BIODIVERSITY MANAGEMENT PLAN

PROJECT PHASE: CONSTRUCTION

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1 INTRODUCTION

The actions of the Ambatovy Nickel Project (AMSA/DMSA) concerning biodiversity are guided by a policy of biodiversity specific to the project (see below). The vision of this policy is based on the principle that paying particular attention to maintaining biodiversity is a moral principle that contributes to the interests of the Ambatovy Nickel Project (AMSA/DMSA), the communities in which the project is carrying out the mining and of the world in general. Five goals have been set in order to sustain this vision of biodiversity, i.e.:

- That there be no loss of species in the areas affected by the Project;
- That the impacts on the flora, fauna and aquatic resources be minimized;
- That the Project produce a net increase in the areas of preservation of critical habitats;
- That the viability of priority habitats be assured by the maintenance or a growth of the connectivity between these habitats; and,
- That the Project's actions in the area of biodiversity be integrated with other regional initiatives for biodiversity.
- These objectives will be reviewed periodically and may be changed based on continuous consultation and experiences acquired. These objectives will be achieved through a combination of goals and actions that are organized into Biodiversity Management Plans (BMP-C). A biodiversity management plan will be established for each phase, that is, construction (BMP-C), operations (BMP-O) and closure (BMP-SD)

1.1 THE BIODIVERSITY MANAGEMENT PLAN FOR THE CONSTRUCTION PHASE (BMP-C)

This BMP-C establishes a group of future actions, associated with the Ambatovy Nickel Project (AMSA/DMSA), providing for conservation or enhancement of biodiversity. The BMP was designed starting with the technical prescriptions in the Project license as well as the mitigation measures and the follow-up/monitoring measures provided by the Environmental Assessment Study. Thus, the BMP is an integral part of the Project Environmental Management System (EMS) and it provides a synthesis of the Project's actions regarding the flora, terrestrial fauna and aquatic resources.

The additional directives regarding the design of the BMP originate from some recent guides on good practices, including ICMM 2006, IPIECA 2005, IFC 2006 and UICN 2004. As noted in ICMM guide (2006), while a BMP may include numerous specific activities, a certain number of primary actions must appear therein. These actions include the following elements, all of which have been taken into account in the Ambatovy Nickel Project (AMSA/DMSA) BMP:

- Limit the unnecessary fragmentation of habitats, in the areas managed by the mining project, both in terms of mining activities as well as the activities of the neighbouring communities. As it is for most actions related to biodiversity, this subject will require various levels of efforts in education about conservation, consultation with stakeholders and co-management.

- Clearly delimit any natural area of the Project reserved for protection, in order to avoid accidental damage.

- Scrupulously monitor the clearing programs in order to optimize the various and appropriate uses of the flora and, eventually, the fauna.

- Implement an effective program against the introduction of destructive insects and invasive species of plants and animals.

- Involve the needs of the local communities in the conservation (wise use) and the management of the biodiversity.

- Integrate the studies on biodiversity and the Project management with regional biodiversity initiatives including those related to research and development. Place information regarding biodiversity arising from the mining project in the public domain, in the common regional and national interest.

- Carry out re-vegetation tests that are often required as a specific subset to the needs of biodiversity research and development.

1.1.1 Biodiversity off-set zones

The Project has followed good practices regarding the creation of biodiversity off-sets (in accordance with the directives of IFC 2006, ICMM 2006, UICN 2004). These efforts at creating compensation areas are not intended to avoid implementing the sound practices of mitigation but are used to complement the latter. The Project is attempting, first of all, to avoid any impacts as much as possible and has done so successfully, as, for example, for the pipeline route. When impacts are inevitable, as is the case for the azonal forest habitats (linked to the location of the ore deposits; see section on flora below) within the mining area, different mitigation measures are used to minimize the impacts. However, where there are significant residual impacts remaining after the implementation of

mitigation measures, as for the azonal forest, then the creation of a biodiversity off-set area is used as an additional compensatory measure. It is due to the creation of these development off-set areas, whether they are next to the ore deposits or off site, that the Project can achieve the objective of creating a net gain in terms of the conservation of the azonal forest.

The Project having proposed a very thorough program for the creation of biodiversity off-sets as well as a strategy for to avoid invasive exotic species, resulted in being selected (in September 2006) as a new pilot project by the *Business and Biodiversity Offset Program* (BBOP). The BBOP is a partnership that brings together corporations, scientists, NGOs, government agencies and research institutes, in reaction to the growing interest in the use of off-sets in order to move toward "no net loss" of biodiversity through conservation activities that will protect endangered habitats, contribute to national biodiversity strategies and address local communities' livelihood priorities. The BBOP is managed through a joint venture between Forest Trends, an independent NGO based in Washington, and the Center of Environmental Leadership in Business, a branch of Conservation International, in Washington D.C (USA).

The objectives of the BBOP are to:

1) demonstrate the results, in terms of conservation and improvement in the quality of life, associated with off-set creation pilot projects for biodiversity,

2) design, test and disseminate the best practices for the creation of biodiversity off-sets, and;

3) influence policy and corporate developments regarding biodiversity off-sets, to meet the conservation and business objectives. Being a BBOP pilot project provides many opportunities to achieve environmental excellence and necessitates responsible behaviour throughout the construction and operation periods.

1.1.2 BMP-C Structure and Design

The BMP-C is comprised of three sections, i.e., flora, fauna and aquatic resources. Each section is divided into the five elements of the Project: mining site, slurry pipeline, processing plant site, tailings facility and port expansion. Additional consideration has been assigned to the off-site creation of the Ankera biodiversity off-set, as in the wetlands at the Torotorofotsy Ramsar site, near the mine site. The actions relative to the marine environment are included in the aquatic resources for the tailing facilities area which includes an ocean discharge pipeline and the expansion of the port at Toamasina. The involvement of local biology experts was significant to the design of the BMP-C, notably during the basic studies for the Project. The lessons learned during the implementation of this phase of the construction plan will be used to assist in the design of the BMP-C for operations. Other specific environmental management plans have direct links to the BMP-C for Biodiversity; these are the restoration and the closure plans, as well as most of the

physical management plans, such as those for water from the mine and the tailings facility. The appropriate procedures for information flow between the plans will be initiated in the overall framework of EMS.

1.2 ESTABLISH BMP CONSERVATION PRIORITIES

The conservation priorities in the BMP are guided by the results of the EIA process, including consultation. Consultation will be used in an on-going way to validate the assigned priorities as well as to gauge the success of the BMP to achieve the goals and objectives.

Mitigation measures: The proposed areas for mitigation and compensation (biodiversity off-sets) have been established in the EIA, following the steps of the established process:

1. Issues review. Issues have been identified through consultation and the expertise of EIA specialists.
2. Creation of diagrams showing the links between the Project's activities and potential biologic impacts.
3. Evaluation of impacts, including the assessment of the environmental consequence levels to residual impacts.
4. Use of biodiversity off-set zones where there remains a high level of residual environmental impacts after mitigation.

Monitoring: The process described hereinunder has been used to establish the priorities for follow-up and monitoring. The monitoring provides the answers to specific questions about compliance. The monitoring data supports decision making by the company and the authorities. This differs from research which is carried out to test the hypotheses about the fundamental issues concerning the structure or the functioning of the ecosystem. The results of research often provide useful new ideas for designing the monitoring program; however, there is rarely a direct link between the research and operational decision-making. Therefore, it was important to make the distinction between research and monitoring during the design of the BMP monitoring program.

The biological monitoring programs are intended to deal with the uncertainties regarding the forecasted project impacts. The Environmental Management System (EMS) of a mine is intended to integrate the mitigation measures with monitoring in order to ensure that the impacts are acceptable; however, one of the objectives of an EMS consists in guaranteeing continuous improvement or incorporating the lessons of adaptive management as new information becomes available.

Such a program should never use indicators or measures that are poorly understood that research has to be carried out before they can be used for monitoring. The first question we must ask ourselves is "Are we certain that we are in a position to make an operational decision based on these data for the monitoring?" If the answer to that question is "no", the monitoring program can be deemed to be inadequate.

As such, monitoring will only be useful if it provides answers to specific questions regarding compliance or about the mining operations. There are three basic questions that must be asked regarding monitoring:

- What is the status of a something?
- Are there spatial or temporal trends?
- Are there effects in the receiving environment?

The issues of status are relevant to conditions at a specific time and generally constitute the preliminary part of the monitoring program since the answers to the questions about status provide feedback essential to daily activities. The questions relating to trends are intended to test the long-term effectiveness of the environmental mitigation measures and the operator's management programs. The questions concerning the effects on the environment are intended to test the forecasts of the initial impact and the effectiveness of the mitigation measures, management and any permit limits established.

As the Ambatovy Nickel Project (AMSA/DMSA) BMP uses a risk-based approach, the key components of the monitoring will include moderate to high magnitude, with a large geographic extent and/or which had a high degree of uncertainty. The monitoring of the environmental effects will make it possible to provide regular status reports, which can be used in adaptive management.

Define acceptable change

Monitoring data are only useful if they allow clear decision-making. Decision-making requires a rational approach. Thus, monitoring programs must define how the monitoring data will provide this approach to decision-making in terms of regulatory compliance or adaptive management.

Linkages between the monitoring components

Several specific monitoring components are often linked with each other and provide data that can be used to interpret overall status, trends or global effects for more than one discipline. Linkages were identified in the design of the monitoring programs. Each component program identifies data to be used from other components and sometimes the monitoring of a component may be sufficient for identifying potential problems associated with other components. For example, monitoring of surface water and sediments can provide necessary data for assessing the health of a wetland or an aquatic system, thereby triggering more or less frequent monitoring of biota if results indicate a problem.

Ambatovy BMP-C priorities

Priorities for mitigation and monitoring are laid out in the body of this plan, broken down by project site. This includes, where appropriate, listings of especially sensitive species (priorities). Broad priorities by project site emerged based largely on the absolute amounts of natural habitats that could not be avoided and which would be

directly affected by the Project, plus the rarity of those natural habitat types. The high priority areas are as follows (note that even in currently disturbed sites, suitable mitigation will be implemented, however, extra efforts will be made in these priority areas):

- *Mine site.* Flora and fauna of the azonal forest and azonal shrub habitats. Aquatic resources from less disturbed streams and ephemeral ponds.
- *Torotorofotsy Ramsar wetlands.* Although not directly impacted to a significant degree, this area near the mine site is a BMP-C high priority site based on its conservation status.
- *Slurry pipeline.* Flora and fauna of the primary forest near the mine site and within the Ankehineny-Zahamena corridor. Aquatic species at river crossings.
- *Plant site.* No high priority BMP actions.
- *Tailings facility.* Marine biology, including coral reefs offshore from tailings outfall.
- *Port expansion.* No high priority BMP actions.

Priorities for taxa (sensitive species), mainly at the species level, have been initially set by considering the following:

- Endemism (local, regional, national), especially endemic local species;
- IUCN status, notably Endangered and Critically Endangered Species;
- CITES status; and
- Additional information from Malagasy specialists on the status of species.

Thus, the most important criterion is local endemicity, which means the actions of the BMP-C must be designed to guard against species loss. The next priority, after endemism, deals with species listed by the IUCN as being “Endangered” or “Critically Endangered”.

Linkage to regional biodiversity conservation initiatives

A number of specific mitigation activities involve linkage to regional conservation initiatives. These include reforestation of the primary forest along the slurry pipeline route in the Ankeniheny–Zahamana Corridor; monitoring in and support for management of the Torotorofotsy Ramsar Site; on-site azonal conservation area management; off-site azonal conservation area management; and forest buffer zone management at the mine site using community-based management systems. A program as well as a mechanism will be developed for information exchange and other discussions between all appropriate management groups.

Specialist advisory groups

As discussed during the hearings, the Project is keen to see specialist advisory groups for biodiversity develop, as the best way to plan for focused consultation on the further development and implementation of this BMP-C. Such groups could be accommodated mainly under the above linkages to regional biodiversity initiatives but they should also include a component comprised of international specialists. Given the particular knowledge needed for mitigation and monitoring, the creation of a biological station at Ambatovy is being considered, to facilitate team work and program implementation.

