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HYDROLOGY SECTION OF MADAGASCAR, ISALO ZIE EIA

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1.0 INTRODUCTION

This section of the EIA describes the activities to be conducted in an evaluation of the water resources needed to serve the proposed eco-lodges. The impacts of the proposed development on these resources, mitigation measures, water supply options, monitoring requirements, and a brief discussion of solid and wastewater management alternatives are discussed. Based on this initial evaluation it is believed that with proper planning and implementation of a water conservation program and engineered systems, any impacts to surface or ground water due to the construction and operation of the hotels will be minimized.

2.0 SURFACE WATER

The area in which the proposed lodges are to be constructed is semi-arid. This suggests that the availability and reliability of surface water as a source of supply is suspect. Where perennial streams do exist in proximity to the proposed sites, consideration of a surface water supply should not be ruled out. An evaluation of surface water will address regulatory issues, the physical environment, current and approved future uses, and potential impacts of the proposed development.

2.1 Regulatory Issues

Laws, rules, and requirements of all political entities having jurisdiction over surface water extraction will be researched and evaluated with respect to the proposed project. Most important are those pertaining to the use of such waters, and secondarily the requirements before designing and constructing diversion facilities. Consideration of regulatory issues will be especially important if the drainage basin is in more than one political entity.

2.2 Physical Environment

A critical part of evaluating a surface water resource is the physical environment. This includes, such things as drainage basin (watershed) area, average annual flow, maximum/minimum flow, quality of water, topographic relief, geology, soils, and vegetation. Knowledge of these factors enables a determination of the baseline or background conditions prior to emplacement of the proposed development.

2.3 Current and Approved Future Uses

Equally important in the evaluation of surface water resources and the potential impacts a development may have on those resources, is an inventory of current and approved future users. An inventory of all uses, the amounts being diverted, the amounts being returned and the quality of those return flows to the stream system will be compiled. This inventory will include agricultural, domestic, industrial and commercial uses in the basin.

2.4 Impacts of the Proposed Development

Potential impacts to surface waters may occur when surface waters are used as a source of supply, and when development occurs within a watershed. Whether a surface water supply is developed from stream flow, or a development occurs within a watershed, the following impacts may occur:

- increased sediment load to the stream during construction of diversion structures
- increased erosion and thus increased sediment to a stream from land clearing in conjunction with construction of buildings and roads
- decrease in aquatic habitat as a result of increased sediment loads
- contamination by hydrocarbon leaks and spills from construction equipment
- increase in flood flow as a result of increased impermeable surface area

3.0 GROUND WATER

Given the climatic environment of the proposed development, the utilization of ground water may be the preferred source of supply. The same considerations given to surface water must be given to ground water; namely an evaluation of regulatory issues, a description of the physical environment, an inventory of current and approved future uses, and an evaluation of the potential impacts.

3.1 Regulatory Issues

Regulatory issues with respect to ground water development typically relate to permits, well locations, depths, well construction, water use and permissible yield. Prior to considering the development of a ground water resource, all jurisdictional entities will be contacted to obtain this data.

3.2 Physical Environment

When consideration is given to ground water development, a thorough investigation of the proposed location must be conducted. This includes: identifying whether the location is in the ground water recharge or discharge area of the watershed, what the potential aquifers are beneath the site, what the geologic characteristics of the potential aquifers may be, and what the anticipated water quality of the aquifer might be. Often times a great deal of this information can be obtained from the published literature. If not available in the published literature, surface geophysical surveys, test drilling, borehole geophysics, and laboratory testing may be required. These investigations will be conducted at those sites where a ground water source appears feasible regardless of the information available in the literature.

3.3 Current and Approved Future Uses

Water availability and usage is always a critical issue in water scarce environments. It is imperative that a comprehensive, basinwide inventory of all uses be conducted. In addition to avoiding potential conflicts, such an inventory provides a wealth of information regarding the physical environment of potential aquifers. As with surface water, the quantity and quality of any discharges from users of ground water will be identified.

