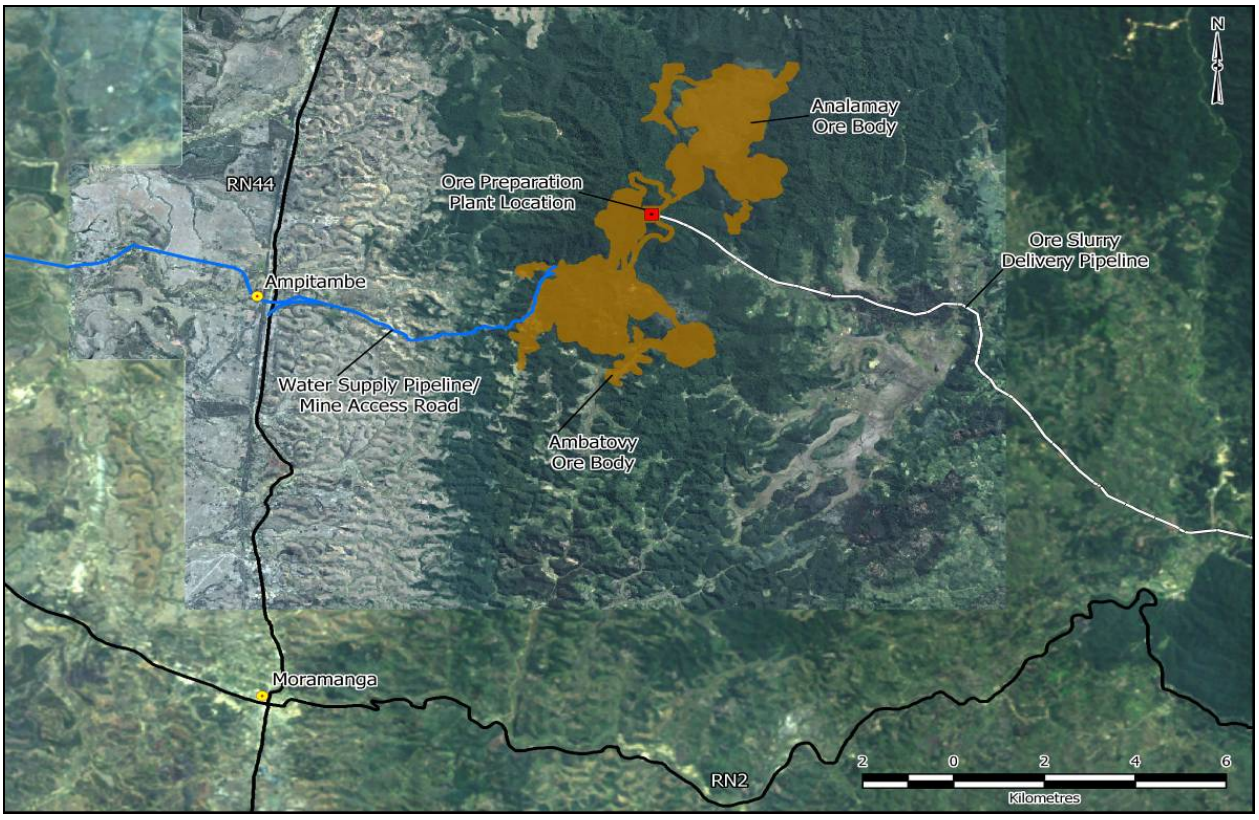
The ore bodies are up to 100 m thick and within several metres of the surface, allowing extraction by the shovel and truck method, which is flexible and economic for ore bodies of this type. The ore would be screened to obtain material of the size needed for mixing with water to make a slurry. The slurry would be sent by pipeline to the coast for processing. In addition to screening and mixing facilities, there would be offices, workshops and accommodation facilities at the mine site.

The access road to the mine site from Ampitambe will be upgraded. Mine site activities would require transport of supplies from Toamasina and Antananarivo. Following mitigation, increased risks to the public and the environment of natural hazards, such as flooding, as a result of the mine, are estimated to be low and within international standards.

Water supply for the operations will be provided by pipeline from the Mangoro River and supplemented with storm water runoff collected from the mine site. On-site diesel generators will supply power. During operations, re-vegetation of disturbed surfaces will be started as ore is removed and areas are released from mining activity.

The development of the mine site will involve removing some land from agricultural use. Compensation for this land will be planned and implemented according to International Finance Corporation (IFC) guidelines, in full consultation with the land users. At the present time, two households in the mine footprint area are planned to be re-settled. A Resettlement Action Plan (RAP) is being developed in parallel with this EA.

Construction can only start after EA review, permitting, additional engineering design and a formal development decision has been made. Construction will continue for about three years. There would be a large construction labour force, hired to the greatest practical extent from the Malagasy population. Details of training initiatives are given below. The total workforce would average 1,420 during construction, of which 540 are predicted to be locals. The operations phase workforce is expected to be about 390 over the mine life, of which 360 are predicted to be Malagasy.




The mine area

# Key Impacts and Mitigation

Main issues identified through consultation and through the professional experience of the Malagasy and international EA team included:

- the need to train local people and optimize employment benefits for the Malagasy population;
- in-migration issues from a migrant labour force, including HIV/AIDS;
- impacts on tombs and cultural sites;
- impacts on rare tropical forest habitats and the biodiversity they contain; and
- water quantity and quality impacts on people and the environment, including the nearby Torotorofotsy Ramsar site.

# Water

The mine layout and water management plan have been designed to minimize off-site impacts, with special attention to the Torotorofotsy Wetlands. Early in the design phase, it was decided to protect the Torotorofotsy Wetlands by keeping project elements away from the basin draining to the Torotorofotsy. A preliminary assessment determined that based on economic, social and environmental perspective the reliability of meeting the water needs for the ore processing plant and downstream users would best be met through the combined use of the Mangoro River and mine runoff collection. As a result, the Mangoro River water pipeline was included to provide water for ore processing, especially in the dry season. Maximum ore processing water requirements represent less than 0.3% of the mean annual flow in the Mangoro River, and less than 1.5% of the flow for dry conditions. The goal of the mine water management plan is to provide enough water for the slurry plant, while maintaining seasonal flows off-site. There will be some additional wet season flows during operations, because of vegetation clearing, but these will be offset by reduced groundwater flow. At closure, the mine area will be returned to natural runoff conditions through reclamation.

Torotorofotsy Wetlands

The water released from the runoff collection ponds into the downstream basins will be designed to meet World Bank suspended solids concentration criteria of 50 mg/L or less, based on a 1 in 10 year storm event. For storm events greater than the design storm, suspended solids levels entering the receiving streams may exceed the 50 mg/L criteria for short periods. The elevated concentrations, however, will be diluted by high downstream flows. Due to the sensitive nature of downstream receiving environments and requests during consultation, additional sediment modelling is being undertaken to better understand the probable suspended solids concentrations that could be released from the ponds during extreme storm events, such as two cyclones in quick succession. There will be flow monitoring in streams around the mine during operations, plus regular contact with downstream users on the acceptability of flows.

For other water quality parameters during operations, it is predicted that chromium will have the greatest increase over baseline, owing to run-off from the mine and waste areas. However, because of mitigation, the predicted concentrations for chromium and other parameters of concern are below the World Health Organization (WHO) drinking water guidelines. During post-closure, predicted maximum concentrations for all substances will be at or below baseline levels. Water quality and suspended solids concentration will be monitored at the clarification pond outlets and key downstream locations.

# Biodiversity

## Habitat level

Activities related to construction and operation of the mine will result in vegetation losses, including rare habitat types. This is due to the direct linkage of these rare azonal habitats with soils overlying the ore bodies. There will be a loss of 1,326 ha of azonal and transitional vegetation types, which represents 46% of these habitats in the local study area. Forest types to be re-established through progressive reclamation will be more zonal than azonal. As a result of the predicted high residual impacts to biodiversity and the importance of azonal and transitional areas to supporting rare plants and fauna within the mine area, the proponent is proposing a comprehensive on- and off-site mitigation plan to preserve key habitat elements. Given current trends in habitat loss due to timber cutting for construction, firewood and charcoal production within Madagascar, the proposed mitigation and compensation plan should provide more positive long-term benefits to the region than if the status quo (no project alternative) were to remain. The main mitigation and compensation to address these impacts include:

Azonal forest – Ambatovy

- two on-site azonal conservation areas totalling 305 ha will be established within the bounds of the ore body complex to provide protection for locally endemic plants, fauna and aquatic resources;
- project participation in design and implementation of a cooperative buffer zone forest management plan (FMP) with the Malagasy government and stakeholders, to provide a framework for sustainable forest management within the local region; and
- establishment of an off-site azonal conservation area as part of the compensation for the impact to this habitat type — a potential azonal off-site conservation area on an ultra-basic outcrop was identified at Ankera near Mantadia National Park during an aerial reconnaissance of a number of ultra-basic sites located from geological maps; work is continuing in this area.

The above biodiversity offsets together cover approximately 7,100 ha off-site, compared to the impacts to natural habitats on the mine site during construction and operations, which cover about 1,700 ha. This does not take into account on-site mitigation initiatives, including progressive reclamation. Thus for the mine, the offsets are four times the impacted area.

### Species level

At the species level several mitigations will be implemented to reduce or eliminate the possibility of species loss in the mine area. These include:

- provision for on-site and off-site azonal conservation areas, which will also provide protection for vulnerable species;
- continue to conduct on-site and off-site surveys to confirm the presence of rare species away from the disturbance area and so reduce or eliminate the list of species of concern, especially for flora;
- establish species-level conservation programs including collection, identification, transplantation and cultivation of any remaining flora species of concern before construction begins;
- preservation of seasonal downstream flows to maintain natural ecosystem functions and aquatic biodiversity; and
- relocation or collection of selected rare fauna before site clearing.

Through these mitigations, the Ambatovy Project is committed to ensure that viable populations of rare species are secure during construction, operations and following closure of the mine. Monitoring programs will be implemented for flora and fauna, especially to confirm the status of on-site azonal conservation areas during operations. Monitoring will also be important to evaluate the effectiveness of progressive reclamation efforts.

## Reclamation and Closure

A reclamation and closure plan has been prepared as part of this EA. This document will be updated throughout the project life to reflect changing conditions and input of regulators and stakeholders. Progressive reclamation will be implemented where possible. Main goals of reclamation are:

- the reclamation and closure design will ensure that long-term physical and chemical stability is provided for disturbed surfaces;
- upon cessation of operations, the area will be decommissioned and rehabilitated to restore the site to forested habitat consistent with the surrounding zonal forest; and
- revegetation research and implementation of progressive reclamation will guide the refinement of concepts for final closure.

Reclamation of exploration disturbance

The mine site is in a near-primary forest matrix at the western edge of the Ankeniheny–Zahamena forest conservation planning area. The primary objective of reclamation at the mine site will be to maintain biological integrity of landscapes, ecosystems, communities, habitats, as well as fauna and flora populations. Forest protection on the mining lease will be planned, implemented and enforced through the forest management agreement being developed by the project proponent with the Malagasy Forestry Service.

# Socioeconomics

Consultation results indicate that economic opportunities created by the mine are a main concern. This includes people who do not expect to directly benefit, but who are interested to see economic alternatives to agriculture are available to young people. Mitigation for socio-economic effects includes reduction of negative effects and enhancement of positive benefits.

## Local labour and businesses

The project is expected to bring large economic benefits to the Moramanga area through creation of employment, demand for businesses, contributions to educational institutions and improvements in infrastructure. The project will partner with Moramanga and commune governments to jointly manage the socioeconomic challenges and opportunities that may arise as a result of the project. Emphasis will be to see that the project is well integrated into the Moramanga area as a sustainable development initiative. It needs to be considered that economic benefits in and of themselves are associated with improved socioeconomic status. To the extent that there is potential for negative effects, direct mitigation and an adaptive management strategy will be put in place to address the evolving effects so as to enhance the realization of benefit.