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1.3 SETTING SPATIAL AND TEMPORAL BOUNDARIES

Areas in which mitigation or monitoring will occur for the BMP-C are shown in Figures 1.3-1 through 1.3-4. These areas have been established such that the project areas and planned conservation areas are included, along with special management areas such as the forest management buffer zone around the mine and Torotorofotsy wetlands downstream of the mine. Finally, a 500 metre buffer for most areas, or a one kilometre buffer along the slurry pipeline, is included in the BMP-C areas in order to account for off-site effects such as edge effects and air and water impacts and uncertainty as to the precise final project locations. Five hundred metres is considered a reasonable distance in which to mitigate and monitor for the indirect biodiversity related effects of the project, with 1 km being more appropriate for the slurry pipeline due to greater uncertainty as to the precise final routing of the pipeline

This BMP concerns two main time periods: pre-construction, which will extend from the start of the construction period in each Project location and the construction itself. These periods consist of the following dates for each component of the Project:

- mine: April 2007 – October 2009
- slurry pipeline: October 2007 – October 2009
- processing plant: April 2007 – February 2010
- tailings facility: November 2007 – December 2009
- port extension: May 2007 – September 2008

1.4 PROJECT BIODIVERSITY POLICY

The Ambatovy Biodiversity Policy is as follows:

At Ambatovy, we recognize the societal and business responsibility for sustaining biological diversity, in the world at large, but especially where we work. Our goal is to cause no net harm to biological diversity where we operate, to *mitigate unavoidable impacts, and to practice responsible closure procedures.*

We will:

- *Engage in stakeholder consultation to accurately measure and adequately mitigate the impact of operations;*
- *Provide responsible stewardship of all land where we operate or which we manage;*
- *Monitor the results of our operations, and implement corrective actions wherever needed;*
- *Assure the conservation of habitats, flora and fauna, using all reasonable actions and technologies; and*
- *Manage responsible closure to attain the optimum long term benefit to local communities and other affected parties.*

We believe:

- *That responsible attention to the maintenance and, where possible, enhancement of biodiversity is in the best interest of our business, the communities in which we operate, and the world at large.*

2 FLORA

2.1 GENERAL

2.1.1 Mitigation measures

Mitigation for construction phase impacts at all sites includes minimizing the area of vegetation to be cleared. To the extent feasible, the number of access corridors to project sites will be minimized by placing roads and water pipelines together or using existing road corridors.

2.1.2 Monitoring

Due to differences in vegetation communities at each project site, the approach for monitoring will be site-specific to focus on key vegetation communities and species groups at each site.

2.2 MINE

2.2.1 Priority Habitats

The analysis of the impacts on the flora focused on two main categories, the vegetation community (habitat) and species. Because of the cause-and-effect relationship between the underlying geology (ore deposits) and the more limited azonal vegetation, a large part of this habitat will be eliminated by the mine. Once again, because of the link between the ore deposits and this type of vegetation, while it is likely that the primary forest will be restored after the closure, it is improbable that it would be possible to restore a similar azonal habitat after the ore has been extracted. the mitigation measures for the habitat will be concentrated on the conservation of certain azonal near the mine but on the site and as an off-set, the there will be conservation of a vast area of similar azonal forest far from the mine (off-site) as a biodiversity conservation zone. It is important to remember that the zonal forest around the mining area also has great value in terms of biodiversity; thus, the sustainable management of this vast zone in the area of the mine but outside its footprint, as a forest zone, is also important in the achievement of the objectives of the BMP-C. The buffer zone is generally intended for forestal and agroforestal development in the West and at other conservation sites in the East (Ramsar CAZ site).

2.2.2 Pre-construction studies and priority species

Literature reviews and taxonomic studies in the field have been carried out by the Missouri Botanical Garden (MBG) since the end of the core studies used for the EIA. The work took place in the mining zone on the footprint as well as outside that area. The goal was to reduce the list of “Species of Concern” to zero (*SOC*, Species of

Concern, species that can only be found on the mine's footprint). According to the MBG's observations in the EIA, it is expected that additional off-site sampling will make it possible to locate all the SOC, but this exercise has to be carried out to prove that hypothesis. By January 2007, 1,089 species had been identified and the SOC list had been reduced to a few residual species, all of them small epiphytic orchids. However, there exists a general taxonomic uncertainty that may require a great deal of time to resolve concerning some 89 morphospecies found in the mining zone, on and outside the footprint.

There is a need for land surveys prior to the April 2007 clearing.

All the 1,089 species will be classified by a number of risk criteria, the highest priority being assigned to the residual species on the SOC list, found only on the footprint. The groupings of those species that are not as much at risk will be explained as an additional aid to the definition of the priorities for the mitigation measures, however at levels less than those for the SOC.

At this time (mid-February), only one SOC is known to be in the April 2007 clearing area. However, some of the 89 morphospecies might also be found only in that area. Therefore, the SIG analyses will be used to determine if this is indeed the case. Using a precautionary approach, any morphospecies only known to be in the area to be cleared in April will be added to the list.

The MBG will carry out a taxonomic audit on all the 89 morphospecies to clarify their taxonomy, with an initial effort directed at the SOC list. This work will confirm if all the morphospecies should really be categorized as SOC.

The field work will be carried out before April 2007 for all the SOC using the above definition. The work will deal with the footprint to locate the plants that require saving and, in the buffer zone/conservation zones on the site, in order to remove SOC from the list.

Pre-construction land surveys, after April 2007

The same procedure described above will be carried out for each proposed clearing zone on the mine, prior to the clearing *per se* and as long as there are SOC remaining on the list.

2.2.3 Mitigation measures

Several mitigation measures are planned in order to reduce the magnitude, the area and the duration of the direct impacts of the Project on the flora in the mine's BMP zone; reduce or eliminate the possibility of species extirpation or extinction as a result of the Project's activities and to mitigate the potential impacts of invasive species. The mitigation measures during the construction phase include:

- Creation of on-site azonal conservation areas at Ambatovy and Analamay that are representative of the key vegetation types affected by the project.
- The protection of Ankera, the off-site azonal conservation area.
- Construction of fencing at strategic locations adjacent to azonal protection areas, to limit damage during construction and operations.
- Development and implementation of a co-operative Forest Management Plan in a buffer area around the mine, designed to allow for sustainable forest use while maintaining biodiversity through conservation and resource use management. This zone will ensure connectivity with the adjacent forest corridor and connectivity between both on-site conservation areas. A fire management plan will be designed for this zone, including for the on-site conservation areas.
- Provision of environmental education to mining staff and the local population to enhance and support conservation and forest management initiatives.
- Continue to conduct on-site and regional flora surveys to reduce or eliminate the list of species of concern prior to mine development.
- In conjunction with local flora specialists, establish species-level conservation programs including identification, transplantation and cultivation of any remaining species of concern before construction begins. This will be carried out for the April 2007 clearing area. In the event of the presence of the SOC but which have not been localized (not in flower and/or located high in the canopy), a 1 hectare parcel of land will be left around the location of the known specimens to temporarily protect the site until the species within or off the site can be localized and in order to remove it from the SOC list.
- The salvaging of additional species for other uses such as medical purposes by the community, in addition to the recovery of construction timber as well as for other uses. Consultation with the stakeholders will be carried out to identify the species to be protected and to identify other uses for the latter.
- Establishing trial plots for reclamation using native species.
- Implementing an invasive species control program.

2.2.4 Monitoring

Monitoring programs will be implemented to ensure that the flora protection systems function well. These programs must:

- Ensure that objectives of the forest management plan within the azonal conservation areas are being met.

- Ensure that atmospheric emissions, including dust, are not detrimental to sensitive vegetation health and plant community composition (such as lichens, mosses and epiphytic orchids) in the azonal conservation areas.
- Verify that water quality and water levels entering the Torotorofotsy Wetlands and other watersheds are having no detrimental effects.
- Monitor the effectiveness of the reclamation plan to assess survival rates and ensure that erosion control measures are working effectively and vegetation cover is maintained. This will be elaborated on prior to operations.

Monitoring programs include:

- Monitoring aerial extent of footprint and areas of vegetation communities lost as construction proceeds; comparing actual vegetation community impacts with EIA predictions and question any discrepancies; pay particular attention to azonal and transitional habitats; to be conducted annually (if a cloudless image is available) during construction, using remote sensed data (i.e. IKONOS) and subsequent mapping; The addition of Torotorofotsy to this cartography will be considered, to help with the management of this area and to monitor the free water and the vegetation community/trends in the use of the lands.
- Monitoring the vegetation health of vulnerable species in the on-site azonal conservation areas to ensure their continued survival. Indicator species, for instance, orchids and lichens, will be selected since they are particularly sensitive to dust and potential decrease in groundwater levels. A more extensive monitoring program will be initiated in the forest buffer zone in accordance with the objectives of the management plan to be designed.
- Monitoring of all the priority species that have been transplanted to *ex situ* safe sites.
- Monitoring the effectiveness of exotic and unwanted species control measures within rehabilitation areas and along azonal forest edges where such species may encroach.

2.3 ANKERA OFF-SITE CONSERVATION AREA

2.3.1 Pre-construction studies

A quick evaluation of the flora took place in 2005, which made it possible to confirm the presence of azonal vegetation on geology similar to that of the mine site. Targeted inventories of the flora will be carried out in this off-site area, after the consultations with the local communities and the other interest groups, planned for the summer of 2007 – 2008, are completed.

2.3.2 Protection

This off-site area will be subject to a legal protection that has been accepted by the surrounding communities and funding will be allocated for its management. Consultations and a regulatory process that will make this objective possible are currently being developed and will be implemented during the construction phase.

2.3.3 Monitoring

Monitoring will occur in the Ankera off-site conservation area to contribute to future management and to serve as a monitoring site for the mining area. Any species translocated to the offsite area from the mine site will be especially monitored.

2.4 SLURRY PIPELINE

2.4.1 Pre-construction studies

The proposed pipeline route will be the subject of an additional investigation using high-resolution LIDAR imagery. A survey of the planned pipeline route will be carried out by an environmental team prior to construction. The study of the terrain will concentrate on any parcel of natural forest in the SIG that cannot be avoided, including at the location of river crossing points. A field evaluation will be carried out on these sites to confirm that groupings of similar species exist on both sides of the crossing area. If this is not the case, a reduced deviation will be suggested in order to avoid the impacts.

2.4.2 Mitigation measures

The main areas of mitigation for flora during construction include:

- Maximize avoidance of native forest vegetation through pipeline alignment design.
- Minimal width manual clearing at the crossing points of watercourses with riparian forests.
- Reclamation using native species and effective soil treatments in designated areas.
- Rapid establishment of prescribed vegetation cover following pipeline installation.
- In sensitive forest areas near the mine, forest reclamation will occur and a maintenance road will not be constructed. In particular, parts of the pipeline descending from the mine towards the Torotorofotsy Wetlands (see the file on the final, definitive LIDAR route) will be reforested. Areas

of the pipeline within the Ankehineny-Zahamena Conservation Corridor directly between Mantadia and Analamazaotra protected areas (about km 16 to 26 - (see the file on the final, definitive LIDAR route) will be reforested with native forest and no maintenance road will be left behind. This high level of mitigation is part of the Project's commitment to the Regional Corridor Restoration and Carbon Sequestration Project. Thus, the pipeline rehabilitation strategies will promote the restoration of natural habitats, where this complies with the local priorites for soil usage (i.e. the Ankehineny-Zahamena Corridor). The Regional Corridor Restoration and Carbon Sequestration Project aims at restoring the condition of the corridor with local native species. The project will cooperate as a partner in the success of this project within targeted perimeters. Early successional species will need to be established at the outset and so the plant communities within the corridor will not contain the same mix of species in the adjacent late successional forest communities. However, the reclamation team is tasked with setting the plant communities on a successional trajectory towards achieving viable, self-sustaining forest ecosystems with similar ecological characteristics as the existing mature forests of Ankehineny-Zahamena.

- Careful consideration applied upon development of access routes, and implementation of an access management plan in biologically sensitive areas, particularly in the forest corridor.
- The pipeline and other disturbed areas such as camps and laydown areas will be progressively reclaimed during and after construction.
- The primary mitigation to reduce or eliminate the invasion of exotic or unwanted plant species due to project-related effects is through the implementation of an invasive species control program. This invasive species control program will be made operational only along targeted sections of the pipeline route, where the local communities wish to conserve adjacent native habitats.