3.4 Impacts of the Proposed Development

Impacts of the proposed development on ground water resources will typically be less severe from a construction, operation, and maintenance viewpoint than those associated with surface water. Potential impacts may include:

- lowering of the water table and potentially causing other wells in the same aquifer to “go dry”
- drying-up of springs
- reducing the ground water contribution to streams
- contamination of the ground water from waste discharges
- land subsidence

4.0 MITIGATION MEASURES

The surest way to mitigate impacts from proposed developments is to minimize the impacts to the extent possible. In this regard, a pro-active approach to water and waste management will be adopted. Because every site has its own set of environmental conditions, not all measures are applicable to every site.
Mitigation measures discussed will be based on contingency planning, conservation, and engineered concepts.

4.1 General

Whether a surface water or a ground water supply source is ultimately employed, mitigation of certain impacts the proposed development may have on these resources can be addressed. These include erosion and sediment control, and water supply management.

4.1.1 Erosion and Sediment Control

Erosion and sediment control during construction of buildings, roads, trails, water supply facilities, treatment plants, pipelines, and other appurtenances is important in protecting nearby water courses. Increased sediment loads to streams can clog waterways, and pose a risk to fish, aquatic habitat, and downstream users. Mitigation as a result of any construction activity will be approached in the following manner:

- Prior to any construction activity an erosion and sediment control plan will be developed. This plan will be site specific and include measures, such as:

The use of sediment ponds, drainage ditches, and sediment traps (straw bales, dugouts, geotextiles, etc.) to contain sediment on site.

A grading plan for disturbed areas outside of the footprint of the hotel or the alignment of the road that takes into consideration existing topography, and uses contour grading to control runoff.

The use of mulch, riprap, and fast growing native vegetation to stabilize disturbed drainage ways and land.

- Requiring construction be done to the extent possible during the dry season between May and October.
- After construction, requiring the use of signs and placards to have tourist stay on trails to decrease the potential for erosion.

4.1.2 Water Supply Management

In an effort to employ a pro-active approach to minimizing environmental impacts on water resources as a result of the proposed development, water management measures will be employed. These measures center on efficient use of available supplies through behavioral, operational, and/or equipment changes.

Management. A water efficiency coordinator will be trained and assigned to each of the facilities. It will be his responsibility to educate other staff on the importance of conserving and protecting water supplies.
Equipment. Each facility will evaluate cost effective equipment for conserving water. This would include such items as ultra-low flow toilets,

efficiency showerheads, water saving appliances, and cooling water recycling methods.

Practices. Facilities management personnel will strive to: detect and repair all leaks; minimize water use for landscaping, cooling, and non consumable uses; use signs to inform guests of the need to conserve; and train kitchen personnel in water conservation.

Landscaping. Landscaping around tourist facilities can be a water intensive effort. Conservation of water can be realized by the following practices: minimizing turf areas and using native grasses; proper watering of trees and shrubs; timing watering operations during coolest part of the day; and utilizing grey water from the treatment plant.

5.0 WATER SUPPLY OPTIONS

In an effort to mitigate any potential impacts as a result of developing a water supply for a specific site, all options will be evaluated. Not only will surface water, ground water, and springs be evaluated, but combinations of these. Detailed hydrogeologic investigations will be conducted at each site. These investigations would include detailed mapping, drilling of test wells, conducting aquifer tests, and water quality test. In some instances, analytical or numeric modeling may be required to determine long-term yield potential and possible impacts to other users.

Where required, surface catchments with reservoirs may be constructed to maximize water availability. In all instances the cost benefit of water supply development will be evaluated. Opportunity may exist for constructing storage reservoirs that could be filled during the rainy season and could be used for water supply. This would equalize the diversion required throughout the year and minimize the impact of withdrawing water during the dry season. Where perennial streams do not exist, infiltration galleries can be constructed in the streambed to collect ground water. These installations require site specific evaluation and construction.

Impacts to or as a result of ground water usage are also site specific. Potential impacts from sewage discharge are mitigated by proper location and construction of sewage treatment facilities and by proper grouting of supply wells during construction. Potential subsidence problems are avoided by conducting geotechnical investigations of the project site, and by locating wells sufficiently removed from structures and by regulating well discharges.