The project will extend employment and business opportunities on a preferential basis to mine site communes. Training and other assistance will be provided to these communes to help residents take advantage of these opportunities. When evaluating proposals for work on the project, the extent to which suppliers and subcontractors employ and contract mine site commune labour and businesses will be considered. Local labour needs at the mine are expected to average 540 during construction and 360 during operations.

Existing local businesses tend to be small and mainly oriented to serving the needs of local residents and tourists. The proponent has worked successfully with some local businesses over the exploration phase of the project. Similar to employment, local business participation in the project is expected to grow with time with the implementation of measures to assist that participation. The project will implement these measures under the Ambatovy Empowerment Program which is designed to enable local companies to participate in the project, with a focus on Small and Medium Enterprises (SMEs).

## Local Economy

Total construction expenditures at the mine site are expected to reach US$150 million. Operational expenditures are expected to be in the order of US$7 million per year over the 27 year operations phase. Closure and post-closure activities will also require local expenditure. Therefore the total inflow of expenditures on local wages, goods and services could be in the order of approximately US$340 million over the life of the project. There are no estimates of the size of the economy in

the Moramanga area, however it is likely that an injection of expenditures in the above amounts will be a large benefit.

Employees during exploration phase

In addition to direct employment and business opportunities, the project will be a stimulus for indirect and induced employment and business opportunities. Businesses contracted to supply the project will require new employees. With increasing direct and indirect local economic activity, individuals and business will spend more on local goods and services. This in turn will induce more employment and perhaps more small businesses as people in the community organize to provide additional goods and services for others with new disposable income. The project is predicted to create 2,200 local indirect and 590 local induced jobs during mine construction and 340 local indirect and 150 local induced jobs during mine operations.

## Training

The project will develop a formal training program for employees. This will include skills upgrading, apprenticeship training and the establishment of entry-level positions with a view to advancing people beyond entry level on a regular interval. At present US$10 million is estimated for training purposes over the life of the project. As the project moves forward, employees and suppliers are also expected to gain valuable experience that will position them to increase their level of participation. To the extent that this training program uses local educational institutions the quality of skills training in the Moramanga area is expected to improve.

## Commune government budgets

Legislation in Madagascar requires a portion of royalties paid in relation to mining projects be directed to communes within which mineral resources lie. In addition, a portion goes to the provincial and national governments. The large scale of the mine means that annual royalty payments will be very large in relation to existing commune revenue flows. However, the project footprint goes beyond the mine area, extending along the slurry pipeline route to the tailings and process plant facilities. These other areas, although far from the ore bodies, will experience project effects that royalty distribution is intended to help address. The proponents are willing to work with the Government of Madagascar to establish an equitable system for distribution of royalties paid by the project.

## Migration

The economic opportunity of a large project such as the Ambatovy Project has the potential to attract large numbers of migrants. Existing trends in rural urban migration, tensions over land in rural communes and the shortage of housing in Moramanga suggest that additional migration as a result of the project could be difficult to manage. The project will develop recruitment policies to discourage migration, and advertise these aggressively. The project will provide accommodation, meals, services and transport to and from their points of hire for all out-of-country workers during construction and operations.

## Water

In addition to various mitigation measures intended to manage water quality and quantity effects around the mine, the proponent will monitor water flow and quality and engage in ongoing consultations with nearby farmers. This will provide more information on the basis of which mitigation can be improved. It will also provide the data necessary to adequately address any grievances about water. Given the priority accorded to improving water management for farmers in the communes around the mine site, it is expected that the project will assist communes in this regard, as part of additional social investment.

## Forest use

The buffer zone forest management plan, being developed with the Government of Madagascar and the local community, aims to preserve the integrity of the forests around the mine while allowing for their sustainable use. Although the plan will be developed in consultation with stakeholders, it could limit access to specific areas and/or specific forest resources, at short term cost to some people's livelihoods. In the event of grievances of this nature, the project will investigate to adequately address them.

## Health and safety

People in the mine area are concerned that out-of-area workers and economic migrants are a threat to health and safety within their communities. There is a link between mining camps filled primarily with men of single status and/or having increased income and public health issues such as incidents of sexual abuse, teenage pregnancy, single parenthood, sexually transmitted diseases including HIV/AIDS, substance abuse and crime. This association guides current best practice in managing the behaviour of workers living in camps near rural communities and in limiting the potential for contact between workers and local people. Although the project will implement these best practices, employees housed at camp, any new migrants, and in-transit workers associated with the project, will inevitably interact in unpredictable ways with people of the mine site area. Attention to the potential for increasing the incidence of HIV/AIDS is particularly critical given the low HIV/AIDS prevalence rates in Madagascar and an aggressive HIV/AIDS prevention program will be implemented.

Consultation with people near the mine

The human and ecological health assessment evaluated the potential for adverse effects to health associated with emissions from the mine. Predicted impacts on human health due to possible changes in water, soil, air and produce quality were considered negligible. Monitoring of operational emissions will take place to confirm that guidelines are met and that downstream impacts are minimized.

Impacts on livelihood resources, including agriculture, livestock and fisheries due to changes in water quality during mine operation are also considered negligible upon application of the water management plan. The health and survival of fish and other aquatic resources, including organisms living in the Torotorofotsy Wetlands, are also unlikely to be affected by the mine.

## Social investment


Andasibe

The Ambatovy Project plans to supplement mitigation and benefit enhancement measures directed at specific impacts, with wider social investment. This investment would be a response to expectations of negative impacts that will occur as a result of the project, but that are not amenable to full mitigation. An example would be negative effects of migration. The project will also address unpredictable impacts that could evolve, as these are discovered through social monitoring, including consultation with project affected people and their governments. Examples could include pressures of migratory populations on schools or increases in crime. Madagascar is in a process of decentralization that has seen the establishment of multiple planning agencies. The project will offer participation in planning to those agencies involved in the implementation of programs if needed. Such project contributions to social investment will be a benefit to communes around the mine site, but also across a wider area insofar as regional planning capacity and initiatives are supported.

## Culture

Although the sacred waterfall at the mine site cannot be relocated, its sacred aspect can be modified. This is accomplished by virtue of the people's loss of contact with it – if rituals cannot be conducted there, it is no longer considered sacred by them. Such cases are common in Madagascar, occurring for example, in areas of urban expansion. For this to occur, however, proper protocol involving correct rites and rituals must be observed. Discussions and negotiations with resident groups will be conducted in this regard, facilitated by the proponents' Malagasy cultural specialists in order to find acceptable solutions.

## Monitoring

It is in the interests of the project to understand socio-economic trends such that where the project is able to intervene effectively, it has the information to do so. The project has a long term interest in healthy communities. In addition, putting in place a monitoring framework that attempts to understand cause and effect is important to both the proponents and affected people. This will contribute both to maintaining a constructive relationship between affected people and the project and to adjusting project mitigation measures in response to evolving impacts. A socioeconomic monitoring plan will be implemented, with three main components:

- operations monitoring of project inputs (benefits enhancement), to track success;
- monitoring effectiveness of mitigation of negative effects; and
- monitoring more widely, to better provide a context for adaptive management and additional social investment.

# SLURRY PIPELINE

## Social Context

Stop during aerial survey of pipeline route

Twelve communes are crossed by the slurry pipeline route, which include: Andasibe, Ambatovola, Andekaleka, Lohariandava, Fanasana, Fetraomby, Vohitranivona, Ambalarondra, Ambinaninony, Ampasimadinika, Fanadrana and Toamasina II. Three major land use zones were defined along the route: the western section, which is within the Ankeniheny–Zahamena forest corridor (corridor zone); the central section, which passes around primary forest fragments through an area defined primarily by tavy (tavy zone), and the eastern section, comprising mainly agricultural lands (agricultural zone). Consultation and socioeconomic baseline data collection took place in over 70 villages along the approximately 195 km route. Communities were mainly accessed by foot in three surveys, one for each zone. In general, people appear to be economically worse off than those in the mine area. While land shortages do not apply, crops are often lost as a result of an inability to manage water through variations in rainfall. Due to remoteness and lack of transportation, people are often unable to access markets to sell surplus products. There are limited options for diversification of livelihood – employment for cash income is generally not available and over much of the slurry pipeline route there are few forest resources.

Aerial view of slurry pipeline route in Tavy zone

### Culture

Field work resulted in an initial list of cultural sites near the pipeline route. In all, 27 tombs, 19 symbolic tombs, two ceremonial sites, three abandoned villages and one church were located within a 1 km wide corridor.

## Environmental Context

The slurry pipeline runs from the hills north of Moramanga, along the north side of the Torotorofotsy Wetlands, through a series of watersheds with steep valleys and granite outcrops and continues over rolling hills until reaching the flat coastal dune area near the east coast. The route assessed crosses about 100 watercourses, ranging from small streams to large rivers. About 80% of the rainfall in the western portion of the route occurs from November to March. Rainfall near Toamasina occurs year-round and is double the amount received at the mine site.

Pipeline stream crossing location

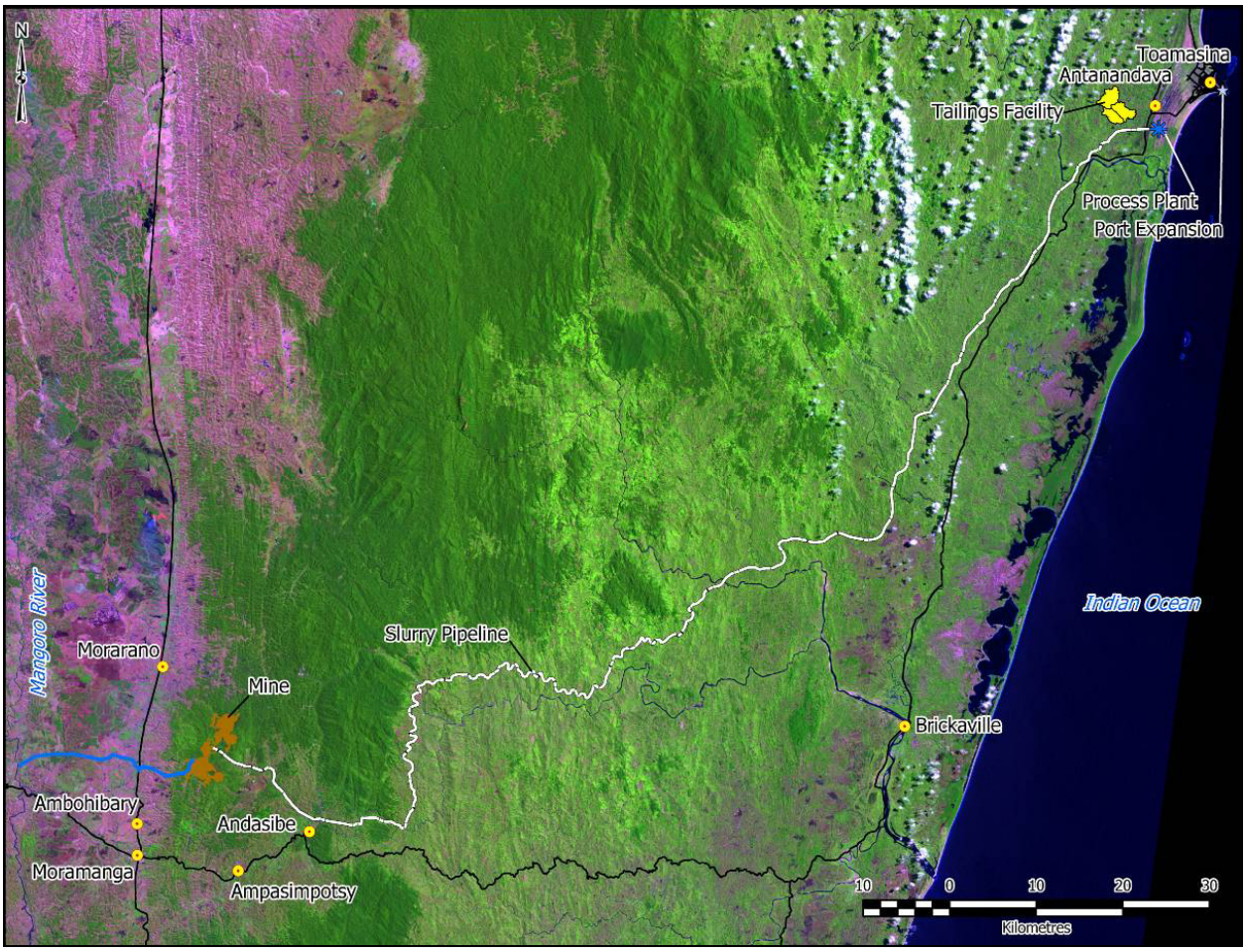
Laterite soils along the pipeline route have developed on old terrain with almost no vestige of the original rock structure. The routing of the pipeline has been chosen to cross mainly disturbed areas, especially through the Ankeniheny–Zahamena forest corridor. The dominant vegetation type along the route is tavy (85%) which is largely disturbed, composed of cleared forest and scattered shrubby vegetation or trees. The second most common vegetation is degraded primary forest (4%) comprised of either heavily logged forest or very small forest patches that have been invaded with exotic species. Primary forest is the third most dominant vegetation type (also near 4%) and occurs near the mine site and within the Ankeniheny–Zahamena Corridor. This is zonal tropical forest that may have been sparsely logged, but still contains species that are characteristic of a pristine forest.