2.4.3 Monitoring

A research-based vegetation monitoring program will be implemented to ensure that vegetation rehabilitation efforts are successful and that the vegetation cover is maintained and erosion control measures are working effectively. Within the high-priority forest rehabilitation zones (i.e., the forested first 2 km of the pipeline from the mine and within the Ankehineny-Zahamena Conservation Corridor), a follow-up monitoring program will be initiated in reclaimed areas, including:

- physical parameters (temperature and humidity) ;
- the presence/absence and the representativeness of endemic species of flora;
- the survival rate for the targeted flora species; and,

- monitoring to ensure that a suitable level of control is being achieved for low levels of exotic and unwanted species. This program includes monitoring the effectiveness of control measures against exotic and unwanted species within the high-priority forest rehabilitation zones. In this high priority area, inventories will be conducted of density, location and distribution of any invasive species.

2.5 PROCESS PLANT

2.5.1 Pre-construction studies

No additional pre-construction studies are required.

2.5.2 Mitigation measures

The intent of the primary mitigation measures has been to optimize means of avoiding key plant communities by identifying preferred sites and designing access in areas that have already been disturbed, which already have a mixture of the vegetation common to the Eastern coastal regions. The remaining wooded areas will be given priority as areas to avoid during construction, as much as possible (camp sites, the area along the Pangalane Canal). After monitoring the off-site impacts, additional mitigation measures related to air or water quality can be implemented in order to reduce any effect on the off-site vegetation.

Opportunities for saving wood for local use will be considered.

2.5.3 Monitoring

Remote imagery (i.e. IKONOS images) will be acquired at regular intervals (annually if a cloudless image is available) to map vegetation changes in area of the process plant.

Vegetation communities surrounding the process plant footprint will be inventoried occasionally and inspected for changes in health that may be caused indirectly by the development of the Project development, especially air. The monitoring results will be compared with the baseline conditions.

2.6 TAILINGS FACILITY

2.6.1 Pre-construction Studies

No additional pre-construction studies are required.

2.6.2 Mitigation measures

The main areas of mitigation during construction include:

- maximize avoidance of key plant communities through siting design;
- the consideration of possibilities of salvaging the vegetation in addition to the recovery of wood for local use;
- progressive reclamation of disturbed areas that are outside of the actual tailings facility footprint;
- establishment of a reclamation trials program; and
- consultation with local planners and stakeholders as to end use.

2.6.3 Monitoring

Monitoring use through remote sensing (i.e. IKONOS) of the aerial extent of the footprint and of the vegetation community areas that will be lost as construction progresses will be carried out to compare the impact on the vegetation community with the EIA forecast and any deviation will be studied. This will be done annually and the results will be reported during the construction, if a cloudless image is available.

Flow and water quality measurements will be carried out as soon as the tailings facility dam construction begins and will be the key parameters for monitoring to ensure that proper water management minimizes any impact on water systems. Depending on the results, focused wetland vegetation monitoring downstream of the dams could be initiated.

2.7 PORT EXPANSION

2.7.1 Pre-construction Studies

No additional pre-construction studies are required.

2.7.2 Mitigation measures

Not applicable.

2.7.3 Monitoring

Not applicable.

3 TERRESTRIAL FAUNA

3.1 GENERAL

3.1.1 Mitigation measures

In general, mitigation for construction phase impacts at all sites includes minimizing the area of faunal habitat to be cleared, as discussed under the section of the BMP-C dealing with flora.

3.1.2 Monitoring

Due to differences in habitat at each project site, the monitoring approaches will be site-specific to focus on key vegetation communities and species present at each site.

3.2 MINE

3.2.1 Priority species

The priority species across all taxonomic groups are listed in Table 3.1. The highest priority species are those that may be locally endemic to the mining area and to the Moramanga region. In this case, these include a species of frog, snake, ant and possibly a small mammal. However, the taxonomy is uncertain for three of the species, except for the ant. Moreover, the frog, the snake and the small mammal were only recorded based on single specimens from 1997 bearing in mind that numerous specimens classed in these same genera from 2004–2005 were categorized in known and more common species. The four specimens in question are described below.

Boophis sp.nov. Only sampled in 1997 and of uncertain taxonomy. The location sampled is number 68, taken at the mine site in azonal forest of South Analamay; not in the azonal conservation area. The genus contains species that are mainly arboreal and nocturnal. They require free standing water for their eggs. The subfamily contains about 40 species of frog.

Liophidium sp. nov. 1. Only sampled in 1997 and of uncertain taxonomy. The location sampled is number 68, taken at the mine site in azonal forest of South Analamay and not in the conservation area, as well as in the plantation forest North of the Torotorofotsy Wetlands. This is a genus of diurnal snake, with 7 species described and others that have not been described.

Colonies of *Pilotrochus besmerus* have been found in a transitional forest near the western edge of the Analamay azonal conservation area (Site number 2). This species is only known in the Moramanga area.

Microgale sp. B, may be a new species. Also only from a 1997 specimen, located on transect T7 in zonal forest, east of the mine footprint. This is a large genus containing shrews and tenrecs. These species vary greatly in size and are insectivorous or carnivorous. Eighteen species are currently recognized.

The next level of priority concerns species that although more widely distributed, are listed by the IUCN as Endangered or Critically Endangered. These include two frogs, four birds and two lemurs.

Mantella aurantiaca and *Mantella crocea* have been found in azonal vegetation at Analamay and also in the Torotorofotsy wetlands.

Sarothrura watersii (slender-billed flufftail) was observed in the Torotorofotsy wetlands and is known from only one other wetland in Madagascar. However, this species is now known to be found in three other regional locations. *Anas melleri* and *Ardea humbloti* have also been seen in the Torotorofotsy Wetlands, while *Tyto soumagnei* has been seen in the forest in the area of the Ambatovy mine.

Indri indri has been observed in the azonal forest, azonal thicket and transitional forest in or near the Ambatovy and Analamay azonal conservation areas (T1, T4 and T5) or near those areas. *Propithecus diadema diadema* has been spotted in logged areas, azonal thicket and transitional forest (T1, T4) in or near the Analamay and Ambatovy azonal conservation areas or near there, as wells as in the Torotorofotsy Wetlands (T6).

Table 3.1 Priority fauna species in the Mine Site BMP-C Study Area

Taxon	Species	Endemism	UICN Status	CITES	Rarity
Amphibians	*Boophis nov. sp.*	Local			Species unconfirmed
	Mantella aurantiaca	Regional	Critically endangered	Appendix II	
	Mantella baroni	National		Appendix II	
	Mantella crocea	Regional	Endangered	Appendix II	
	Mantidactylus plicifer	National	Quasi-endangered		
	Plethodontohyla cf coronata	National	Vulnerable		
	Plethodontohyla nov. sp.	Regional			Species unconfirmed
	Scaphiophryne marmorata	National	Vulnerable		
Reptiles	*Brookesia superciliaris*	National		Appendix II	

Taxon	Species	Endemism	UICN Status	CITES	Rarity
	Brookesia therezieni	National		Appendix II	
	Brookesia thieli	National		Appendix II	
	Calumma brevicornis	National		Appendix II	
	Calumma cf nasuta	National		Appendix II	
	Calumma gastrotaenia	National		Appendix II	
	Calumma malthe	National		Appendix II	
	Calumma nasuta	National		Appendix II	
	Furcifer lateralis	National		Appendix II	
	Furcifer willsii	National		Appendix II	
	Liophidium nov. sp. 1	Local			Species unconfirmed
	Liophidium nov. sp. 2	National			Species unconfirmed
	Micropisthodon ochraceus	National			Rare according to specialists
	Phelsuma lineata bifasciata	National		Appendix II	
	Phelsuma lineata lineata?	Regional		Appendix II	
	Phelsuma pronki	Regional		Appendix II	High risk of extinction
	Phelsuma quadriocellata bimaculata	Regional		Appendix II	
	Phelsuma quadriocellata quadriocellata	National		Appendix II	
	Sanzia madagascariensis	National	Vulnerable	Appendix I	
	Uroplatus phantasticus	national		Appendix II	
	Uroplatus sikorae	national		Appendix II	
Birds	*Accipiter francesii francesii*	national		Appendix II	

Taxon	Species	Endemism	UICN Status	CITES	Rarity
	Accipiter henstii	National	Quasi-endangered	Appendix II	
	Accipiter madagascariensis	National	Quasi-endangered	Appendix II	
	Agapornis cana cana	National		Appendix II	
	Anas melleri	National	Endangered		
	Ardea humbloti	National	Endangered		
	Asio madagascariensis	National		Appendix II	
	Aviceda madagascariensis	National		Appendix II	
	Bernieria cinereiceps	National	Quasi-endangered		
	Brachypteracias squamigera	National	Vulnerable		
	Circus m. macrosceles	National	Vulnerable		
	Coracopsis nigra nigra	National		Appendix II	
	Coracopsis vasa vasa	National		Appendix II	
	Crossleyia xanthophrys	National	Quasi-endangered		
	Falco eleonorae	No		Appendix II	
	Falco newtoni newtoni	National		Appendix II	
	Gallinago macrodactyla	National	Quasi-endangered		
	Lophotibis cristata	National	Quasi-endangered		
	Milvus migrans	No		Appendix II	
	Neomixis flavoviridis	National	Quasi-endangered		
	Ninox superciliaris	National		Appendix II	
	Otus rutilus rutilus	National		Appendix II	
	Polyboroides radiatus	National		Appendix II	

Taxon	Species	Endemism	UICN Status	CITES	Rarity
	Rallus madagascariensis	National	Vulnerable		
	Sarothrura watersi	National	Endangered		
	Tyto alba	No		Appendix II	
	Tyto soumagnei	National	Endangered	Appendix I	
	Xenopirostris polleni	National	Quasi-endangered		
Lemurs	*Avahi laniger*	National	Quasi-endangered	Appendix I	
	Cheirogaleus major	National		Appendix I	
	Eulemur fulvus fulvus	Regional	Quasi-endangered	Appendix I	
	Eulemur rubriventer	National	Vulnerable	Appendix I	
	Hapalemur griseus griseus	National	Quasi-endangered	Appendix I	
	Indri indri	National	Endangered	Appendix I	
	Lepilemur sp.[(a)]	National	Quasi-endangered	Appendix I	
	Microcebus cf. rufus	National		Appendix I	
	Propithecus diadema	Regional	Critically endangered	Appendix I	
Small mammals	*Eliurus webbi*	National	Quasi-endangered		
	Microgale sp. B	Unknown			Species unconfirmed
	Microgale thomasi	National	Vulnerable		
Bats	*Myotis goudoti*	National	Quasi-endangered		
Ants	*Amblyopone sp. mad-01*	Regional			Rare genus
	Amblyopone sp.2	Regional			Rare genus
	Cerapachys lividus	Regional			
	Cerapachys sp. mad-38	Regional			
	Cerapachys sp.3	Regional			
	Cerapachys sp.5	Regional			
	Mystrium mysticum	Regional			Rare genus

Taxon	Species	Endemism	UICN Status	CITES	Rarity
	Mystrium rogeri	Regional			Rare genus
	Pilotrochus besmerus	Local			Moramanga area
	Proceratium sp.1	Regional			Very rare
	Pyramica ambatrix	Regional			
	Vitsika sp.1	Regional			
Butterflies	*Artitropa hollandi*	National			Rare
	Coeliades fidia	National			Rare
	Colotis lucasi	National			Outside the biome
	Fulda imorina	National			Rare
	Heteropsis andasibe	Regional			
	Heteropsis paradoxa	National			Rare and outside the biome
	Heteropsis turbata	National			Wetlands specialization
	Hovala 1	National			Probably widespread but rarely observed particularly in the biome
	Hovala 2	Regional			Rare
	Hypolimnas dexithea	National			Probably widespread but rarely observed particularly in the biome
	Malaza carmides	National			Rare
	Malaza empyreus	National			Probably widespread but rarely observed particularly in the biome
	Pharmacophagus antenor	National			1st recording in the biome
	Smerina manoro	National			Rare
	Strabena andriana	National			Wetlands specialization
	Strabena consobrina	Regional			Rare
	Strabena consors	National			Widespread but rare
	Strabena dyscola	Regional			
	Strabena modesta/modestissima	National			Rare
	Strabena niveata	National			Rare
	Strabena perroti	National			Rare

(a) (a) At least two species of *Lepilemur* occur in the eastern rainforests. The taxonomy of this genus is currently under revision and as such we prefer to list this species as *Lepilemur sp.* with the understanding that it is likely either *Lepilemur mustelinus* or *Lepilemur microdon*.