Faunal survey team in Torotorofotsy Wetlands

The number of fauna species surveyed was generally highest in the primary forest with fewer species in the more disturbed areas closer to the coast. Seventy-six species of reptiles and amphibians were surveyed in primary forest. With the exception of one amphibian species, all reptiles and amphibians were endemic to Madagascar, with three species listed by the IUCN. Disturbed habitats, such as primary forest fragments, secondary forest and tavy, had five or fewer reptile and amphibian species. Most bird species were also detected in forested habitat (62 of 86 species), including all eight IUCN-listed species. A total of 26 fish species were recorded at pipeline stream crossing survey sites. Eight species were endemic, 11 were native (indigenous but not endemic) and seven were exotic. No fish species are listed by CITES. Thus main areas to focus on with respect to potential impacts from the pipeline on biodiversity are primary forest and stream crossings.

## Regional conservation planning

Two proposed or existing protected areas and a Ramsar site are located near the pipeline route: the Torotorofotsy Ramsar site, the Ankeniheny–Zahamena Corridor and Mantadia National Park. The right-of-way avoids the national park, but crosses the Ramsar site and the forest corridor. The routing of the pipeline has been aligned with a proposed infrastructure right-of-way, which will be excluded from the future protected area of the corridor. The Torotorofotsy Ramsar site contains the largest and most intact natural marsh in eastern Madagascar. However, the marsh is not pristine, with about 40% disturbed by either slash-and-burn (tavy) agriculture, eucalyptus plantations or rice paddies. The Ankeniheny–Zahamena forest corridor is planned to accommodate both biodiversity protection (75%) and multiple-use areas (25%). Mantadia National Park is representative of the humid tropical forests of eastern Madagascar, characterized by high levels of biodiversity and endemicity.




Slurry pipeline route

# Project Description

Mined ore will be mixed with water from the Mangoro River and supplemented with collected storm runoff water, to prepare a slurry of 40% ore and 60% water. The slurry is then pumped through a 55 cm diameter buried pipeline to the process plant on the coast. A number of pipeline route alternatives have been compared during project planning, with respect to engineering, economic, social and environmental costs and benefits. The assessed route runs adjacent to an old forest railway line from the mine site to near Andasibe. It then turns east to Fanovana avoiding the Mantadia National Park, before heading north to near Fitanisirana. Here it turns east to the north of Lanonana, up to Androsalabo and generally parallels the RN2 to the Toamasina plant site. The assessed pipeline route was chosen, in consultation with government representatives and NGOs, to avoid crossing national parks and primary forest in the Ankeniheny–Zahamena forest corridor. In the Torotorofotsy Ramsar site it is routed along an old railway line at the north edge of the wetland.

Aerial survey of pipeline route

The pipeline will be buried along its approximately 195 km length, with the exception of some steep sided river channels, which would have aerial crossings. Pipeline burial depths beneath streams will be at a depth that will prevent pipeline scouring within the stream. The disturbed surface near crossings and elsewhere will be reclaimed to minimize erosion. A control system will be built into the pipeline to monitor the movement of the slurry and to halt the flow of slurry if required.

Hydrostatic testing of the pipeline will be conducted before it is commissioned to ensure there are no leaks. That testing will require water withdrawal from rivers and/or streams. Withdrawal locations will be selected with the aim of minimizing changes in affected water bodies. Water will typically be disposed of to designated vegetated areas. Any water disposed directly to water bodies will be controlled to minimize flow impacts and ensure there are no water quality related issues.

Long-term safe and reliable operation of the slurry pipeline began in the design phase and will continue through operations. Application of proven design practices and development of project-specific safety systems ensures this reliability can be achieved. Commercially operating slurry pipelines have provided reliable service in high earthquake zones (Chile and Peru), extremely wet environments (Brazil), and in remote regions (China and Australia). The proposed slurry pipeline route does not present unique conditions for which successful pipeline designs have not been achieved. In all aspects, the pipeline is within commercially proven limits. The residual risks during all project periods are in the low category and within international standards to minimize risk to downstream public and environmental resources.

Pipeline construction would utilize local labour where possible. However this would not be high, because of a rapid construction schedule and

little time for training. Once the pipeline becomes operational, only a few maintenance and monitoring jobs will be required.

Results of this EA, combined with the start of detailed engineering design in late 2005, have prompted consideration of a modified routing of the pipeline in the eastern part of the assessed alignment. This re-route of some 60 km would follow a more southerly course from Fanovana to the coast and appears to have some constructability and environmental advantages. Specifically, it avoids running close to the east side of Mantadia National Park. This change, once fully developed and confirmed to be an improvement to the current routing, would be submitted as an EA amendment, supplementing the assessment provided here.

## Key Impacts and Mitigation

Main issues identified through consultation and through the professional experience of the Malagasy and international EA team included:

- compensation for any needed re-settlement, damage to crops and livestock, or hindrance to movement;
- concern over safety should the pipeline break during operations;
- the possibility of new roads associated with the pipeline were viewed positively, however there was concern that outsiders could come in and exploit the pipeline area;
- fragmentation effects on the Ankeniheny–Zahamena Forest Corridor, which would negatively affect biodiversity; and
- effects on water quality, fish and other aquatic resources at stream crossings, including in the Torotorofotsy Wetlands.

## Socioeconomics

As for other project sites, consultation showed that economic opportunities created by the pipeline are of great interest to people. Whereas it is the project's policy to maximize local employment and procurement and to provide training, the pipeline provides fewer jobs than other sites and almost all during the construction phase.

### Economic opportunities

The pipeline construction process has job skill and health and safety requirements that will make it difficult to employ many people. As well, given only a short presence of construction crews along any given stretch of pipeline and a tight schedule, there will be fewer training opportunities than at other project sites. Total labour requirements during construction for the pipeline would be around 800 people of which, about 345 would be local. Employment of local people would mainly be in support of construction and reclamation activities. The workforce requirement for the operations phase is very small and occasional. The remoteness and rural nature of the local economies

along the route suggest that any business benefits will also be lower than at other sites.

### Infrastructure

There is some potential for short-term disruption of travel and transport routes, both by land and water. However, consultative forward planning of disruptive construction activity and provision where necessary of alternative means of travel and transport, will be used to mitigate these. In order to construct the pipeline, access roads will need to be built both to and along the route. There are a number of alternatives for access routing to service the pipeline, but due consideration is being taken for the needs of local populations for a permanent road. It was clear during consultations that there is a strong desire for roads on the part of people in the less accessible communes between Moramanga and Toamasina. In addition, baseline studies indicated very poor health and education status of remote populations and an inability to market agricultural surplus. Access roads, with government or private transport services, would significantly assist in addressing fundamental socio-economic constraints.

RN2 bridge over Mangoro River

### Culture

A cultural specialist will be part of the team working with the land survey crew prior to construction of the pipeline. The objective will be to fine tune the route so as to avoid damage to cultural sites identified during baseline studies and any additional ones that might be found. Should this not be possible, then a relocation process for the resource would need to be agreed to with affected people, using accepted local cultural practice.

## Biodiversity

The main potential impacts to biodiversity concern the required routing through the Ankeniheny–Zahamena forest corridor, plus potential impacts to endemic fish and other species at river crossings.

### Flora and fauna

Avoidance of primary forest during design, provides the best mitigation to limit native plant community losses with associated reduction of impacts to fauna. Over 90% of the route occurs in areas that have already been disturbed by people. A total of 116 ha of forest land (12% of the route) will be affected by construction of the pipeline. Of this portion, primary forest amounts to 28 ha while disturbed or managed forests amount to 88 ha.

Ankeniheny–Zahamena Corridor

Two general methods of reclamation will be used along the route. For a majority of the route where areas have been previously disturbed, the primary reclamation objective is erosion control. However, within sections where transitional and zonal forest exist near the mine site, and in currently disturbed sections in the Ankeniheny–Zahamena Corridor, habitat rehabilitation will incorporate the use of native species with the long-term objective of re-establishing primary forest on the right-of-way. The restoration program will cover 60 ha and be within the framework of a well designed research project. Re-establishing tropical forest in

Madagascar is a developing field and revegetation trials will be established to increase this knowledge base and develop pragmatic restoration solutions. The lessons learned from these trials will also be made available to other restoration efforts planned by other organizations within the Ankeniheny–Zahamena Corridor.

Impacts to faunal populations as a result of habitat fragmentation are predicted to be low because most of the route was sited along pre-existing disturbance and the pipeline will be buried. Construction will create temporary barriers to movement (e.g., roads, construction activity) for fauna in environmentally sensitive forest areas near the mine. Connectivity will be restored once the pipeline is buried and the route reclaimed to forest on the right-of-way in these sensitive areas. In some areas, roads will be left in place as part of regional planning, so barriers to movement will remain. However, the majority of these roads will be in areas of existing disturbance and higher population density. No maintenance road will be constructed alongside the sections of pipeline to be reclaimed to primary forest near the mine and in the Ankeniheny–Zahamena Corridor.

## Aquatic resources

Minimization of impacts to aquatic and riverside resources will come from mitigation applied at stream crossings. Construction of the slurry pipeline will involve about 100 watercourse crossings of a variety of sizes. Initial assessments of the crossings have been conducted to assist in pipeline routing. Just prior to construction, an environmental team will conduct a further field survey of the crossing locations and identify any with high sensitivities with respect to aquatic and riverside resources. Where feasible, the pipeline route will be adjusted through design or minor reroute to avoid or minimize impacts on the sensitive areas. The majority of watercourse crossings will be buried and will involve excavating across the channel, laying the pipe and backfilling the trench. Where possible, water will be diverted to one side of the stream to enable a relatively dry work space on the opposite side. Construction of crossings will typically be conducted during low flow conditions to minimize water depths and the amount of suspended solids generated and transported to downstream reaches. The effects on suspended solids levels are expected to be high during construction, but to last only a short time, on the order of hours for small streams and up to a few days for very large streams. No effects on sediment levels are expected in the streams during operation or post-closure since revegetation and erosion controls will have been applied and stream banks will be stabilized.

Aquatic organisms survey

Endemic fish species were mainly associated with the presence of natural forest stream habitat (40% of sample sites). Assuming open cut installation of the pipeline, effects will be primarily short-term disturbance of riparian and instream habitat and limited to the construction period.

In addition to the slurry pipeline route, access roads will be required for people and equipment. These roads will create additional access to watercourses crossed by the pipeline. Harvesting of flora and fauna by project staff will be restricted to control direct impacts on terrestrial and aquatic resources.

## Monitoring

A survey team including Malagasy environmental and cultural specialists will work with the engineering team before construction to fine tune the route to further minimize impacts. Inspections during construction will monitor the effectiveness of erosion and sediment control along the route. Inspections of the route will be conducted during operations to monitor the effectiveness of erosion control measures, slope stability, stream bank stability and revegetated and reclaimed areas. Monitoring to control rates of water withdrawal and disposal of hydrostatic test water will ensure that impacts are minimized. A vegetation monitoring program will be implemented during operations to ensure that specific vegetation restoration efforts are successful in the reclaimed areas and that vegetation cover is maintained to control erosion.

# PROCESS PLANT

## Social Context

The process plant will be located within Toamasina II commune. With the exception of people living along the RN2 highway, where renting is more common, most people have at least traditional rights to the land they use. A census was conducted on 35 households in and near the plant site. Wage employment takes a larger role in livelihood strategies than it does at the mine site, since there are more opportunities for part time or occasional work for people who live close to a large urban area. Wage employment, artisanal production and business together account for the primary economic activity for over 60% of the population near the plant. The plant area is sparsely settled by new arrivals who are trying to gain livelihoods through participation in wage employment and business. However, there remains a dependence on agriculture.

### Culture

During the assessment of the plant area, six tombs, four ceremonial sites and four archaeological sites were found. All are within the plant property boundary and are considered to be in the project footprint.

# Environmental Context

The process plant is located about 2 km from the coast. The area is flat with beach ridges extending north-south. Seasonal wetlands are located in low-lying areas between many of the ridges. The elevation varies between 6 and 10 masl. Vegetation within the region was once part of an extensive coastal band of eastern lowland rainforest. Now, the primary forests are gone at the plant site and in most parts of the coast. They have been replaced with degraded secondary forest patches, shrublands and grasslands, as a result of clearing and invasion by exotic species.

The dominant vegetation at the plant site is a coastal shrubland/ grassland. The second most common vegetation is degraded residual coastal woodland. Exotic tree species have altered species composition and forest structure; however, there are still remnant species that once existed here in greater numbers. The third most common vegetation is a beach ridge complex. Vegetation within this type varies with position. It is characterized by coarse grass on the ridges and dense wetlands vegetation on organic soils within the low areas.

Three endangered or vulnerable IUCN-listed species were found in the area. In total, 185 flora species were inventoried. Due to the disturbed nature of the site, many species are invasive and common within the region. No locally endemic species were identified.

All terrestrial habitats are already disturbed and support low numbers of fauna species. Four amphibian and six reptile species were recorded. Thirty-four bird species were observed, of which two were IUCN-listed and one CITES-listed.

Aerial view of the plant site

The plant site contains only a few seasonal wetlands. Outside the property boundary, permanent watercourses which are associated with plant infrastructure (adjoining pipelines and access roads) include the Pangalanes Canal (a series of freshwater and brackish lakes, lagoons and rivers that were joined for commercial traffic) which is only a few hundred metres from the sea, the Ivondro River south of the plant site and an unnamed tributary to the Ivondro River.

In the Ivondro River and Pangalanes Canal, several fish species and invertebrate species are commonly harvested by local fisherman. In the Ivondro River, exotic species such as tilapia were the most commonly harvested fish. Some smaller fish along with crustaceans were also captured in reed traps.

# Project Description

An analysis of alternatives was conducted to compare potential plant site locations at the mine site, Brickaville and Toamasina. A number of factors favoured Toamasina as the preferred location. The site was already disturbed and zoned industrial; good logistics were nearby, including the port; and it was close to a large source of potential labour. An offshore refinery was chosen for final metal processing.

The process plant is to be situated on an 80 ha site on the southern outskirts of Toamasina, about 10 km from the port. The process plant has an annual capacity of 60,000 tonnes of nickel and 5,600 tonnes of cobalt over a period of 27 years. The plant includes a leach plant and associated utility plants. The utility plants include: power, steam and water plants, a hydrogen plant, a hydrogen sulphide plant, a sulphuric acid plant, and a limestone and lime plant.

Ore will arrive at the processing plant via the slurry pipeline. The ore slurry will be treated in autoclaves to extract the nickel and cobalt. Processing includes first the addition of acid at high temperature to dissolve the nickel and cobalt. The solid tailings are then separated from the solution, which contains the nickel and cobalt. This solution will be neutralized with limestone and then treated with hydrogen sulphide to precipitate a concentrate of nickel and cobalt. This mixed metal sulphide is approximately 54% nickel and 5% cobalt. It will be exported for refining to pure metal products.

Water for the process plant will come from the water used as the transport medium in the ore slurry pipeline, with makeup as required from the Ivondro River, delivered to the plant by a buried water pipeline. The process plant would use about 60 megawatts of electricity and a large quantity of steam, both to be produced in a coal burning plant. Additional steam is produced in two sulphur burning sulphuric acid plants.

The process will require the import of large quantities of sulphur, limestone and coal. The plant will produce sulphuric acid from the imported sulphur, which will be consumed at the plant site. The plant will also produce hydrogen, hydrogen sulphide and lime for use in processing the ore to the mixed metal sulphide.

Construction of the process plant is expected to take about three years. There will be a large construction labour force of about 2,800, with the intent of hiring over 1,100 from the Malagasy population. There will also be a large operations phase workforce of about 1,150, of which 1,100 will be from the Malagasy population, following extensive training programs.

Model of process plant south of Toamasina

The plant is designed for an operating life of over 27 years. With closure of the Ambatovy mine, the plant could continue to process ore from other mines that may be developed either within or outside of Madagascar.

Risks to the plant from high winds and cyclones will be mitigated by a combination of detailed engineering design and appropriate emergency response protocols. Best management practices will be utilized for the construction and operation of the plant to ensure the health and safety of the workers and people near-by. Similarly, high environmental standards will be established for operations. All water and air emissions will be managed to meet regulated criteria.

## Key Impacts and Mitigation

Main issues identified through consultation and through the professional experience of the Malagasy and international EA team included:

- concern about air emissions that would affect peoples' health and about greenhouse gas emissions;
- concern that the design of the plant has accounted for extreme natural events, including cyclones;
- optimization of local hiring and use of local businesses to serve the needs of the plant;

- concern over the development of a "worker-based" city near the plant, with public health and safety impacts; and
- concern that the use of an offshore location for final metal refining would reduce economic opportunities within Madagascar.

# Environment

## Air quality

Activities during operations of the plant will result in the release of sulphur dioxide ($SO_2$), nitrogen oxides ($NO_X$), particulate matter and hydrogen sulphide ($H_2S$) to the atmosphere. Air quality modelling was conducted to identify the needed emission controls to achieve ambient ground level concentration criteria in the vicinity of the process plant. The proponent has committed to installing equipment that will meet or better the World Bank criteria based on 24-hour and annual average emissions.

With respect to odour, it has been estimated that the average $H_2S$ concentration may exceed the World Health Organization recommended 30-minute odour threshold at some communities south of Toamasina, close to the plant site. Unlike the 24-hour $H_2S$ criteria, the shorter period criterion is based solely on odour perception. A worst-case prediction is that odour may be detectable about 4% of the time.

Emissions of carbon dioxide ($CO_2$), methane ($CH_4$), nitrous oxide ($N_2O$) and total greenhouse gases (GHG), expressed as equivalent carbon dioxide ($ECO_2$) were estimated for the operations phase of the process plant and associated power plant. Greenhouse gas emissions from the whole facility are predicted to be 1,920 kt $ECO_2$/yr. Malagasy GHG emissions in 1994 were estimated to be 456,323 kt $ECO_2$/yr by the National Ministry of the Environment. The emissions from the process plant would therefore represent a 0.4% increase in national GHG emissions.

## Noise

Noise level modelling was conducted to predict continuous noise levels at various communities as a result of the process plant operations. To ensure a "worst case" was assessed, the model is based on the assumption that all equipment will be in use at full design capacity. The modelling demonstrated that World Bank noise criteria will be met at all communities.

## Biodiversity

Of the habitats that will be impacted as a result of the plant, all are highly disturbed. Avoidance of native vegetation through site selection provides the most effective mitigation to limit native plant community and associated fauna losses.

Disturbed vegetation at plant site

# Socioeconomics

## Human health

The human and ecological health assessment evaluated the potential for adverse effects to human health associated with emissions from the plant. The incremental health risks of human exposure to drinking water, eating fish and produce, as well as air inhalation, skin contact with soil and accidental eating of soil during operations and post-closure were considered low to negligible. Potential impacts on aquatic life and livestock resources were also considered negligible.

## Socioeconomics

The scale of the plant project is expected to bring large economic benefits to the Toamasina area through creation of employment, demand for businesses, contributions to educational institutions and improvements in infrastructure. Such an economic stimulus will result in improved socioeconomic status overall. The potential for economic and social change in the local area requires an adaptive management strategy to optimize benefits and minimize negative effects rather than specific mitigation measures. The socioeconomic analysis provided here includes the three coastal project components (port expansion, tailings area and plant site), since they will affect the same local area, which includes the city of Toamasina.

## Economic opportunities

The project will offer pre-employment training, basic skills training, jobs and other benefits to local people. To mitigate uncontrolled migration to the project site, the recruiting area for job training, employment and procurement opportunities will be Toamasina. Business opportunities in the immediate vicinity of the plant site and tailings are likely to be fewer than for Toamasina generally, given there very few small businesses in what is a largely rural setting, however this has potential to grow with time. Given the size of the project, the high volumes of materials required for operations and the fact that many of these materials will pass through the port, there will be a large number of business opportunities created by the project. Businesses with capacity to supply, even if located elsewhere in Madagascar, can be expected to expand or relocate to Toamasina in order to be close to what will become a major customer. In addition, assistance to businesses under the Ambatovy Empowerment Program will expand their capacity to supply project goods and services over time.

River taxi on Pangalanes canal

Direct Malagasy labour force requirements at all three Toamasina area project sites, will be about 1,100 out of the total work force of 2,800 over the 36-month construction phase. About 1,100 individuals from the local Toamasina area would be employed during operations. As local people gain skills and experience through the construction stage and through training, they would be in a better position to access more skilled jobs.

It is estimated that US$100 million annually will be spent in the Toamasina area, during the three years of construction. The estimated annual spending during operations would be US$67 million. In addition to the local expenditures, the indirect and induced employment benefits and economic activity will be significant. It is predicted that an additional 1,100 direct jobs, 6,700 indirect jobs and 1,470 induced jobs will be created during construction. The equivalent numbers for operations would be 1,100, 3,810 and 710. As well, it is expected that the improvements to infrastructure will stimulate the local economy through employment creation. Because anticipated project expenditures are expected to be comparatively large relative to the size of the local economy, the benefit is considered of high consequence.