3.2.2 Pre-construction studies

3.2.2.1 Mining area

As will be done for the flora, additional studies of the fauna deemed necessary will be initiated with the progressive disturbances of the mine site surfaces. The highest priorities will be to carry out some surveys and work in the area to be cleared in April 2007, prior to that clearing. In general, this work will consist in testing the effectiveness of the proposed mitigation measures in order to change them if necessary and then implementing them for future clearings.

Studies prior to the first wave of clearing (April 2007)

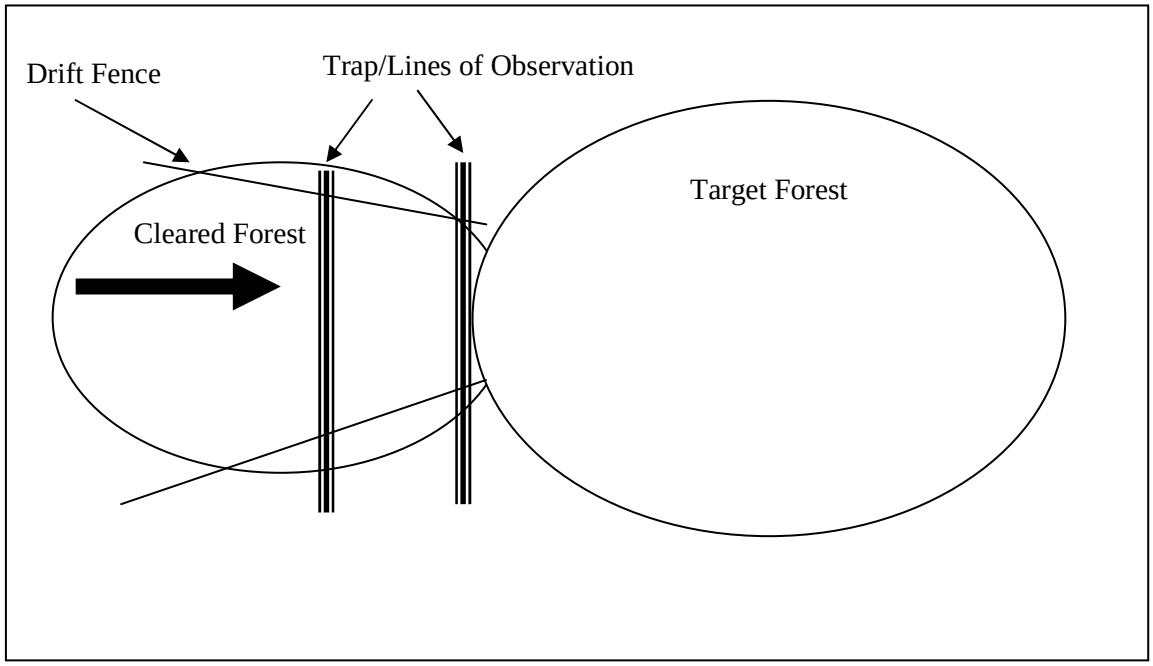
Help with the migration of animals outside the area. One of the main mitigation measures consists in facilitating the movement of animals from the areas to be cleared, in advance of the edge of the cut. This is predicated on a slow clearing that follows a specific direction as well as the construction of structures for crossing the roads.

The effectiveness of **slow clearing** will be subject to monitoring of a number of techniques, including marking individuals from priority species of fauna (i.e. endangered, etc.). The first task will be to reach an agreement with the staff responsible for the Project's forest clearing regarding the direction and the speed of the clearing in order to slowly "push" the animals towards the site's conservation area or the forest buffer zone. In general, the slower the clearing, the better the results; the felled trees will be left in place for at least one night after they have been cut to allow nocturnal species (i.e. *Microcebus*) and/or species that live in the tree trunk cavities or which are present in the stumps (such as birds that built their nests in the ground) to leave the area. The marking will be necessary for some priority species. This will be the case for *Indri indri* and *Propithecus diadema,* initially using visual identification collars with the possibility of using radio-collars during later phases of the clearing. Capture will be carried out by experienced veterans in fauna capture, in cooperation with the studies currently under way on lemurs in other parts of Madagascar. Collars will also be considered for the more common and numerous *E. fulvus* in order to obtain a larger quantity of data on the movements of lemurs. If, after the status of the terrestrial birds is updated, it turns out that they are listed by the IUCN as being endangered, these species will be banded and their movements monitored. Both endangered species of *Mantella* in the mining area will also be subject to marking and a study of their movements.

One or two cut lines will be cleared ahead of the construction "front", as shown in the diagram below. The monitoring will take place before, during and after the clearing, using a variety of methods, notably direct observation (birds, lemurs), pitfall traps (reptiles, amphibians, small mammals), and nets (birds, bats, eventually small lemurs). The monitoring will take place during the day and at night.

Research will also be carried out for dead animals in the felled trees and during the stacking, before removing them from the trees.

To help in identifying appropriation locations for building the road-crossing **structures**, monitoring of the animals and their preferred points for crossing the roads in the mining zone will start in March 2007 and will continue monthly to identify as best as possible the main existing areas of movement. This will be combined with a monitoring of animals killed by road traffic. Any primary area of movement will have crossing structures built at that point.



Research will also be undertaken on the dead animals in the felled trees before and during stacking, before removing them from the trees.

Salvage and relocation. As indicated above, the needs for salvage and relocation will be better evaluated after a review of the results of the studies of the movement of species in front of the forest clearing. One exception will be the investigation to establish if the *Pilotrochus besmerus* ant exists in the area to be cleared in April 2007. If it does, colonies will be located and moved to a laboratory then towards an off-site location (buffer zone), in order to test the salvage methods.

Studies during the clearing process (April 2007)

Taxonomy. Annual updates will be carried out for all the fauna groups concerning the changes that have occurred to the taxonomy or on the statuses listed by the

IUCN and CITES, bearing in mind that these could influence the BMP priorities. Additional taxonomic studies, including samplings in the field, will be carried out for the species in the mining area for which there are still doubts regarding the presence of the species and/or regarding the local distribution or over a larger area for the species in the zone, which would necessitate an eventual need for salvage and relocation. All the species in question are distributed far from the mine footprint, so these studies are not vital for the initial development of the mine (April 2007). The studies will take place on the mine site, the forest zone and in the Torotorofotsy Wetlands at the same time. The species to be studied include: *Microgale* sp B and *Lepilemur* spp (mammals); *Boophis* sp. and *Liophidium* sp nov 1 (amphibians and reptiles). Additional support will also be considered for taxonomic studies on the ants, for any morphospecies sampled during the supplementary surveys on the distribution of *Pilotrochus besmerus*.

Movement in advance of the construction. Depending on the results of the initial studies on movement, it is probable slow clearing will be optimized and will function as the main mitigation measure. In addition, these results combined with the surveys of the potential receiving habitats will assist in making a decision regarding the usefulness ("more good than harm") of the implementation of the relocation programs for the priority species. However, it is probable that additional marking and studies of movement will have to be undertaken to confirm the need for relocation for each of the subsequent areas to be cleared. Currently, such studies are being considered mainly for *Indri indri* and *Propithecus diadema*.

Studies regarding eventual relocation. Based on the results of studies of movements ahead of the construction and in some cases of additional taxonomy, potential release sites will be identified for those species considered in the framework of the salvage program. This could include *Indri indri*, *Propithecus diadema*, some terrestrial mammals, terrestrial birds, *Mantella aurantiaca* and *M. crocea*, *Boophis* nov. sp., *Liophidium* nov sp. 1 and *Pilotrochus besmerus*. Release sites will be the subject of a field study intended to try to ensure that these zones be of good quality for each given species. This will help in the decision-making process regarding the eventual relocation of a given species.

3.2.2.2 Torotorofotsy Wetlands

The following studies will be implemented in the Torotorofotsy Wetlands

Investigations may be considered for *Hapalemur (Prolemur) simus.* This rare lemur found in bamboo growths has not yet been observed but some evidence of its actual presence has been found, which, in fact, would constitute an extension of its range, given its current area of geographic distribution.

3.2.3 Mitigation measures

To mitigate effects on fauna numbers, distribution and movement, the following mitigation will be conducted:

- Mitigation measures will be implemented to encourage the fauna to relocate as construction progresses. Maps of the vegetation/habitats will be studied and the main potential movement corridors will be identified. The primary mitigation measures will be:
  - Slow clearing of the trees in a direction that "pushes" the animals towards on-site conservation areas or towards the other forests outside the mine's footprint (forest buffer zone). In addition, felled trees will be left in place for at least a day and a night before cutting the branches and before stacking them in order to give the nocturnal species (i.e. *Microcebus*) living in cavities in these trees and species living in burrows time to leave the cleared area.
  - Help with movement across roads using modified culverts (for amphibians, reptiles, small mammals) and pits or a drift fence to guide the animals towards these modified culverts. These should be located in the less elevated drainage zones, which are preferred by amphibians and reptiles.
  - Rope ladders for small lemurs and more stable wooden "bridges" for the larger lemurs. These crossing structures will be built to allow fauna to cross at specific locations, the route between the highest quality habitats. Depending on the results of the monitoring, these structures will be modified and improved as needed.
- As indicated above under the heading 'Pre-construction Studies", the construction in April 2007 of the ore processing plant and the construction camp will be used as an experiment to study the reaction of the animals to the disturbance. Direct and indirect observation methods will be used for all the main taxons, including marking individuals from the priority species. Some observations will be made at night, others during the day.
- Groups of some key species may be relocated from the site to other habitats that can accommodate them. Every species that is relocated will be recorded. Relocation of fauna is often difficult and rarely successful. Therefore, there must be valid reasons and scrupulous planning if relocation has to take place. In fact, salvaging of fish (including for consumption by the local population living near the project) from the waterways that would be affected is more common for development projects. As far as the terrestrial fauna in the project area is concerned, the best mitigation measure is to first help the animals to leave the area as construction progresses. For this project, a phased approach is proposed, with an initial focus on the evaluation of how the animals are reacting to the initial construction, followed by the design of mitigation measures to determine how best to help them move towards the adjacent forest. For terrestrial fauna, their biology of the priority species must be considered to determine if relocation is required and

whether there exists another practical option. The following considerations have been studied:

- Are species likely to be unable to move ahead of construction?
- What is the existing social structure and how will this influence capture needs/methods and the choice of locations where animals could be released?
- What suitable (good quality habitat), secure (protected areas) release options are available and what is known of the capacity of those areas to "absorb" additional animals? Should some species be moved to the on-site azonal conservation area?
- Is release for *in situ* conservation purposes the only reason for capture? Are there any species unlikely to move ahead of construction for which *ex situ* (i.e. zoo) or legitimate trade (trade in domestic birds) exist?
- Meeting of the team of specialists in 2007 will provide the answers to these questions, after the publication in April of the results of the observations on how the species are reacting to the forestry clearing. Decisions will then be made as to the capture and/or relocation of a particular species. We also have to monitor the survival of the priority species that relocate themselves ahead of construction towards the buffer zone, since it is not possible to assume that a mitigation measure will be successful until it has been implemented.

- A campaign will also be launched against the introduction of exotic and nuisance species such as rats, mice and insects. Discussions will be held with health personnel and veterinarians concerning the best practices for fumigation or other methods to apply to construction materials arriving through the port at Toamasina. Moreover, a program to eliminate *Rattus rattus* will be implemented in the area around the mining camp and in the on-site azonal conservation areas. Live capture methods will be used for the registered endemic species as part of the overall monitoring program, then released.
- Noise, dust and light will be controlled to limit the indirect impact on animal life caused by these disturbances.
- The forest management plan will maintain habitat connectivity around the mine. Details are provided in the section about flora.
- Any traps or snares found in the immediate mine buffer zone during monitoring will be documented and removed.
- Animals that fall into trenches dug for the Mangoro water pipeline will be registered and then released.
- The use of markers such as aviation spheres to mark transmission lines where collision with birds is considered a danger, will be considered.

- Installing signage to encourage safe driving with speed limits being posted.
- Driving behaviour will be monitored both for safety and fauna protection concerns.
- A waste management plan will be designed to ensure that the fauna are not attracted to waste storage areas.