Conducting seismic survey at plant site

It is the project's policy to provide training to employees. This will improve skills needed for better job performance and promotion, and broaden the skill base of employees and prepare them for new opportunities in the future. It is also the project's intention to address the need for a broader-based education and training strategy through support for educational institutions in Toamasina. The formal training program developed for the project will be accessible on a preferential basis for employees local to Toamasina and the tailings and plant site areas. As at the mine site, the project will also address the need for a broader-based education and training strategy to provide assistance to those who wish to develop skills that could position them for employment and/or supply of goods and services at levels beyond those they would otherwise be qualified for.

Induced urbanization may begin with the construction stage. Migrants may be attracted initially to construction camps and the perceived potential for employment with the project. Controls will be put in place through:

- the establishment of recruitment offices located only within Toamasina (no recruitment at the plant and tailings sites);
- fencing will be placed around the camp and plant site; and
- workers will be transported to and from the site.

Through the project development, the city of Toamasina may see a rapid growth rate outside its current boundaries. The more rapid urbanization is a process that would have likely occurred even without the project because Toamasina is in the process of expanding residential areas southward. Developments in conjunction with the port have also been proposed for nearby land. The project will work with planning authorities to develop a comprehensive strategy for monitoring and dealing with uncontrolled labour migration.

## Access to natural resources


Settlements near the plant site

People whose lands are required for the project will be resettled as per the Resettlement Action Plan. Depending on livelihood resources that are affected by the project, additional people may or may not be resettled. There are alternatives that may be preferable, including replacing that portion of livelihood resources affected with alternative resources. This could include compensation and/or employment. At present, two households will be fully resettled at the plant site, with additional compensation being developed for 25 households.

## Social services and infrastructure

It is not expected that migration can be limited to such an extent that additional pressures on not only services, but also goods and land, can be fully mitigated. In the interest of original residents and of any migrants, flexibility in the response to migration is necessary. The proponent alone cannot address in-migration and urbanization issues in the Toamasina area. It is the project's intention to supplement mitigation and benefit enhancement measures directed at specific project impacts with participation in additional community development efforts. The approach will be to partner with government, NGO and community groups to support interventions to address the effects associated with induced urbanization.

The project itself will make few demands on services and infrastructure, in so far as out-of-country workers will be housed at camps where all their service requirements will be met. As well, the project will have independent systems for power, water, communications etc. Improvements to transportation infrastructure associated with the project, including roads, the port and the railway, will strengthen the capacity of Toamasina to serve as a full-service transportation node relative to other Madagascar alternatives.

## Wellbeing

Attention to the potential for increasing the incidence of HIV/AIDS is particularly critical, especially at the plant site given that the incidence in the Toamasina area is suspected of being higher than in Madagascar generally. Movement of workers and migrants into the area as a result of the project could contribute to increasing the incidence of HIV/AIDS. To mitigate this potential impact, vigorous codes of behaviour and aggressive HIV/AIDS prevention and treatment programs for the workforce will be implemented at the plant site, in line with practices at the mine site.

As described for the mine site, the project represents a significant force of socioeconomic change. The potential of the project to generate such change is greater than at the mine site, given the size of the plant facility and the expected employment it is to generate locally. The project intends to participate in this transformation as a positive force,

contributing to economic and social development through employment, business opportunities and training, as well as through support of planned urban growth.

### Closure

The current plan calls for closure after 27 years. It is likely that this will occur later as a result of the addition of reserves at the mine site over time and the plant site being able to continue to operate using ore from other Madagascar or offshore sources. One of the goals of the project leading up to closure will be the sustainability of the local community, with the aim to leave it in a viable position to continue to prosper and build on the socioeconomic progress made through the life of the project and plant operation.

### Culture

The cultural sites within the plant site will be relocated. For this to occur in a culturally acceptable manner, proper protocol involving correct rites and rituals will be observed. Discussions and negotiations with resident groups will be necessary in this regard, facilitated by the proponents' Malagasy cultural specialists. Any archaeological sites deemed of value by regulators and local experts, which cannot be re-located, will be visited by a Malagasy archaeologist and excavated prior to disturbance to record information from each location.

## Reclamation and Closure

At the time of project completion, the plant will be assessed for potential future use in other industrial projects. It is expected that the site will be partially decommissioned and sold to another industrial user so that the benefits of the constructed facilities can continue to support the local economy. Buildings and infrastructure at the site with no useful function will be dismantled and removed from the site at the time of project closure. Waste materials will be removed from the site and disposed of properly.

## Monitoring

The process plant would be the largest industry in the Toamasina area. Ambient air monitoring beyond the fence line and process monitoring will take place to ensure emission criteria are met. Consultation will take place with local communities to address any issues or concerns residents may have, particularly with respect to any odour issues.

Social monitoring programs, ongoing consultations and the grievance and dispute resolution mechanisms are also critical to capturing the actual effects of urbanization so that these can be addressed with additional mitigation where warranted. These mechanisms are important, since while the types of effects can be predicted to some extent, the magnitude of the effects and the individuals specifically affected cannot be.

# TAILINGS FACILITY

## Social Context

The tailings facility will be located on the boundary between the communes of Toamasina II and Fanandrana. The number of households surveyed in or near the tailings facility site was 406, of which 165 are identified for resettlement. The tailings site population is a long established rural population. They experience constraints to agricultural production due to extreme rainfall and reduced access to both services and markets. The area is remote without easy access to the opportunities presented by Toamasina. Artisanal production (largely weaving and the making of small stools) is important, but given the generally low returns to this type of economic activity, this importance suggests marginal livelihoods. Agriculture, including crops in addition to rice, is an important economic activity. Other agriculture includes cultivation of fruit trees, but also maize, manioc, sweet potatoes and other subsistence crops, as well as limited cultivation of cash crops, particularly ginger.

Valleys in the tailings area

Water management is not generally perceived to be a problem, as there seems little demand for irrigation systems. This is likely because the high year-round rainfall ensures continual river flow and thus the capacity to route water for agricultural use. There is a problem with excess flow during periods of exceptionally high rainfall. Potable water comes mainly from springs, which are characteristic of the higher altitude hills and are considered to be cleaner than rivers.

Forest cover has largely been removed, although some stands of secondary vegetation appear to be maintained and isolated woodlots have been established. There is some harvesting of available vegetation for household needs and for artisanal products. Fishing contributes to wellbeing, however, biological resources do not make the degree of contribution to livelihoods that forests make in the mine site area.

### Culture

During the assessment of the tailings area, seven tombs, 12 ceremonial sites, 10 archaeological sites and one symbolic tomb site were found. Seven ceremonial sites, three tomb sites and two archaeological sites were also found near the tailings area boundary.

## Environmental Context

A series of three valleys west of Toamasina make up the planned tailings facility. The valleys are moderately steep often with vegetated hillsides and valley walls which descend into flat, wide valley floors. The highest elevation is 90 masl at the western end and the lowest elevation is 4 masl in the eastern portion of the tailings study area. The valley floors, in particular the northern valley, have been developed into rice paddies.

The streams and rivers at the site contain the headwaters of three sub-basins of the Ambolona watershed. Drainage flows in an easterly direction in the valleys along a natural gradient of less than six degrees (10%). The mean annual precipitation is about 3,300 mm. March is the wettest month (473 mm) and October is the driest month (115 mm). Estimates of maximum 24-hour rainfall amounts range from 273 mm once in 10 years, to 465 mm once in 100 years.

Based on the Madagascar classification system, baseline surface water quality in the tailings facility area is typically classified as moderate (Class B), with some watercourses classified as poor (Class C). There were no surface waters that are considered to be excessively contaminated (Class HC). Manganese was the only water quality substance with some observed baseline concentrations above the WHO drinking water guideline value.

Aerial view of tailings facility area

Tailings area soils are naturally acidic, low in nutrients and well drained on upper slopes. Soils in the depressions are often water-logged with some peat accumulation. Although nutrient poor, these depression soils are suitable for rice production.

The vegetation is composed of secondary habitats influenced by an array of human-induced disturbances, mainly agricultural. Due to the disturbed nature of the area, many plant species are invasive and common within the region. One tree species present (pallisandre) is identified as vulnerable by IUCN, but is a widespread species in Madagascar exploited for its valuable wood. No locally endemic plants were found.

Biodiversity in the tailings area is mainly linked with the remaining natural wetlands. Wetlands in the tailings area had the highest number of amphibian and reptile species and the second highest richness of bird species, compared to other habitats. Seven amphibian and 11 reptile species were recorded within the tailings area, none of which were listed by IUCN. One amphibian and five reptile species are listed by CITES. Fifty-two bird species were documented, of which two are IUCN-listed and five CITES-listed.

All aquatic sampling sites in the tailings area exhibited significant disturbance and loss of natural ecosystem function. Much of the valley bottom area and associated stream habitat has been developed into rice paddies. However, 17 fish species, comprising five endemic, four native, and eight introduced species were collected from the tailings area, which is actually similar to the mine site. One species of Madagascar rainbowfish (*B. madagascariensis*) was the most abundant endemic, which is listed as “Near Threatened” by IUCN. The tailings area contains a low number of endemic species relative to the 27 described endemic species reported for this region of Madagascar.

Within the tailings area, biodiversity within aquatic systems is the main concern with respect to potential project impacts.

## Existing marine conditions

The outfall for the effluent pipe from the tailings facility is located approximately 8 km south of Toamasina harbour, on a straight section of coastline without any visible rock outcrops. The sandy bottom is gently sloping at depths exceeding 10 m. The location is in a high energy near-shore zone with high natural levels of turbidity, strong currents, and rough seas. The average recorded wave height was 1.4 m, but wave heights of up to approximately 11 m can be expected for a 1:100 year cyclone.

The southward flowing east Madagascar current generates an offshore reverse current adjacent to Isle Sainte-Marie. Farther south, the east Madagascar current generates inshore, northward-flowing reversal currents. Toamasina lies within the convergence of these two systems. In summer, the currents cause low-grade up-welling south of Isle Sainte-Marie, further contributing to the turbidity in the area.