3.2.4 Monitoring

On-site azonal conservation areas and forest area. Key fauna groups (indicator species and endangered species) will be monitored in areas adjacent to the mine, especially in the on-site azonal conservation area, and in the Torotorofotsy Wetlands, in order to confirm the absence of mining impacts on the fauna. Monitoring in the Ankera off-site area will provide reference (control) data. The objective will be to follow trends in species richness and relative abundance to ensure that the azonal conservation areas remain viable habitats and that the buffer zone is generally achieving its management goals (still to be determined). Monitoring a range of taxa will help identify specific stressors that may be affecting fauna, so that remedial action can be taken. Surveys will occur along transects away from the mine site, to again facilitate interpretation of any observed trends, particularly around the edge of the mine. Main potential impacts are the result of potential hydrologic effects, the effects of atmospheric emissions and the effects of disturbances. Habitat patch size and its fragmentation from similar azonal habitats could also be a factor. Species to be monitored will include priority species and any transplanted species. Species/taxonomic groups will also be chosen so that all main impact mechanisms on fauna are being well monitored:

- **Mammals.** One of the main monitoring methods in the on-site azonal conservation areas, consists in capture and eliminating *Rattus rattus* using traps. Small endemic mammals that are captured will be registered then released. Lemurs will be the subject of an annual survey during the rainy season, using methods such as those used in the core studies and the data will be presented as lists of species, relative richness and abundance. Given that no lemur is specialized in the azonal habitats, the monitoring will take place in the overall forest area and will include the azonal conservation areas.
- **Amphibians and reptiles** have increasingly been shown in recent years to be suffering declines in many parts of the world, likely owing to a variety of causes. In the Project areas, they will represent indicator species for possible impacts mainly resulting from the effects of the project on water, water quality and atmospheric emissions. Amphibians and reptiles will be monitored annually during the rainy season to document trends in species richness, relative abundance and population health. Some survey sites will be linked with water quality monitoring sites.

- **Bird species** have a multitude of feeding and habitat requirements. Birds will be monitored in the forest areas, including on-site conservation areas, and results will be presented as species lists, relative species richness and abundance (observations per unit effort). Monitoring will take place annually during the rainy season.
- **Insects.** Colonies of a rare species of ant, *Pilotrochus besmerus*, will be monitored annually during the rainy season in the buffer zone and in the on-site conservation areas. In addition, the exotic, invasive ant, *Technomyrmex* sp., will be the subject of field surveys as an indicator of habitat disturbance. The initial clearing for construction will be considered as an opportunity to fumigate the trees for a general collection in the framework of acquiring better knowledge of the taxonomy or for other research needs (in case a research institute might wish to collaborate). This work would be research above and beyond the requirements for Project monitoring.

Roadkill. As described above, there will be monitoring of fauna (dead or alive) at their main crossing points in the Project area. This monthly monitoring will assist in the positioning of fauna crossing structures and in the siting of signage for vehicle drivers. This work will be carried out every month, from March to July 2007 and then reduced bimonthly and linked to the monitoring of crossing structures (see below).

A record of fauna sightings by the workers will be maintained. Workers will be encouraged to report animal sightings or calls, especially if they detect key species or spot rare species. A log will be prepared before June 2007 to provide details on sightings that should be retained. The workers will be asked to report cases of animals using the crossing structures, to contribute to the determination of the primary crossing points.

Crossing structures/road crossings will be monitored from the time they go into operation to determine how successful they are. The culverts will be monitored weekly by direct observation during the rainy season and monthly during the dry season. The wooden bridges and the rope ladder will be monitored monthly by direct observation at a distance. Depending on the results, consideration will also be given to the installation of motion-sensing activated cameras. The results will be used to determine their likely relocation or design in order to improve their effectiveness.

Noise and dust will be monitored periodically in the azonal conservation areas on site. The siting of the measuring points will be linked to the locations of investigation of fauna.

Open trenches dug for the water pipelines will be monitored daily and any animal found there will be registered and then released.

Torotorofotsy. The amphibians in the Torotorofotsy Wetlands, including the endangered *Mantella* spp., will be monitored annually during the rainy season, as an indicator of aquatic impacts. *Rattus rattus* will be captured, eliminated and their numbers recorded in an index of the disturbances. Captured endemic species will be released and monitored. A monitoring program for the aquatic birds, including the endemic local species, *S. watersi,* will be implemented as an indicator of habitat quality. Species, their distribution and their relative abundance will be monitored using a series of appropriate techniques.

3.3 ANKERA OFFSITE CONSERVATION AREA

3.3.1 Pre-construction studies

Planning for the investigation of the fauna in the off-site protection area at Ankera will be initiated during the first year of construction. These inquiries will cover all the main groups of fauna studied for the core studies on the mine site and will include research into the priority species in the mining area. However, it is necessary to consult with the local communities, stakeholders and the relevant authorities before implementing the field work to ensure the broad consensus and support that will be necessary for the long-term protection of this site. The field work is expected to start during the 2007–2008 rainy season.

3.3.2 Mitigation measures

The Ankera off-site protection area will have legal protection in agreement with the neighbouring communities and will have funding for its management and to meet its ongoing monitoring needs.

3.3.3 Monitoring

Any species relocated to the offsite area from the mine site will be monitored. In addition, an ongoing biodiversity inventory in the offsite conservation areas will be carried out to document the presence and status of the populations of various animal groups: diversity, distribution, diet and key habitat areas. The planning for this work will commence during the pre-construction phase and will be implemented during construction and operations. Data obtained will aid in the management of the area and will act as control data for on-site conservation area monitoring. All taxa studied in the mine site will also be surveyed using similar methods. Species lists, relative species richness and abundance data will be presented by habitat once a vegetation map has been produced.

3.4 SLURRY PIPELINE

3.4.1 Priority Species

Priority faunal species observed during studies along the slurry pipeline are listed in Table 3.2. However, no high priority local endemic, endangered or critically endangered species were recorded. Most of these priority species were recorded in the Ankehineny-Zahamena forest corridor zone.

Table 3.2 Priority Fauna Observations in the Slurry Pipeline Local Study Area

Taxon	Species	Endemism	IUCN Status	CITES Category
Amphibians	*Boophis rufioculis*	National	Quasi-threatened	
	Mantella baroni	National		Appendix II
	Mantella pulchra	National	Vulnerable	Appendix II
Reptiles	*Brookesia minima*	National		Appendix II
	Brookesia therezieni	National		Appendix II
	Brookesia thieli	National		Appendix II
	Calumma furcifer	National		Appendix II
	Calumma gallus	National		Appendix II
	Calumma nasuta	National		Appendix II
	Phelsuma flavigularis	National		Appendix II
	Phelsuma lineate bifasciata	National		Appendix II
	Phelsuma quadriocellleta parva	National		Appendix II
	Sanzinia madagascariensis	National	Vulnerable	Appendix II
	Uroplatus fimbriatus	National		Appendix II
	Uroplatus phantasticus	National		Appendix II
Birds	*Accipiter francesii francesii*	National		Appendix II
	Accipiter henstii	National	Quasi-threatened	Appendix II
	Accipiter madagascariensis	National	Quasi-threatened	Appendix II
	Asio madagascariensis	National		Appendix II
	Aviceda madagascariensis	National		Appendix II
	Brachypteracias leptosomus	National	Vulnerable	
	Coracopsis nigra nigra	National		Appendix II
	Coracopsis vasa vasa	National		Appendix II

	Crosseyia xanthophrys	National	Quasi-threatened	
	Falco eleonorae	National		Appendix II
	Falco newtoni newtoni	National		Appendix II
	Lophotibis cristata	National	Quasi-threatened	
	Milvus migrans	National		Appendix II
	Neodrepanis hypoxantha	National	Vulnerable	
	Newtonia fanovanae	National	Vulnerable	
	Ninox supercilliaris	National		Appendix II
	Otus rutilus rutilus	National		Appendix II
	Polyboroides radiatus	National		Appendix II
	Tyto alba	National		Appendix II
	Xenopirostris polleni	National	Quasi-threatened	

3.4.2 Pre-construction studies

3.4.2.1 Pipeline route

The main mechanism for improving the pipeline route prior to construction requires further GIS work with the help of LIDAR imaging (described in the section about the flora), then for the water crossing sites, followed by additional field work (described in the section about fish). However, some additional faunal sensitivities will be taken into consideration:

- The studies at the mine regarding the distribution and the taxonomy of the species, *Liophidium*, will be carried out along and in the areas near the pipeline route north of the Torotorofotsy Wetlands, where this species was also recorded in 1997. This is an additional control in order to ensure that there is no need for further improvement to the pipeline route or for additional species salvage.
- A study of resting areas for bats and birds will be carried out along the pipeline route where the latter unavoidably leaves the mine area and in all the other areas of native forests and elsewhere along the route. Resting areas are sensitive and important places (over several years) which can be easily found through observation and by consulting local villagers. These areas should be avoided during the improvement of the pre-construction improvement of the pipeline route.

3.4.3 Mitigation measures

Mitigation that will reduce the effects of habitat loss and alteration from site clearing and changes in hydrology include:

- The pipeline route is mainly (approximately 95%) through previously disturbed or degraded areas. It was routed to avoid primary zonal forest fragments and wetlands of biological value, particularly the Torotorofotsy Wetlands, the Mantadia National Park and the forest-covered areas in the Ankehineny-Zahamena forest corridor. Greater improvement to the pipeline route will take place as described above to minimize the impacts.
- Along the pipeline route between the two protected areas of the Mantadia National Park and the Andasibe Special Preserve, the pipeline will be constructed to allow overgrowth of trees and shrubs and improve forest cover and connectivity during operations and post-closure.
- The pipeline will be buried except for a few locations across rivers and near mine and plant facilities.
- Clearing by hand and the reduction of the size of the encroachment will take place if the route must pass through natural riparian forests abutting rivers to minimize the impacts on faunal and floral habitats.
- Culverts or bridges will be installed at access road stream crossings (access and maintenance roads), providing connectivity for species along the stream.
- Sediment control and water quality protection will be ensured and specific mitigation measures to the site implement, particularly at river crossings. Details are provided in the section on fish and aquatic resources.
- During pipeline construction, open trenches will be limited to short sections and duration which will reduce potential for animals to be trapped in the trench. Animals that fall into trenches will be captured and released daily and their numbers (by species) will be recorded.
- During construction, mounds of earth or sandbags can be placed against the pipeline before it is buried so that certain animals can cross this obstacle more easily. This will only be done if the pre-construction monitoring identifies significant habits to be reached by these taxons (wetlands, etc).

Reclamation

Mitigation measures in terms of reclamation are described in the section of the BMP-C dealing with flora and, in greater detail, in the pipeline reclamation plan. Furthermore local labour will work with the regional planners to reconstitute the connectivity between the Mantadia National Park and the conservations areas to the south, as an element of *Projet Carbone*. This will be achieved by reconstituting the primary forest along the pipeline route in these sectors. The increase of the forest

cover in this sector will improve faunal movement and the connectivity of the population over and above the conditions described in the reference study.

3.4.4 Monitoring

Monitoring will be conducted to help determine if mitigation is effective or if adjustments must be made. The principal contractor will carry out a fauna monitoring program that includes:

- Monitoring will confirm that any resting area for bats or birds is avoided.
- If sandbags are used to help animals cross the pipeline before the latter is buried, the effectiveness of such a mitigation measure will be monitored.
- Driving behaviour will be monitored both for safety and fauna protection concerns. Game trails intersecting access routes will be noted to identify areas for signage.
- As part of vegetation monitoring, research-based reclamation trials will be carried out after progressive ROW reclamation to document the effective re-establishment of habitat. (See Flora management plan).
- Monitoring of open trenches and the recording and removal of trapped animals will occur daily soon after dawn.

3.5 PROCESSING PLANT

Priority fauna observations in the plant and tailings areas are all included in Table 3.3. No high priority local endemic, endangered or critically endangered species were seen.

Table 3.3 Priority Fauna Observations in the Toamasina Local Study Area

Taxon	Species	Endemism	IUCN Status	CITES Category
Amphibians	*Hoplobatrachus tigerinus*	Non endemic		Appendix II
Reptiles	*Calumma nasuta*	National		Appendix II
	Furcifer paradalis	National		Appendix II
	Phelsuma lineata bifasciata	National		Appendix II
	Phelsuma lineata lineata	National		Appendix II
	Phelsuma quadriocellata parva	National		Appendix II

Birds	*Accipiter francesii*	National		Appendix II
	Agapornis cana	National		Appendix II
	Falco newtoni	National		Appendix II
	Otus rutilus	National		Appendix II
	Rallus madagascariensis	National	Vulnerable	
	Tachybaptus pelzenii	National	Vulnerable	
	Tyto alba	Non endemic		Appendix II

3.5.1 Pre-construction studies

No other pre-construction study is required.

3.5.2 Mitigation measures

Mitigation measures for the fauna during the plant construction phase include:

- Use of existing disturbances reduces the area of new clearing.
- Noise level specifications applied to all major noise-causing pieces of equipment.
- The installation of culverts passing under the roads to facilitate crossing roads by the fauna if the roads cut through good quality habitats, particularly any relicts of wetlands. Monitoring should help to define the locations to install the culverts, as described for the mine site.
- The use of markers such as aviation spheres in order to mark transmission lines in areas where collision with birds is considered to be a hazard, will be considered.
- Reduce the disturbance of the shorelines and the aquatic environment during the construction of the water inlet in the Ivondro River and the water pipeline.
- Trapping and elimination of exotic rodents such as *Rattus rattus* around the camp and other buildings.
- Dust control measures, particularly in the dry season.
- Possible relocation or salvage of key fauna that will not have moved itself during construction, that is, before clearing, in the chosen sectors. The issue of knowing if this will be necessary or not, is similar to a question that arises regarding the mine. Currently, no forecast of fauna salvage is planned but the results of the 2007 complementary study on mammals will be considered.
- Signage and speed limits.

- Development of a waste management plan.
- During the construction of the pipeline to obtain water from the Ivondro River, open trenches will be limited to sort sections and limited durations, which will reduce the possibility for those animals to become trapped in them. Animals that fall into these trenches will be captured then released daily and their numbers (by species) will be monitored.

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3.5.3 Monitoring

A limited amphibian monitoring program is proposed for the Toamasina area to measure potential changes in priority species distribution, abundance and health as a result of changes in water flows and water quality. The monitoring will take place mainly downstream of the tailings facility (see below) but may be extended closer to the plant site. In addition, the monitoring will be carried out to determine if the mitigation measures are effective or if adjustments are necessary:

- Any species removed prior to and during clearing or operations (i.e., nuisance animals) will be recorded.
- To assess the impacts of fauna interaction with project infrastructure, project pond areas will be monitored for sign of fauna use. This will take place principally during the operations phase and the details of the program will be developed before the beginning of operations.
- A periodic inventory of fauna species on the plant site will be conducted, every three months using day time and night time direct observation methods.
- Driving behaviour will be monitored both for safety and fauna protection concerns.

3.6 TAILINGS FACILITY

3.6.1 Priority species

Priority species for the Toamasina area are as listed in Table 3.3.

3.6.2 Pre-construction Studies

No further pre-construction studies are needed.

3.6.3 Mitigation measures

Mitigation measures for the construction phase include:

- Footprint of all sites represents smallest feasible size to meet needs of the project.
- Use of existing disturbances (e.g., road to tailings facility) reduces the area of new clearing.
- Build precautionary design features in tailings dam to reduce the risk of rupture and design emergency planning to mitigate effects in event of a failure.
- Noise level specifications applied to all major noise-causing pieces of equipment.
- Lights will be softened and/or directed away from adjacent habitat.
- Modification of below-road culverts to facilitate faunal crossing, if high quality habitats (i.e., wetlands) are separated because of the road construction. Monitoring will be used to define the locating of such structures.
- Use of markers such as aviation spheres to mark transmission lines.
- The buffer zones for the rivers will be maintained as long as possible to help maintain the water quality and to provide habitats for the fauna.
- Dust control measures, particularly in the dry season.
- Post speed limits.
- During pipeline construction, open trenches will be limited to short sections and duration to limit trapping animals. Animals that fall into trenches will be captured, recorded and released.

3.6.4 Monitoring

Monitoring will be conducted to help determine if mitigation is effective or if adjustments must be made. The principal contractor will carry out a fauna monitoring program that includes:

- An amphibian monitoring program is proposed for the Toamasina area to measure potential changes in key species distribution, abundance and health as a result of changes in water flows and water quality. This will take place annually during the rainy season, starting during the construction phase, to determine the presence of species, their diversity and their relative abundance. Monitoring will take place at three locations, starting downstream from the eastern edge of the tailings facility. The stations will be coordinated with the water quality monitoring stations. A monitoring site will be located in a watershed unaffected by the Project.
- Any species removed prior to and during clearing or operations (i.e., nuisance animals) will be recorded.

- Crossing structures at roads will be monitored to determine the success of these structures in the early stages of their use.
- Driving behaviour will be monitored both for safety and fauna protection concerns.

3.7 PORT EXPANSION

3.7.1 Pre-construction Studies

No further pre-construction studies are needed.

3.7.2 Mitigation measures

Not applicable for fauna (see discussion below on marine biology).

3.7.3 Monitoring

Not applicable for fauna (see discussion below on marine biology).

4 FISH AND AQUATIC HABITATS

4.1 GENERAL

4.1.1 Mitigation measures

In general, mitigation for the construction phase will have an impact at all sites including the maintenance of water quality and water volume at natural levels, and the avoidance of pristine aquatic habitats wherever possible. During construction, erosion control measures will be applied along any areas bordering water to minimize siltation.

4.1.2 Monitoring

Surface water monitoring will be carried out at all sites in accordance with the surface water management plan.

4.2 MINE

4.2.1 Priority species

All fish species recorded in the mine area are listed in the following table. Priority species are the four endemics.

Table 4. 1 Fish Species Recorded at the Mine Local Study Area During the 1998 and 2004-2005 Surveys

Family	Species	Origin	Conservation Status[a]	IUCN Status[b]
Anguillidae	*Anguilla mossambica*	N	S	NL
Atherinidae[c]	*Atherion sp.*	N	S	
Cyprinidae	*Carassius auratus*	I		
Gobiidae	*Chonophorus aeneofuscus*	N	S	NL
Gobiidae	*Glossogobius giuris*	N	S	NL
Anabantidae	*Ctenopoma ansorgii*	I		
Belontiidae	*Macropodus opercularis*	I		
Channidae	*Channa maculata*[e]	I		
Cichlidae	*Oreochromis niloticus*	I		
Cichlidae	*Tilapia zilii*	I		
Eleotridae	*Ratsirakia legendrei*	E	T	DD
Eleotridae	*Ratsirakia sp.*	E	NL	NL
Bedotiidae	*Rheoclès alaotrensis*	E	T	VU
Bedotiidae	*Rheoclès "ambatovy"*[d]	E	NL	NL
Poeceliidae	*Xiphophorus maculatus*	I		

Poeceliidae	*Gambusia holbrooki*	I		

- Notes: E = endemic, I = Introduced, N = native; S = Secure, T = Threatened
- IUCN status: NL = not listed, DD = data deficient , VU = vulnerable.
- [(a)] Sparks and Stiassny (2003).
- [(b)] International Union for the Conservation of Nature (IUCN) Red List (2004).
- [(c)] From 1998 survey only (Sparks et al. 1998).
- [(d)] Unconfirmed
- [(e)] Misidentified as *Ophicephalus striatus*.

4.2.2 Pre-construction studies

Seventeen fish species were collected from the mine study area during baseline surveys. These fauna included four endemic fish (*Rheocles alaotrensis*, *Ratsirakia legendrei (species"A"), R. legendrei (species "B")* and *Rheocles "ambatovy"*). The endemic species were most prevalent at undisturbed and headwater habitat sites in the local study area (the mine footprint). *Ratsirakia* "B" is clearly an undescribed species and was found either in the immediate vicinity of the ore bodies or at a station situated along the upper reaches of the proposed pipeline route. This extremely dense distribution requires an endangered classification for the population in the mine area unless it also occurs more widely in the headwaters of the Rianila basin. Also, if *Ratsirakia* "A" proves to be widely distributed within the Rianila and in the Mangoro as well, or if the two populations are conspecific (determined by genetic analysis), the conservation status for this species could change to low risk. *Rheocles "ambatovy"* is an unidentified species first collected in the mine area in 1998, but confirmation of its distribution and conservation status in the mine area requires follow-up surveys and additional taxonomic and/or genetic assessment.

The identity and conservation status of the two *Ratsirakia* and one unidentified *Rheocles* endemic fish species, and the extent of impact of the mine operation on these endemic fish, requires additional surveys of the drainages within and contiguous to the mine to confirm their distribution, abundance, habitat requirements and conservation status. ((Proposed Work – based on assessment and taxonomic analysis, report to Golder Associates by USA-based Malagasy fish taxonomic specialists Loiselle and Stiassny (2006), post EA completion).

Additional surveys of aquatic habitat will also be carried out in the mine footprint area to help focus species salvage efforts prior to construction; for fish in streams and invertebrates in ephemeral ponds. Surveys will be phased into the mine development plan, with field programs scheduled for the year immediately prior to development of the mine block or disturbance of each watercourse. Fish habitat assessment at this time will document critical functions (i.e., spawning) and qualitative samples of macro-invertebrates for proper taxonomic identification, biodiversity assessment and cataloguing. Fish species, relative abundance and local distribution will be catalogued. Ephemeral ponds will be surveyed to determine and

catalogue physical /chemical limnology, invertebrate (macrobenthos and plankton) species present and aquatic plants.

The need for studies prior to the clearing (April 2007)

Species of fish of uncertain taxonomy were well distributed in the mine study sector, including in the buffer zones and the Torotorofotsy Wetlands. Therefore, the initial clearing, planned for April 2007, will serve mainly as a test of the methodologies for the study of distribution and abundance, to collect specimens for taxonomy and finally, to assist in planning for possible salvage and relocation during later clearings. Should one of these species be found, specimens will be raised in aquaria to test if it is possible to keep them in captivity.

As indicated above, the slow lowering of the water levels of the rivers will be evaluated in April 2007 to see if this technique helps the fish to distance themselves from the site to be affected. A marking program will be implemented for the initial clearings, if possible (e.g., if the targeted species of fish are found); otherwise, the marking will be tested in a sector of the mine to be cleared later.

Several ephemeral ponds can be found in the April 2007 clearing area. These ponds are already disturbed. However, they will be studied in order to collect the micro and macro invertebrates to carry out later taxonomic work and to confirm the presumed absence of fish (presumed absence in all the ephemeral ponds).

The need for studies during and after the April 2007 clearing

Preconstruction studies of the waterways and the ephemeral ponds will be carried out in each sector after the mine clearing, one year prior to construction. The goals would be to obtain other samples to clarify the taxonomy of the target species and to plan the requirements for fish salvage.

Moreover, the waterways that could potentially be used as refuges, will be identified and tested to determine if they are suitable to release fish (including the use of physiochemical measures). The emphasis will be initially on the nearby waterways of a similar type in the forest buffer zone, including them that already have water quality monitoring stations.

4.2.3 Mitigation measures

The following mitigation measures are proposed to reduce effects on aquatic habitat, reduce effects on endemic species, preserve aquatic community structure and limit effects on artisanal fishing resources:

- Mitigation measures to reduce water quality and quantity changes will be implemented as described in the surface water management plan.

- Pristine habitats will be avoided where possible.
- If possible, a staged reduction of the flow in the waterways concerned should be initiated at the start of construction, to try to incite fish migration from the watershed.
- A relocation program for fish will be carried out in the waterways, prior to the disturbances. The program will be planned and implemented as follows:

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  - The program should include a detailed record of the biota and habitats lost to enable justification and quality control of the mitigation measures use. This will allow for a comparison with the habitat loss estimates in the EIA and to allow consideration of any subsequent compensatory measures if required.
  - Focus on salvaging endemic species. The primary endemic species in the mine area are those belonging to the families Bedotiidae (*Rheocles sp*) and Eleotridae (*Ratsirakia* sp.), although some native Cichlidae could still be encountered. Populations of *Ratsirakia "B"* (potential new species) require specific consideration and conservation.
  - Release the endemic species, after salvage from the waterways that will be affected, into suitable receiving habitats. A release strategy, including priorities, should be established i.e. :
    - Released back to their natural watershed (conservation genetics) if possible
    - Released in existing waterways not currently supporting populations (i.e., isolation because of migrational barriers such as waterfalls, etc.)
    - Transfer of endemic fish species to "conservation breeding" centres; captive breeding and restocking in locations close to their natural range.
    - If salvage and release options are not practicable, eventually provide desirable endemic species to the ornamental fish trade market (for local income benefit).
  - The Mangoro watershed has a high risk of transfer of predacious exotic fish; therefore all collections from this basin should be separated and releases made back into this watershed.