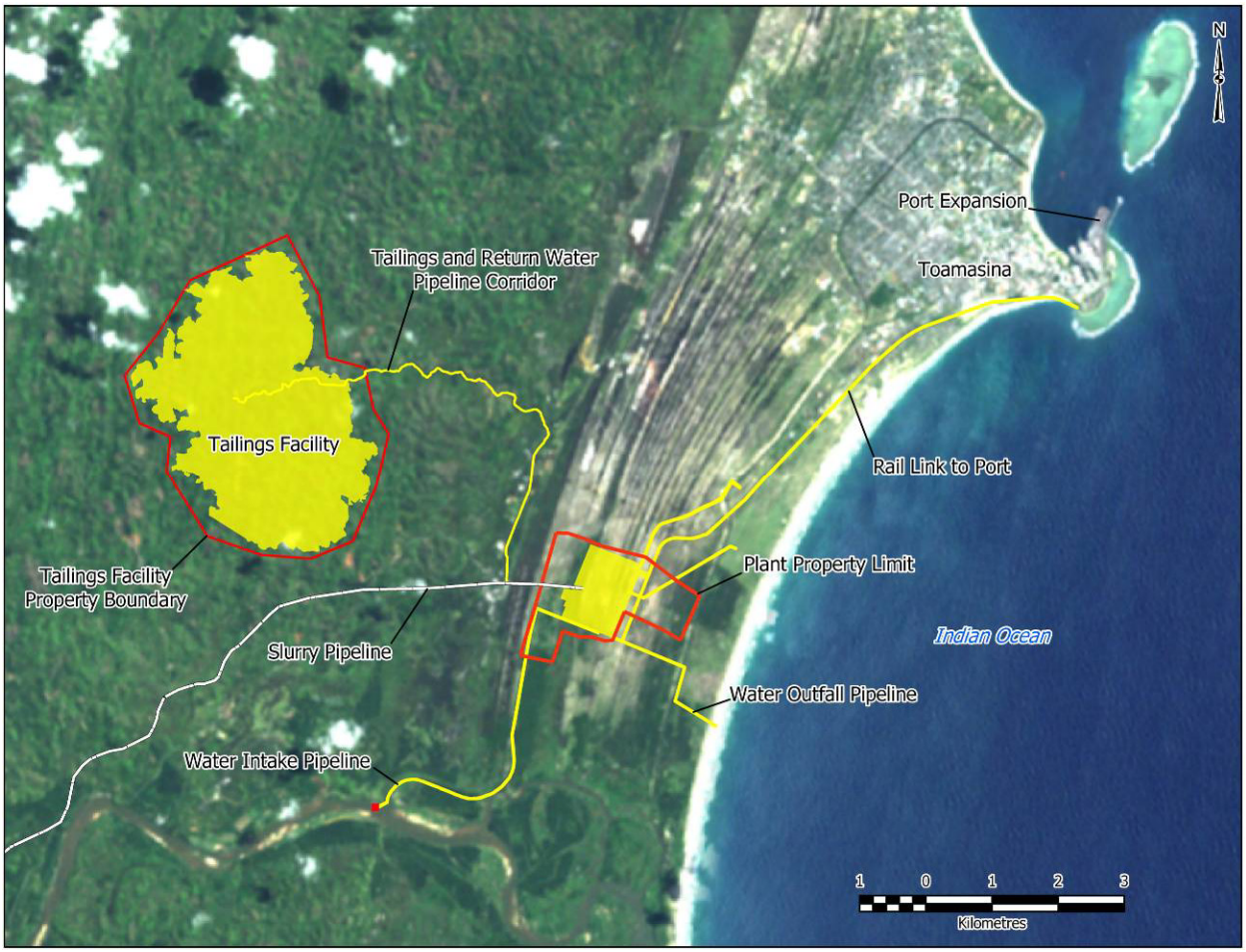
The combination of high summer rainfall, terrestrial sediments, cyclones, and strong winter winds cause nearly year-round turbidity in the region. The area is thus not conducive to coral reef development and the damage caused by cyclones and rough seas adds to this stress. Existing literature highlighting environmental indicators in the Province of Toamasina lists major littoral reef complexes, none of which is near the project site. Diving surveys for this EA confirmed that assessment. The closest reef of consequence is at Isle Sainte Marie over 60 nautical miles to the north.

Fishermen near Toamasina

Dive surveys conducted for this EA showed that the reefs around Toamasina were fairly homogenous. They were relatively flat in profile, probably due to rigorous conditions generated by frequent cyclonic seas and they formed shallow fringing reefs, with the exception of Recif du Sud, which shelved off at a depth of 5 m. Most reef profiles were only broken by shallow gullies, forming spur and groove formations. In a few instances, the reefs rose on the seaward side in a steep wall before flattening out. Reefs observed were poor in terms of their biodiversity. At Recif du Sud, the hard coral cover was poor, but it had a moderately high cover of the soft coral genus, *Sinularia*, on the shallow reef flat; this is typical of such wave-cut platforms. This habitat was not found elsewhere during the survey and Recif du Sud had higher biodiversity with some species not encountered on the other reefs investigated.

Several turtles were observed; all were believed to be Green turtles. Marine turtles are regarded as a key indicator species in Madagascar. Turtles are listed as Endangered by IUCN due to extreme hunting pressure.

Dives also showed that while many of the major fish groups are represented in the outfall area, some are more noticeable either by their absence or poor representation. These include the snappers, emperors, kingfishes, seabream, rockcods and rubberlips. The absence of many of these fish may be due to high regional fishing pressure, although the outfall location itself is not used much as a fishing ground.




Location of project sites near Toamasina

# Project Description

Three alternative tailings facility locations were selected for detailed consideration:

- a valley site north of Brickaville;
- a valley site south-west of Toamasina; and
- a Toamasina ring dyke alternative on flat land near the coast.

The Toamasina area was selected as the preferred site for the plant, thus the Brickaville location was not considered further for the tailings. The high cost of the ring dyke precluded its further consideration. Four alternative options were then compared within the Toamasina valley site. Minimizing the tailings footprint and locating the site to minimize effects on people living in the area were the main goals in developing the preferred tailings option. There is a relatively large population in the eastern end of the Toamasina valleys, and this would have a high socioeconomic impact, as well as an adverse effect on project cost and

schedule. The option chosen does not use the lower elevation areas of the valleys, avoiding the areas of highest population density.

The tailings facility will be constructed and operated in three phases to permit progressive reclamation and progressive resettlement of affected people. The processing of the ore results in about 1.3 tonnes of residue (tailings) per tonne of ore – about 220 million tonnes in total over the 27 year life of the project. The tailings would be neutralized to a pH of 8 at the process plant and then pumped as a slurry into the tailings pond. Due to the neutralization process most of the metals will be precipitated as solids and immobilized in the tailings facility. The tailings area will offer an opportunity for the solids to settle and consolidate.

Water, which will include rainwater, will be pumped from the tailings facility back to the process plant where some will be reused; the balance will be disposed of to the ocean via an outfall pipeline. In order to minimize the discharge of water directly to the downstream environment, the tailings facility is designed to be capable of temporarily storing rainwater from a 1 in 50 year storm, above the maximum normal operating level.

Dams containing the tailings would be built according to rigorous safety standards that take into account extreme rainfall events and seismic activity. Following mitigation, the residual risks during all project periods are predicted to be low and within international standards. The main risk concerns heavy rains causing maximum flows over pond spillways. However, the extent of predicted flooding is relatively similar with or without the tailings facility in place.

## Key Impacts and Mitigation

Main issues identified through consultation and through the professional experience of the Malagasy and international EA team included:

- concerns over re-settlement and the resettlement process, including land tenure, conflict resolution and adequacy of funding;
- concern that the movement of tombs be compensated and conducted in a culturally appropriate manner;
- concern that water quality and quantity will be affected around the tailings area, with impacts to crops, livestock and people;
- concern over what will be pumped into the ocean from the tailings area; and
- danger to people if water comes over the top of the dam in a cyclone or if the dam breaks.

# Freshwater

During operation, flows downstream of the tailings embankment will be reduced considerably due to the reduction in drainage area as a result of runoff diversion in the upper basin. The expected changes along the main stems of the streams are high (greater than 30%) in basins affected by the development. The high impact extends through to the large tributary that joins the Ambolona River system. Changes in downstream flows for post-closure conditions are low.

A stream below tailings area

Six water quality assessment scenarios were modelled, corresponding to key project phases that represent baseline, operations (years 14, 20 and 27), post-closure (15 years after closure) and far-future conditions (80 years after closure). The results of initial assessments showed that groundwater seepage would result in elevated levels of mainly manganese in downstream surface water, above the World Health Organization drinking water guidelines. Based on these observations, a groundwater interception system is proposed to collect seepage immediately downstream of the tailings facility to minimize the downstream impact to the surface water. The intercepted seepage will be managed with the tailings facility effluent.

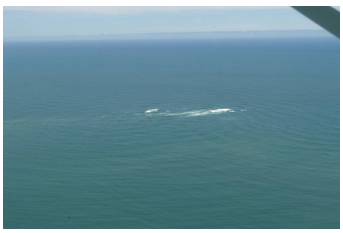
The final modelling results predict that during operations all surface water parameters of concern will be below WHO drinking water criteria. Copper, manganese and zinc do exceed the South African Ecosystems guidelines in some downstream basins, but only marginally for copper and zinc. Baseline conditions for copper and zinc also exceeded these guidelines. Therefore, manganese is identified as the critical substance to manage in water below the tailings facility. For the post-closure scenarios, parameters were predicted to be below drinking water guidelines and there were marginal exceedences in some of the basins of the South African Ecosystem guidelines for copper and manganese.

# The Ocean

The marine outfall will be assembled on land, floated out to sea, flooded and sunk onto the sea bottom. The construction activities will result in increased turbidity around the pipeline which will have an effect on the local marine resources. The effects will be short-term and on a local scale. The effluent to be discharged into the marine environment contains a variety of minerals, many of which are constituents of seawater. However, the continuous discharge of large volumes of effluent water will lead to the elevation of certain minerals to levels above those which occur naturally in the Toamasina region.

The impact of tailings water discharge on marine water quality was modelled based on predicted tailings water quality estimates derived from laboratory testing of processed ore samples. The dilution and settling modelling of the effluent, indicated that TSS, manganese and sulphate were the constituents which would be above natural levels or

above the Malagasy water quality standards. These parameters require further dilution on disposal into the marine environment in order to reduce possible negative impacts.



Reef near Toamasina

According to the modelling, effluent components will be diluted to within water quality limits by the time they reach the water surface. However, the discharge of effluent may result in a change in species composition and abundance in the immediate sea bed area (500 – 1000 m) around the effluent disposal site. This will prevail throughout the operational phase of the mine until natural recovery of the benthic biota occurs once the mine is decommissioned. However, the impact occurs within an area of low conservation importance, which already experiences high levels of turbidity. Therefore, the overall environmental consequence has been predicted to be low.

Although increases in turbidity are generally non-toxic, they can have both direct and indirect impacts on the marine environment. Specific consideration was given to the corals found at Nosy Faho, south of the proposed outfall. The modelling indicates that the outfall plume could move in the direction of Nosy Faho, but due to dilution, the TSS would be similar to present conditions and the impact would be low around this reef.

Predicted manganese concentrations derived from conservative modelling indicate that guideline levels will be achieved through rapid dilution in the outfall area. Manganese is not predicted to pose a risk to ecological health.

A local change in sea bed biota near the pipe outfall may result in a moderate impact on the local fishery right by the outfall. The fisheries sometimes operating within the area are the small scale commercial operators and artisanal fishers who occasionally venture out to sea from the Ivondro estuary. The line fishery operates on deeper reefs, none of which are found around the proposed outfall location.

# Socioeconomics

## Human health

The human and ecological health assessment evaluated the potential for adverse effects to health associated with seepage from the tailings facility. Human exposure to drinking water and eating fish and aquatic life exposure to water and sediment were evaluated as well as potential effects on changes in livelihood resources due to impacts on surface water quality. With the proposed mitigation in place, potential effects were rated as low to negligible for people, aquatic life, livestock and produce.

## Socioeconomics

For the population between the tailings facility and the plant site, the impact analysis is similar as has been summarized for the plant area, with some differences of emphasis as noted below. Differences are

largely related to the more rural setting of people closer to the tailings area, with less linkage to Toamasina.

## Resettlement

People whose lands are required for the project will be resettled as per the Resettlement Action Plan (RAP). This applies to people who live and/or have agricultural lands within the tailings site boundaries. At present, the RAP identifies 165 households to be resettled from the tailings site. Planning for resettlement has been facilitated by the establishment of a Resettlement Committee that currently includes 16 persons representing the regional and local governments, traditional authorities from the affected population, the NGOs working in the area and the proponents.

## Economic opportunities

Business opportunities will be few adjacent to the tailings facility, as this area is more rural than is the case nearer the plant site. The intention to deepen training and education, to target people who are less educated and require more education is especially relevant to those in the tailings area.

## Access to natural resources

Depending on livelihood resources that are affected by project infrastructure land disturbances and requirements for rights-of-way (for roads, pipelines and power lines) people may or may not be resettled. There are alternatives that may be preferable, including replacing that portion of livelihood resources affected by alternative resources, which could include compensation and/or employment. The intent is to ensure that people are not harmed by the project. The water flow reductions below the tailings area will be monitored to see if people are affected by it; it is possible there will not be an impact in this very high rainfall area. Water management practices and fisheries management may be improved with assistance from the project to avoid impacts and enhance benefits.