- Salvage is carried out by capturing live fish using appropriate techniques such as the use of seine nets, traps and electro fishing. Specialized logistical support may prove necessary, including, vehicles water tanks/transfer tanks (with a water circulation and oxygenation system).
- All of the fish should be identified and recorded, information on their biological background collated and functional data on their habitat collected to help with quality control and identification of appropriate release sites.
- Exotic/non-native species will be offered to the local population for their consumption.
- Off-site receptor sites will be inventoried and studied in order to characterize the existing local piscicultural populations' carrying capacity.
- The program should aim at full relocation of all the fish present in the waterways that will be affected. This will require using collection techniques until the waterways are exhausted (multiple passes through the reaches); this technique will be tested and refined from the very start of the salvage program (i.e., for electric fishing, 3 to 4 successive sweeps may be needed in order to collect the majority of the fish).
- Preserve representative samples of each species to be released to confirm their identification; a sample of the genetic material will be prior to the conservation of the specimens.
- The habitat data should include (qualitative) samples of the macrobenthos, for an appropriate identification and evaluation of the biodiversity present.
- The timing of the salvage: the salvage should take place before the physical impacts of the construction that would eliminate and/or seriously affect the flow and quality of the water on the mine site. If the salvage takes place long before the construction, downstream barriers at the furthest point to prevent immigration, will have to be installed. It would be preferable to carry out the salvage when the waters are low (ease of access and effectiveness of the removal).
- The main waterways of the mine where salvage may be necessary:
    - Review of existing data on the stations and focus on the waterways/reaches that are nearest to the sources (1^{st}, 2^{nd}, 3^{rd} order) that contain or in which the presence of endemic fish populations is suspected.
    - The waterway reaches that will be destroyed within the mine sector.

  - Additional studies of the various pre-construction sectors of the mine will make it possible to plan the salvage operations.

- An emergency aquatic environmental and reclamation plan will be developed to mitigate any potential spill.
- The inlets on the Mangoro River will have filters to prevent the catch fish and/or larvae and eggs. The size of the filter mesh will take into account the sizes of the fish, larvae and eggs (if the water is treated after the inlet, than a larger mesh could be used).
- Limit the accessibility to nearby sectors of the mine that have endemic fish to reduce the impact of artisanal fishing.

The mitigation measures that will moderate the impact resulting from the loss of or change in habitat, are described below:

- The footprint of the Project sector will include two protected azonal forest habitats and will thus avoid a total loss of sensitive aquatic habitats. The Ambatovy conservation sector will contain almost six of the eight ephemeral ponds remaining in the study zone. This conservation zone also offers partial protection to the seven 1st order azonal transitional waterways. The Analamay protected area also ensures a certain protection of areas upstream of the primary forests of the Sakalava watershed.
- Disturbances caused by sedimentation or the effects on the water quality of the Torotorofotsy watershed will be reduced to a minimum to protect the sensitive habitats in the Torotorofotsy Wetlands and to maintain the ecosystem's current conditions.
- The mine's water management plan will use variable flows to simulate the seasonal variations and the duration of the natural run-offs to maintain the ecosystem's natural function and the aquatic diversity.
- Directives regarding waterway crossings and ecological action plans will be applied to minimize any work in the waterways and the disturbances of aquatic/riparian habitats, as well as to control sediment levels.
- Work closely with stakeholders in order to align the Project's initiatives with regional conservation plans.
- All mitigation procedures and measures specifically targeting the habitat will ensure a certain direct or indirect protection to the piscicultural communities and the aquatic resources.
- Any excess waters from the Mangoro River transferred to the mine will be returned to the Mangoro watershed to minimize risks of spills or the introduction of exotic aquatic organisms into other watershed.

- Design and installation of intake screening on the Mangoro River pumping station to prevent the entrainment of small fish and/or fish larvae and eggs as described above.
- Immediate re-vegetation of all disturbed riparian habitats at road and/or water pipeline waterway crossings.
- Include protection of endemic fish and any other fauna (as well as the risk of species introduction) in environmental education initiatives.
- Protection of unique aquatic ecosystems and communities (ephemeral ponds and 1st order waterways) within the proposed Ambatovy, Analamay and offsite azonal conservation areas.
- Support the Torotorofotsy Ramsar management initiative, including helping to develop fish management plans.

4.2.4 Monitoring

Effects on water quality and volume will be monitored as described in the water management plan. Follow-up monitoring on the success of other mitigation measures will be carried out.

- Any relocated species will be monitored after release to ensure its survival and to modify the process in case problems arise.
- The protection and conservation measures applied to the ephemeral ponds and 1st order streams in the on-site azonal protected areas will be monitored to ensure these areas are being preserved. An initial survey of aquatic biota and their habitats will establish current baseline conditions (in addition to data from studies previously carried out), with subsequent annual monitoring in the rainy season. Standard methods (such as were used to determine the baseline) will be employed to describe the aquatic resources and the health (community diversity, relative abundance, species change) of the populations and habitats. Some sites will be co-located with the water quality monitoring stations.
- Downstream monitoring of waterways will be based on monitoring environmental effects, which include flow and water quality integrated with periodic observations of habitat conditions. This monitoring program for the effects of the construction will be focused on the reaches located immediately downstream of the waterways boundaries of the mine area. This will include monthly physical measurements of the habitat (flow, depth, wetted width, sedimentation rates), seasonal (dry and rainy periods) assessment of sentinel fish (a selected endemic fish such as *Rheocles sp*) and macro-invertebrates (a water quality indicator species such as a plecopteran) at 1 to 3 locations. Focus will then be placed on the “ecological” watersheds in the Ankehineny-Zahamena forest corridor, including the Torotorofotsy watershed.

- Water flow and quality monitoring will be implemented downstream to ensure protection of downstream habitats. Because of the potential for bioaccumulation, analysis of the flesh of fish will be carried out to detect contaminants that could affect ecological and human health. These analyses will be carried out annually in the "ecological" watershed of the mine sector as well as in the 'agricultural" watersheds. This will start during the mine construction.

- Monitor to ensure that conservation measures to preserve the ephemeral ponds are working successfully in both on-site and off-site conservation areas.

- Routine maintenance and inspection of the water intake screen to ensure proper operation.

- In case of spills, the location and result of each spill will be documented along with the measures taken to preserve aquatic habitat.

4.3 OFFSITE CONSERVATION AREAS

4.3.1 Studies

An off-site protection area survey of ephemeral ponds and waterways in the off-site Ankera conservation area will be initiated during the first year of construction and will be implemented during construction. The objectives will be to document species, species richness and relative abundance to aid in management and to ascertain if biology similar to that of the mine site footprint ponds.

4.3.2 Mitigation measures

An off-site azonal conservation area is to be conserved. It will include ponds and other aquatic habitat.

4.3.3 Monitoring

Any species translocated to the offsite area from the mine site will be monitored. General monitoring will also take place after the initial inventories are completed.

4.4 SLURRY PIPELINE

4.4.1 Priority species

All fish species recorded along the pipeline study area are shown in Table 4.2. Priority species are the endemics, with focus on those species on the IUCN Red List.

Table 4.2 Fish Species Recorded at the Slurry Pipeline Local Study Area During 2004-2005 Surveys

Family	Species	Origin	Conservation Status[a]	IUCN Status[b]
Ambassidae	*Ambassis fontoynonti*	E		DD
Anabantidae	*Ctenopoma ansorgii*	I		
Anguillidae	*Anguilla bicolour*	N	S	NL
Anguillidae	*Anguilla marmorata*	N	S	NL
Anguillidae	*Anguilla mossambica*	N	S	NL
Bedotiidae	*Bedotia madagascariensis*	E	T	NT
Bedotiidae	*Rheoclès alaotrensis*	E	T	VU
Cichlidae	*Oreochromis macrochir*	I		
Cichlidae	*Oreochromis niloticus*	I		
Cichlidae	*Paretroplus polyactis*	E	S	VU
Cichlidae	*Tilapia zilii*	I		
Clupeidae	*Sauvagella madagascariensis*	E		NL
Eleotridae	*Ophiocara macrolepidota*	E	U	NL
Eleotridae	*Ratsirakia legendrei*	E	T	DD
Gobiidae	*Chonophorus aeneofuscus*	N	S	NL
Gobiidae	*Glossogobius giuris*	N	S	NL
Gobiidae	*Stenogobius polyzona*	N		NL
Kuhliidae	*Kuhlia sauvagii*	E	NL	NL
Kuhliidae	*Kuhlia splendens*	N	NL	NL
Mugilidae	*Mugil cephalus*	N	U	NL
Channidae	*Channa maculate* [c]	I		
Ophichthidae	*Caecula pterygera*	N		NL
Osphronemidae	*Osphronemus goramy*	I		
Poecelidae	*Gambusia holbrooki*	I		
Poecelidae	*Xiphophorus maculatus*	I		
Syngnathidae	*Microphis leiaspis*	N	U	NL
Terapontidae	*Terapon jarbua*	N		NL

- Notes: E = Endemic; I = Introduced; N = Native; S = Secure; T =Threatened
- IUCN Status: NL = Not Listed; DD = Data Deficient ; VU = Vulnerable.
- [a] Sparks and Stiassny (2003).
- [b] International Union for Conservation of Nature (IUCN) Red List (2004).
- [c] Misidentified as *Ophicephalus striatus*.

4.4.2 Pre-construction studies

In advance of pipeline construction, crossing locations will be assessed in relation to the quantity and quality of fish habitat and fish species present. Subsequently, the

pipeline route will be fine-tuned and special crossing techniques evaluated as needed so that the effects on sensitive habitats are minimized. A standard evaluation of the piscifauna and the piscicultural habitats will be used to establish and estimate of the sensitive of each waterway crossing. The use of a precautionary approach will make it possible to identify the measures required to mitigate the impact on the waterways. LIDAR aerial photography will be used initially to identify potential sensitive crossings, based on the waterway and riparian parameters. Field work will than be carried out on this subset deemed to be sensitive.

Factors affecting the sensitivity of ecosystems at each crossing and which will be assessed during the survey will include:

- The potential for a sedimentation effect during and following construction;
- The presence of endemic fish populations in the area;
- The presence of physical barriers affecting fish movements;
- The potential effects of elevated total suspended sediment (TSS) levels;
- The presence of critical fish habitats (in the waterways and on the shores) that could be disturbed by construction;
- The presence of critical fish habitat downstream of the crossing that could be affected by sedimentation;
- the use of aquatic resources by artisanal fishermen; and
- The stability of the crossing points (banks and adjacent areas).

Watercourses will be rated as sensitive or non-sensitive and construction procedures will then be implemented based on these ratings while applying a precautionary approach to *ex post facto* taxonomic audits. Avoidance measures for impacts on waterways defined as sensitive will include (see under “mitigation measures” below for details):

- moving the crossing location upstream or downstream to avoid specific sensitive habitat points;
- implementation of trenchless crossing methods (directional tunnels or boreholes);
- implementation of construction timing windows;
- employ isolation of downstream flows; and

- species salvage and transfer.

There will be training (in-office and in-field) of all persons to be utilized (for all areas). Training will include short courses on sampling techniques, taxonomy (identification keys), data recording, mapping and management, and quality assessment and quality control procedures. Surveys should be completed several months in advance of construction to enable effective route refinement. Logistical considerations include the following:

- assumption that access to the sites will be obtained and timing co-ordinated with the land /pipeline route design survey team;
- there may be a need for more than one team of hydrobiologists; for the sake of efficiency. The teams could be separated based on sampling requirements (i.e., small waterways/large streams or rivers); and
- protocols to be used for live-capture and release; minimizing of specimen sampling of fish for taxonomy/genetic determinations.

Effective environmental planning information requires “seasonal” data (rainy season/dry season) as critical life functions and critical habitat use is seasonal. At crossings/waterways where significant endemic species/populations are encountered, seasonal sampling or directional drilling should be scheduled.