## Infrastructure

Project contributions to the development of local infrastructure, including road improvements, will be especially useful near the tailings area.

## Wellbeing

As described above, the project represents a significant force of social change, particularly in the more rural areas near the tailings site. This area will be part of more general monitoring to be undertaken, as described below.

## Culture

Of the ten archaeological sites found in the tailings footprint, five were judged to represent significant historical resources. For these five sites, which cannot be relocated, further work consisting of preliminary archaeological excavations to determine the exact nature of

A Malagasy family southwest of Toamasina

the sites is required. Depending on the nature of the data recovered, additional excavations may be warranted. The tombs, symbolic tomb and ceremonial sites situated inside the proposed tailings impact zone will be relocated. For this to occur, proper protocol involving correct rites and rituals must be observed. Discussions and negotiations with resident groups will be necessary. The resettlement of people that will be required also implies a requirement to relocate tombs or other cultural sites associated with households that have to be resettled, irrespective of the position of the tombs in relation to construction impact zones.

## Biodiversity

Avoidance of native vegetation through siting the tailings facility in a disturbed area, provides the most effective mitigation to limit flora and fauna impacts.

Main impacts will occur to biodiversity associated with remaining aquatic habitats. Effects on fish will occur as a consequence of the loss of watercourses in the tailings area and impacts to downstream habitats resulting from reduced flows. The upstream areas in the tailings footprint are likely less important than the larger water bodies downstream. However, salvage of selected endemic fish will take place prior to construction, if suitable release sites or use can be identified.

## Reclamation and Closure

Reclamation and closure of the tailings facility will be based on the following goals:

- the reclamation and closure design will ensure that long-term physical and chemical stability is provided;
- progressive reclamation will be implemented where possible; and
- upon cessation of operations, the area will be decommissioned and rehabilitated to allow for future land use as guided by local authorities and stakeholders.

The tailings reclamation and closure plan will be updated throughout the project life to reflect changing conditions and the input of local authorities and stakeholders.

The tailings will be allowed to air dry for a period of time and progressively revegetated to provide a stable erosion-resistant surface which may be safely crossed by people and livestock. A research-based reclamation trials program will be utilized to help ensure that adequate and desired vegetation cover can be achieved. A residual sedimentation pond will be left in place to collect sediment until the vegetation becomes well established and may remain as a wetlands area. Suitable drainage measures will be designed and implemented for maintaining stability

during storms and cyclones. A closure spillway will redirect flows from the tailings basin into the original valley downstream. The groundwater pump back system located at the base of the tailings basin will operate for about 15 years post-closure, or until groundwater monitoring demonstrates that seepage quality will not reduce the surface water quality downstream.

## Monitoring

Operational monitoring of stream flows and suspended solids concentrations within the affected basins will be conducted to support an improved understanding of water flows in the study area. Stream flow records will be evaluated along with climate data to further assess water availability for various environmental and social needs downstream of the tailings facility.

Water quality monitoring will be routinely conducted on the tailings effluent within the collection pond, the groundwater seepage from the interception system, the down gradient groundwater wells and the downstream surface water systems. Monitoring will be conducted during operations and will continue through the short-term and long-term closure scenarios, until results indicate that seepage from the tailings facility will have no detrimental effect at downstream sites. Monitoring downstream of the tailings of selected aquatic resources will occur, linked with ongoing stakeholder consultation and any needed assistance for local fishery management. A vegetation monitoring program will be implemented to ensure that reclamation efforts are successful and erosion control measures are working effectively.

Fishermen's boats near Toamasina

Additional marine baseline water quality information will be obtained along with further assessment of environmental health, to provide a stronger baseline against which to compare operational monitoring. More detailed information on the fish and fisheries will also be obtained (particularly the southern gillnet fishery) prior to construction. Along with effluent water quality monitoring, periodic monitoring of the marine biota will occur during operations to track species distribution, composition and abundance. The involvement of local fishermen in marine monitoring will be most important, including evaluating any trends and considering possible additional mitigation. Water samples will be collected during operations at the outfall and at reference sites for the determination of TSS levels. In order to monitor regional water quality, the sample strategy being used to assess baseline conditions will continue into the operational phase. Currently, the focus is on sampling the waters in and around the reefs (reference sites). During operations, water samples will also be taken within the outfall area. In addition, suitable marine indicator organisms which are sensitive to outfall constituents will be identified for use in a biological monitoring programme. Species which are frequently monitored in these programmes include algae, mussels and territorial reef fish. Selected sites on Nosy Faho and Le Grand Recif would represent good long-term monitoring sites.

Social monitoring programs, ongoing consultations and the grievance and dispute resolution mechanisms are also critical during construction and operations in the Toamasina area. The primary objectives of socioeconomic monitoring are to:

- record the uptake of employment, business and training opportunities over time and analyze the trends in relation to expectations and targets;
- monitor the implementation and effectiveness of socioeconomic impact mitigations; and
- evaluate the trends in local economic and social development and well-being, as well as the relationship between these and project operations.

# PORT EXPANSION

## Social Context

Flooded road, Toamasina

Toamasina is a large city, with an educated population, institutional presence and some depth to business activity. The port at Toamasina is Madagascar's main port, handling approximately 80% of the country's imports and exports. In 2003, the port handled 1.5 million tonnes of traffic. From 1997 to 2003, container traffic increased steadily, at an average rate of 10% per year. Much of the country's non-perishable products are transported from secondary harbours to Toamasina where shipments are loaded onto international cargo carriers. Education and job experience in Toamasina is somewhat better than found in more rural areas, and the urban population is over 200,000. As a result, it is expected that there will be many people who would qualify for employment.

The expansion of the port, construction of the plant and tailings facilities and improvements to other infrastructure in association with the project, all have the potential to transform the city's economy. Whereas the tailings and plant facilities will have effects on the immediate area around their locations, the largest economic effect will be seen in the city of Toamasina, including those parts of Toamasina II which are more urban in character. This enables Toamasina to be in a position to take good advantage of project benefits over time.

## Environmental Context

The port has been active for about 75 years, while nearby shore areas have been mainly dedicated to, or influenced by the port. Toamasina is built on a 5 to 6 km-wide coastal sandy plain. The plain is bordered by coastal reefs and inlets, which lie parallel to the coast at depths of 20 to

40 m. Due to these coral reefs and local sea movements, two coastal extensions developed. Hastie Reef to the southeast of the port, assisted with the formation of a land extension on which the port and old town were constructed. Grand Recif helped form Tanio Point, upon which Toamasina has expanded since 1981. Tanio Point and the north coast have been impacted by erosion for almost a century, however this is more of an issue now with the town's expansion northward.

Port of Toamasina

Moles A and B at the port are constructed on sandy zones within the protection of Grand Recif, while Mole C is constructed on the edge of the reef. Diving surveys have shown the seabed near the docks to be covered by muddy sediments and solid wastes from port activities. Recent studies of sediment quality in the harbour have confirmed contamination from heavy metals and organic compounds associated with anti-fouling paints, fuels, and zinc used for anticorrosion on metal structures. The marine environment in the harbour is seriously degraded, as are many major ports, with few free-swimming organisms present.

Outside the harbour, Toamasina Bay is up to 10 m deep, with a bed of sand and clay sediments. The bay has limited species richness, likely because of strong water movements coupled with large erosion and sedimentation processes. Both Hastie and Grand Recif have been transformed by the port, including being used to stock dredged material.

# Project Description

Materials required by the project that are not available locally, especially raw materials required during operations, will be purchased on international markets and shipped to Madagascar. Studies showed that due to the quantities involved, an expansion of the existing port will be required. Several expansion alternatives within the port were compared, as the three moles at the port each have their advantages and limitations. Extension of Mole B was eventually chosen for the following reasons:

- the berth and its approach are deep enough to accept 30,000 to 40,000 dwt vessels without dredging;
- berthing is sheltered; and
- both sides of the mole may be used for berthing, thus increasing the availability of the berth.

The extension will be about 250 m long and constructed on open pilings. This construction type represents the lowest cost option and provides a typical fit-for-purpose solution, which does not offer the option of handling significant quantities of any other type of cargo. This option also has the least potential for creating environmental problems with minimal interference with existing water movement patterns within the

harbour. The table below summarizes predicted cargo movements for the project.

### Port of Toamasina – Predicted Ambatovy Cargo Movement Through Mole B

| *Material* | *Import / Export* | *Description* | *Annual Quantity (tonnes nominal)* |
|---|---|---|---|
| sulphur | import | dry bulk | 700,000 |
| coal | import | dry bulk | 300,000 |
| limestone[(a)] | import | dry bulk | 1,600,000 |
| nickel sulphide | export | bagged | 117,000 |
| **total** | | | **2,717,000** |

[(a)] Limestone requirement is 1.5 – 1.6 Mt/a depending on limestone grade.

Railway just south of Toamasina

Two main alternatives, rail and truck, were considered for transport of imported materials between the port and the plant and for export of metal sulphides. For its reliability and lower social and environmental impact, the railway alternative was selected, although some trucking will still occur. The railway method requires the project to invest in extra railway equipment, in addition to loading facilities at the port and unloading facilities at the plant.

The design of the port structures takes into account extreme storm events. The berth would be vacated during cyclone activity. An initial investigation of the wave penetration through the gap between Grand Recif and the port breakwater indicated that wave penetration would not be a problem for the extension.

## Key Impacts and Mitigation

Main issues identified through consultation and through the professional experience of the Malagasy and international EA team included:

- a request for project proponents to cooperate with public works companies and to provide training, so as to maximize opportunities to create jobs for local people;
- concern that design will take account of potential impacts from cyclones;
- concern over health and safety effects from increased road traffic in the port area; and
- concern of possible increased coastal erosion if the port extension affects coastal currents.

## Socioeconomics

Port of Toamasina

The effects of the port expansion need to be considered as part of an analysis of all project activities in the Toamasina area. The project is expected to bring enormous economic benefits to the Toamasina area, through creation of employment, demand for businesses, contributions to educational institutions and improvements in infrastructure. Such an economic stimulus will result in improved socioeconomic status overall. The project will partner with the city of Toamasina and commune governments to jointly manage the challenges of urbanisation. Emphasis will be to see that the project is well integrated into the Toamasina area as a sustainable development initiative. It needs to be considered that economic benefits in and of themselves are associated with improved socioeconomic status. To the extent that there is potential for negative effect, direct mitigation and an adaptive management strategy will be put in place to address evolving effects are expected to enhance the realization of benefit.

In a context of already ongoing rural urban migration, the Ambatovy Project is certain to provide additional stimulus. Given constraints on housing and physical infrastructure in Toamasina, and distance between the city and the plant site, it is expected that many migrants will choose to relocate closer to the site than in the city itself. However as businesses gear up to supply the project, this will attract migrants to the city centre. Also, since many project employees will live in Toamasina, the induced economic effect of increases in disposable income will provide opportunities for migrants. As noted for the plant site, an influx of workers also brings a potential array of negative effects. The project will work with the city of Toamasina and communes affected, to manage to the extent possible the expected increases in population.

## Environment

During construction, drilling of the pilings will disturb sediments and cause re-suspension of contaminants. During final design, drilling options to best limit this contamination will be chosen. However, at the present time Mole A is regularly dredged, which releases sediment. Although noise impacts will be short term, investigation will continue on the utilization of techniques such as a bubble curtain around the pile driver, to reduce the spread of acoustic noise in the marine environment.