4.4.3 Mitigation measures

Mitigation measures that will moderate the impact of habitat loss or alterations as a result of riparian clearing, in-stream construction and changes to water quality on the slurry pipeline include the following:

- Route alterations have been made to avoid protected areas, parks and pristine aquatic habitats (i.e., within primary forests). Additional adjustments will be made, where feasible, to avoid sensitive local habitats at watercourse crossings.
- Matching the pipeline installation method with the watercourse type, habitat condition and critical aquatic life history features to avoid potential adverse effects.
- Locating sites away from watercourses and minimizing footprints for construction camps, effluent discharges, laydown areas, soil disposal areas, and petroleum storage sites.
- Implementing Environmental Management Plans which implement protection measures to avoid or reduce environmental disturbance from construction activities at watercourse crossings. These include measures such as

- Using trenchless or pipeline isolation techniques at pristine, sensitive or significant endemic fish habitats to minimize in-water work and thus, the disturbance of aquatic/riparian habitats. This will also make it possible to control TSS levels within specified levels to protect aquatic habitat and biota
- Limiting right-of-way (RoW) clearance and width at watercourse crossings, use of minimum setbacks from watercourses for equipment, maintain vegetative buffers (no stripping) and selective hand-clearing to minimize potential for erosion, sedimentation or other effects on water quality.
- Installing silt traps in small streams and sediment containment ponds in large streams to reduce TSS levels and ensure that the released water meets water quality guidelines for the protection of aquatic life. Other options include cofferdams, stream diversion channels, and overland pumping of the stream in low flow conditions.
- Construction will be carried out whenever possible in low flow conditions.
- Construction sediment monitoring (TSS levels) and implementation of shut-down levels for excessively high levels.
- Controlling water withdrawal locations, withdrawal amounts and discharge from hydrostatic tests to protect fish and aquatic habitat conditions.
- Implementing pre-construction field assessments at each crossing location on the pipeline route to identify sensitive and endemic aquatic biota, critical life stages and habitat, and classify biota and important habitat features as to the level and timing of protection required, including possible fish salvage.
- Implementing fish salvage or avoidance procedures at crossings containing communities of endemic, rare, or locally important (artisanal fisheries) fish, where in-stream crossings may potentially result in death or severe impact to local habitats.

- Developing an aquatic environmental emergency response and clean-up plan for potential spills or release of contaminants during construction.
- Limit access (through consultation with local representatives) to areas identified that contain rare endemic populations targeted for protection. Non-local residents will not be licensed to fish in the newly accessible areas.
- Regulated closure of waters to construction personnel.

- Use of physical and vegetative reclamation at all watercourse crossings or approaches to protect aquatic resources from increased TSS levels from the pipeline and service/access roads. This will include:
  - Immediate revegetation of all disturbed riparian habitats at pipeline and/or access road watercourse crossings.
  - On-site drainage management and erosion control programs at slopes and approaches to watercourses.
  - Protection of bank and in-stream channel features from high flow erosion.

4.4.4 Monitoring

Construction monitoring of the effectiveness of in-stream mitigation will be carried out, focusing mainly on Total Suspended Solids (TSS). Reclamation immediately after construction will be monitored to ensure integrity is re-established. The program will therefore focus on monitoring of suspended sediments (likely using turbidity as an indirect method). The intent of the sediment monitoring component will be to evaluate the effectiveness of in-stream mitigation measures because of the potential for production and transport of suspended sediment into fish habitat downstream of the construction location. Specifically:

- Specific work instructions will be developed to monitor and verify TSS levels during all phases of the project. This will include, but not be limited to, sampling locations, frequency, methodology, quality control, etc.

- Measures will be developed to be implemented in the event of non-compliance with regulatory agency requirements. This will include a description of all assessment and response procedures.

- Reporting requirements will be described. These will include an assessment of monitoring protocols, any overflow and a determination of potential impacts

4.5 PROCESS PLANT

4.5.1 Priority species

All fish species recorded in the Toamasina area are shown in Table 4.3. The endemic species are deemed to be priorities.

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4.5.2 Pre-Construction Studies

No additional pre-construction studies are required. However, a quick inventory of the biota in the flooded areas will be carried out to obtain recent pre-construction data.

Table 4.3 Fish Species Recorded in the Toamasina Study Area (Process Plant and Tailings Facility) in 2004-2005

Family	Species	Origin	Conservation Status[(a)]	IUCN Status[(b)]
Ambassidae	*Ambassis fontoynonti*	E		DD
Anabantidae	*Ctenopoma ansorgii*	I		
Anguillidae	*Anguilla bicolor*	N	S	NL
Anguillidae	*Anguilla marmorata*	N	S	NL
Anguillidae	*Anguilla mossambica*	N	S	NL
Bedotiidae	*Bedotia madagascariensis*	E	T	NT
Clupeidae	*Sauvagella madagascariensis*	E		NL
Cichlidae	*Oreochromis macrochir*	I		
Cichlidae	*Oreochromis niloticus*	I		
Cichlidae	*Tilapia zilii*	I		
Cichlidae	*Tilapia rendalli*	I		
Cichlidae	*Paretroplus poliactis*	E		NL
Eloetridae	*Hypseleotris tohizanae*	E	U	NL
Eloetridae	*Ophiocara macrolepidota*	E	U	NL
Gobiidae	*Glossogobius giuris*	N	S	NL
Gobiidae	*Stenogobius polyzona*	N		NL
Kuhliidae	*Kuhlia sauvagii*	E		NL
Channidae	*Channa maculata* [(c)]	I		
Ophichthidae	*Caecula pterygera*	N		NL
Osphronemidae	*Osphronemus goramy*	I		
Poeceliidae	*Xiphophorus maculatus*	I		
Syngnathidae	*Microphis leiaspsi*	N		NL

- Note: E = Endemic, I = Introduced N = Native; S = Secure; T = Threatened; U = Unknown; IUCN Status: NL = Not Listed; DD= Data Deficient ; NT = Near threatened).
- [(a)] Sparks and Stiassny (2003).
- [(b)] International Union for the Conservation of Nature (IUCN) Red List (2004).
- [(c)] Misidentified as *O. striatus*.

4.5.3 Mitigation measures

Mitigations that will moderate the impacts include the following:

- Implementation of watercourse crossing guidelines and plans which minimize in-water work and disturbance of aquatic /riparian habitat and control sediment levels within specified levels to protect aquatic habitat and biota.
- Water intake design at the Ivondro River to prevent impingement or entrainment of fish during hydrostatic testing and operations.

- In the area surrounding the permanent core of the plant site, and along disturbed pipeline and road routes, re-establish vegetative cover immediately after construction or closure (part of other Environmental Management plans).

4.5.4 Monitoring

Control systems designed for sediment control will be monitored to ensure protection of the surrounding water resources.

The Ivondro intake system, designed to prevent accidental fish capture, will be monitored on a regular basis (weekly) to ensure effectiveness.

Periodic (annual) inventories of fish in the Ivondro River and Pangalanes Canal will be undertaken, starting in 2007. Fish abundance and health will be measured based on direct surveys, and artisanal catch rates will be tracked based on surveys of local fishers.

4.6 TAILINGS FACILITY

4.6.1 Priority species

Priority fresh water species are the same as those discussed above for the plant site.

4.6.2 Pre-construction Studies

Freshwater

Additional surveys of aquatic habitat will be carried out in the tailings facility footprint area to help focus fish salvage efforts prior to construction. Programs such as new fish breeding programs or fish conservation areas for the local populations (downstream of the tailings facility) will be discussed and implemented with input from Malagasy fisheries experts in advance of start up of construction.

Marine

A program will be conducted to define the baseline marine environment at the location of the proposed marine outfall and at reference sites (coral reefs). Marine resources in the area potentially affected by the outfall plume will be inventoried. Additional modeling will be performed to consider the reduction of manganese level at the outfall diffusion zone by modifying the diffuser design of the discharge pipeline.

An inventory of the marine fish and fishing activities in the area of the outfall will be completed before the beginning of operations. Targeted species and analyses of flesh samples will be carried out for the initial status study.

4.6.3 Mitigation measures

Mitigation measures that will moderate the impacts on fish, invertebrates and their habitat during construction include the following:

Freshwater

- Staged clearing of the tailings area to minimize disturbance to watercourses.
- Maintain waterway buffers within the tailings pond area as long as feasible to maintain on-site water quality and habitat function.
- Implementation of watercourse crossing guidelines and plans which minimize in-water work and disturbance of aquatic /riparian habitat but which also maintains sediment levels within specified levels to ensure the protection of aquatic habitats and biota.
- Other mitigation measures related to water management in the tailings facility are provided in water management plans. Because of the potential for bioaccumulation, analyses of fish flesh for key contaminants that affect human and ecologic health will also be monitored annually in the ecological and agricultural watersheds downstream of the mine. This will start during the operations of the tailings facility.
- Water management plans and facilities will be designed to minimize potential releases or spills of tailings water to the Ambolona watershed; tailings supernatant along with collected storm water will be discharged to the ocean via pipeline to avoid disposal to the smaller freshwater environments in the BMP area.
- Revegetation of all disturbed riparian habitats at road and pipeline watercourse crossings.
- Implementation of a fish salvage program to allow for the release of salvaged endemic fish into similar or suitable habitats where available. Provide salvaged fish for local consumption or sale. (same approach as for the mine).
- Work closely with Malagasy fisheries experts on developing fishery management techniques, including development of local pond fisheries located downstream of the tailings facility.

Marine

- In order to prevent accidents involving local fishing vessels, all construction infrastructures on or near the water's surface will be equipped with navigation lights.
- A complaints log and procedure will be implemented to manage complaints effectively.
- All fuel storage tanks will be appropriately equipped to ensure containment of any spillages. Fuelling will only occur in demarcated areas in which spill containment equipment will be readily available, should an accident occur.

4.6.4 Monitoring

Freshwater

During construction, water flow and quality will be monitored in the wastewater and downstream. Selected aquatic resources (diversity and density of macroinvertebrate species, diversity and relative abundance of piscifauna species) will be monitored at three stations (nearby, at mid-range and remotely) in the waterways downstream of the tailings facility to test the predicted outcomes. These stations will be co-located, when possible, with the water quality monitoring stations.

Marine

The water quality monitoring parameters will be adhered to as described in the water management plan for the marine environment at the outflow point from the tailings facility. Proper environmental construction practices will be used for the outflow as well as for all accidental spills. Once the pipeline is operation, fish will be collected periodically to track the accumulation of pollutants in the food chain. The fish near the outflow and at control coral reef sites will be monitored for richness of species and relative abundance. This will take place turning the operation but also potentially between the construction and operations if necessary to produce a complete initial status report.

4.7 PORT EXPANSION

4.7.1 Pre-construction Studies

No additional pre-construction studies are required.

4.7.2 Mitigation measures

During construction, the latest drilling techniques will be used to minimize disturbance of bottom sediments, drilling noise and impacts to water quality. The drilling program will take the prevailing tidal and weather conditions into account when planning daily activities. The use of a bubble curtain around the pile driver, will be considered because, according to reference material, this technique makes it possible to isolate the suspended sediments and reduce noise transmission.

To reduce water quality effects, due consideration will be given to construction materials and pouring of concrete. Stockpile areas and batching plants will not be located in proximity to the construction area. Containment areas and emergency spill procedures will be in place prior to any construction activity.

In order to reduce any impacts associated with the construction of Mole B, stringent safety guidelines will limit the chances of a fuel leak. American Petroleum Institute (API) specifications will apply to all pipelines and systems during this phase should be monitored and maintained frequently (daily). In addition, the current fuel spill contingency plan in the port needs to be reviewed to ensure a rapid and effective response should the need arise.

To mitigate potential water quality effects or the release of unwanted exotic species, ballast water can be dealt with in three general ways: treating the water prior to release into the harbour; transfer of ballast water to onshore tanks for treatment; and offshore disposal.

Transfer of ballast water to onshore tanks for treatment eliminates the issue of ballast water being released directly into the harbour. Treatment systems that can be applied include oil skimmers, and chemical or physical treatment, e.g., chlorination or ultra-violet irradiation as applied to some European domestic or hospital wastes. Water to be returned after treatment can be checked that no organisms are still alive in it. However, there are currently no shore-side treatments available in Toamasina.

Treating the water while still on board and then releasing it is possible as is the offshore disposal and re-ballasting of water (water exchange). Independent validation of this procedure is problematical and water exchange is weather dependent. Treatment of the ballast water while still on board and prior to release from the vessel would enable independent verification. It is essential that a ballast water plan be drawn up for the port prior to the operations phase.

An emergency plan will be set up to deal with any unexpected spills from the port area or from incoming or outgoing ships.

4.7.3 Monitoring

Surveys will be conducted to evaluate any changes in the marine environment following construction. Spills into the marine environment and follow-up mitigation for all such spills will be documented.

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