The possibility of the introduction of exotic marine organisms by ships will occur throughout the life of the port and as such it is an impact that occurs during both the construction and operational phases. This threat is not unique or new, and is a problem currently faced by the Port of Toamasina and ports around the world. The main mechanisms by which organisms could be introduced will be through ballast water of ships, which originate from their previous area of operation. Mitigation in the form of a rigorous ballast water plan and extensive cleaning of the dredgers will be important to reduce the probability of occurrence.

Ship berthed at Toamasina port

The port expansion will result in an increase in vessel traffic and as such there is an increased chance of ship collision. The following mitigations will reduce the likelihood of collisions:

- the proponent will participate with port authorities in a revision of the future traffic movement control systems for the region; and
- revisions will ensure that the larger fishing ship movements will be integrated into the traffic control of the bay.

A coordinated approach to vessel traffic control by trained personnel will help to lower risks of vessel collision.

The development and use of preventative Health and Safety Plans plus Emergency Spill Response Plans will mitigate for potential impacts from fuel and other materials handling during operations.

## Monitoring

Monitoring with respect to the port area, will mainly be routine measures required to assess the success of health and safety measures.

# CUMULATIVE EFFECTS

The cumulative environmental effects analysis of the Ambatovy Project with other projects will be limited to an evaluation of those other projects and activities within the region that are planned or are reasonably foreseeable. A precursor to that evaluation will be a consideration of all project effects (i.e., considering all project components together), since outside of the cumulative case, project components have generally been assessed independently.

## Combined Project Site Effects

The majority of combined project impacts for physical, biological and social issues are similar to the results obtained when each site was assessed separately. In many instances, the geographical separation of project components means that no combined effects are predicted. Some exceptions are noted below.

Although several kinds of natural risk consequences may combine to produce cumulative consequences, all of these combinations are considered extremely unlikely. All identified risks are being managed through mitigation measures to achieve international standards as described in the natural risks section of each component EA.

Torotorofotsy Ramsar site

For effects on area of conservation significance, the mine will impact 300 ha of the Torotorofotsy Ramsar site and the slurry pipeline will impact an additional 70 ha. Combined, the mine and pipeline will result in clearing 370 ha of vegetation from this 9,300 ha area (4%). These impacts will be mitigated as described in the flora section for the mine and slurry pipeline. This combined impact is moderate in magnitude and regional in geographic extent because it extends beyond one Local Study Area. Because impacts were rated as local in extent in the individual mine and pipeline assessments, they were considered low in magnitude in both individual assessments.

As required by the ToR, an economic evaluation of residual project impacts on biodiversity has been conducted for the mine and other project elements. This methodology is developing, especially when considering impacts from a single project as opposed to eco-regional analyses. However, economic evaluation helps consider a range of impacts that are otherwise very difficult to appraise and compare. Economic impacts are assessed through consideration of ecological services provided by high biodiversity habitats, especially forests. In addition, project benefits from biodiversity offsets are described in terms of carbon sequestration. Where possible, project impacts to ecological services have been estimated in dollar terms. Main ecological services determined to be of relevance in the analysis were:

Ankeniheny–Zahamena forest corridor

- atmospheric gas regulation by natural vegetation;
- regulation and maintenance of water flows by undisturbed watersheds;
- erosion control and sediment retention by undisturbed watersheds;
- detoxification of contaminants by forests and wetlands;
- food production in natural and agro-ecosystems; and
- supply of raw materials.

The whole project macroeconomic analysis provides the best overview of project economic benefits. The economic benefits will be derived from three major areas of activity:

- direct project investment;
- increased consumption by workers employed both directly and indirectly as a result of the project; and
- government spending of increased revenues generated from the project.

Over the 30 year project life cycle, US$3.2 billion (over US$100 million annually) will be spent in Madagascar. It is expected that the Ambatovy Project will:

- increase local capital investment in Madagascar by over US$1.3 billion (over 30 years) or US$45 million annually and create 1,400–2,000 direct jobs for local workers, through the project lifetime;
- generate over US$80 million lifetime or approximately US$2.8 million annual income and 4,600 indirect jobs, in other sectors, through local project expenditures;
- induce the creation of approximately 2,800 jobs in other sectors to satisfy the demands of increased consumer spending; and
- contribute approximately US$25 million annually to government revenues, of which about 50% might be used to create additional indirect job opportunities.

## Cumulative Effects With Other Foreseeable Projects

The following are the main ongoing and planned projects and activities which could overlap with effects from the Ambatovy Project:

- deforestation due to logging and tavy agriculture;
- conservation protection for the Ankeniheny–Zahamena forest corridor;
- reforestation brought about by the regional Carbon Project;
- future management of the Torotorofotsy Ramsar site;
- growth in ecotourism;
- Andasibe sawmill activities;
- four graphite mines (Andasibe, Toamasina, Brickaville and Vatomandry);
- paved and unpaved roads upgrading;
- upgrading a segment of the Madarail system operating within the study area;
- growth in urban centres and villages;
- dry port development south of Toamasina; and
- Logistique Pétrolière Terminal project south of Toamasina.

Analyses were undertaken of the potential for Ambatovy Project impacts to combine with these foreseeable future activities to produce cumulative impacts. Cumulative impacts of higher magnitude than that already assessed for the project alone, were usually not identified. Some exceptions are noted below.

Toamasina looking south

Air emissions from the growing city of Toamasina include vehicle exhaust and other fuel combustion sources that may combine with air emissions from the process plant and port expansion during certain meteorological conditions. The air emissions from Toamasina were not quantified, therefore a cumulative assessment could not be made. An ambient air quality monitoring program around the plant will be implemented to track background levels and plant performance.

In terms of natural risks, a natural event resulting in flood-runoff of contaminants from the project plant site and the Logistique Pétrolière terminal and other industrial developments south of Toamasina could result in an elevated cumulative impact in local small watersheds and especially in the marine environment. The probability of such an event is very low and no additional mitigation is proposed.

During operations of both the Logistique Pétrolière terminal project and the Ambatovy Project, there is the potential for increased cumulative risk of ship collisions. However, Ambatovy Project mitigations, including working with port authorities on a revision of the regional traffic movement control system, are predicted to offset potential cumulative negative effects.

Forest clearing

Forestry data indicate that past, current, and future clearing likely represents the largest incremental impact to loss of plant communities in the cumulative effects study area during the life of the Ambatovy mine. For certain vegetation types, the magnitude and geographic extent of impacts from deforestation are predicted to be higher relative to all other future projects and activities in the study area, including from the Ambatovy Project. These clearing activities will impact primary zonal forest the greatest because it supports fertile soils for slash and burn agriculture, the desired species used in home construction and is a source of firewood and charcoal. The potential for logging activities to directly impact azonal vegetation types in the mid-altitude eastern forest region is predicted to be negligible. However, indirect impacts could occur through fire and other disturbance, as has occurred in the past. Azonal forest outcrops in the region are uncommon and the only intact site known to occur in the cumulative effects region will likely be designated as a conservation area as part of the biodiversity offsets planned for the project. Even when other regional activities are considered, planned mitigation and off-site compensation provided by the Ambatovy Project will still result in a net positive effect to azonal flora. Site clearing activities will also affect primary zonal forest within the mine site and western portion of the slurry pipeline. Following project mitigation and off-site conservation, analysis indicates there would be a low negative to positive cumulative environmental consequence to this vegetation type.

Initiatives such as the Carbon Project and public awareness programs on the ecological benefits of conducting land use practices away from conservation and reclamation areas should provide positive benefits to

flora and fauna, including fish, their habitats and to biodiversity in general. Combined with the proponent's involvement in a buffer zone Forest Management Plan, plus on and off site azonal conservation areas, biodiversity should increase in previously altered habitats in the regional study area.

The greatest cumulative effect for traffic is expected to occur along the new direct access road between the port and process plant. Several other future projects have a relatively high probability to require this road for substantial traffic volumes, including the Logistique Pétrolière Terminal and the dry port development. Cumulatively, these developments will result in a substantial traffic increase both on the portion within Toamasina (which is presently congested) and south of Toamasina (which is presently a little-used dirt road). This cumulative impact will mainly be mitigated by improvement of the road.

# CONCLUSION

The success of the Ambatovy Project requires that the needs of Malagasy people are addressed and that their concerns are fully assessed in the EA. Through project disclosure and consultation the proponent has been made aware of the socio-economic challenges facing Malagasy people and the many linkages between people and the environment in Madagascar. Having an EA team comprised of Malagasy and international specialists, plus undertaking extensive consultations, has allowed key issues to be identified upon which to focus the EA.

Key socioeconomic issues include the need to optimize benefits to Malagasy individuals, businesses, communities and the national government. These issues are addressed through proposed local hiring and training programs, support for local businesses and payment of taxes and royalties. Potential negative socioeconomic effects are addressed through resettlement planning and programs concerning health, wellbeing and cultural sites. The project also offers to provide planning assistance and capacity building as a contribution toward enhancing the net benefits.

Key environmental issues that are being addressed include potential impacts to water quantity and quality below the mine and tailings areas, plus potential impacts to biodiversity at the mine site, and subsequent effects on people in the project area. Water management is a project priority, with a commitment to monitoring and ongoing consultation with local people, to gauge the effectiveness of mitigations and quickly address any deficiencies. The high importance accorded to biodiversity, especially in the mine area, has been reflected in extensive baseline studies, interactions with the design team and impact analyses. A main mitigation is a commitment to on-site and off-site conservation areas. Along with future monitoring, these mitigation and compensation

initiatives aim to provide net benefits to the region compared to the existing conditions.

The proponents are committed to translating the results of this EA into an effective Environmental Social Management Plan (ESMP) for the construction, operations and closure phases of the Ambatovy Project. A participatory approach will be followed, so that stakeholder input, and where appropriate teaming, will help ensure that negative impacts are minimized and positive benefits enhanced. The mitigations developed in the EA, and laid out in the ESMP, are believed to be practical and achievable. After the implementation of mitigations and compensation, it is predicted that the Ambatovy Project will cause a net positive outcome for Madagascar, in terms of both socioeconomics and the environment.

# STRUCTURE OF THE ENVIRONMENTAL ASSESSMENT

The EA for the Ambatovy Project is intended to meet the information requirements outlined in the ToR in an easily understood and comprehensive package of information. Information is presented in 11 volumes that address specific subject areas. The volumes are as follows:

- Volume A: Introduction
- Volume B: Environmental Assessment - Mine
- Volume C: Environmental Assessment - Slurry Pipeline
- Volume D: Environmental Assessment - Process Plant
- Volume E: Environmental Assessment - Tailings Facility
- Volume F: Environmental Assessment - Port Expansion
- Volume G: Environmental Assessment - Cumulative Effects
- Volume H: General Appendices
- Volume I: Physical Appendices
- Volume J: Biological Appendices
- Volume K: Social Appendices

Volume A introduces the project and the EA process and contains study area and methodological information pertaining to all disciplines and all project components.

For the convenience of readers who wish to read only specific parts of the EA, each of the assessment Volumes B through F provides the project description and environmental assessment for each specific project area. Therefore, a reader who is interested in one particular project site may read the corresponding assessment volume.

Volume G contains a cumulative effects assessment that addresses the combined effects of all project components and cumulative effects of the whole project plus other foreseeable developments in Madagascar. The economic assessment of all project components combined is provided in this volume.

Where appropriate, the EA refers to separate documents in Volumes H through K called Appendices, which contain additional technical and baseline information on all project sites. These volumes also contain environmental assessment appendices for some disciplines with information of relevance to the environmental assessment for multiple components of the project. Environmental and Social Management Plans are included in Volume H. The glossary, acronyms and references for all volumes are listed in Appendices H-12 and H-13.