Impacts to springs and the water table are avoided by conducting a thorough site investigation and aquifer testing before placing a well on line.

Inititial evaluation of water quality information indicates that some water treatment will be necessary to bring surface water to safe drinking water standards. To minimize the impact of the construction and operation of the treatment plants, each site including storage will be located in an environmentally safe location and protected from potential intruders. Chemicals used will be stored in a safe manner observing proper Hazmat protocols.

6.0 MONITORING

Once a decision has been made with respect to a water supply source or sources, a monitoring plan would be designed and implemented. These plans would be specific to each facility and may include monitoring wells and surface water gauging stations. Monitoring wells would be so located as to reflect any changes in water levels as a result of production wells, and be so designed as to enable sampling for water quality.

Surface water gauging stations would be positioned upstream and downstream from facility intakes, and consist of a staff gage, a measured cross section from which a stage-discharge curve could be developed. Alternatively, a weir, or a flume might be installed to measure flow on a monthly basis. In addition water samples would be collected at these stations and tested for pH, conductivity, temperature, turbidity, and other parameters to be determined on a site-specific basis.

Based on the monitoring data, a program could be developed with regulators and other stakeholders where problems exist or are anticipated. By initiating this pro-active approach to water management, potential problems will be eliminated or significantly minimized.

7.0 WASTE MANAGEMENT

Ecologically compatible management of wastes generated by the facilities planned in environmentally sensitive and remote locations may require the use of procedures and processes that are not typical of the waste management techniques used in urban centers.

Additionally, the costs of disposal on a per unit basis is likely to be more expensive than those employed elsewhere unless creative strategies are implemented to reduce the quantity of waste generated. Zero impact on the local environment is a goal consistent with the ecotourism concept. The degree to which this can be realized will be based on a variety of factors, including accessibility to urban waste management systems, local land use and climate, need for waste material by-products such as soil amendment and/or energy, and the nature of the ecotourism experience desired by the facility operators.

Ideally, waste management is implemented using a hierarchy of techniques. The degree to which each is employed is based on a detailed analysis of the economic and environmental impacts controlled by the factors itemized above.

- Waste Reduction / Minimization
- Waste Reuse
- Waste Recycle
- Waste Treatment
- Waste Disposal

While the priority of waste management is skewed heavily towards waste minimization, these techniques generally command a knowledgeable and committed populace to ensure its success. Thus, the disposal options become the economic and implementation reality in many cases, particularly if sufficient environmental standards that will adequately protect the environment are not adhered to. Only when external incentives are applied do other waste minimization options become truly viable. The basis of comparison of alternatives thus assumes that adequate, modern standards for implementation are uniformly applied to all options for waste management. Thus a logically, economically viable and ecologically sensitive management system can be established.

Waste Minimization, Reuse and Treatment:
In an ecologically balanced waste management strategy, landfill disposal is minimized or combined with a waste treatment / minimization program to enhance recovery of materials or energy. The following options can be implemented independently or in combination to optimize economic and ecologically responsible waste management.

Waste Minimization:

A Variety of waste minimization techniques can be employed with success in an ecotourism environment. Some of these would include the implementation of:

- **Purchasing Options:** Purchase of environmentally friendly products that use recyclable or decomposable packaging materials. As a consumer, the ecotourism industry can exercise its option to purchase products that minimize packaging, or use packaging that is biodegradable. In this way, the packaging materials can be managed in an ecologically friendly manner, rather than the land disposal of non-biodegradable materials. In keeping with the environmental theme of ecotourism, the industry can opt to purchase products made of post-consumer materials. Paper products are an example of a product that can be purchased with a high post-consumer content. Additionally, items such as chairs and other furniture can be purchased that are comprised of wood and natural fiber cloth, rather than plastic and/or metal materials, or that use synthetics for cloth components.

- **Ecotourism Culture:** As a component of the ecotourism experience, it can be suggested to visitors that they can play a role in the preservation of the unique and sensitive environment that they are experiencing. Literature can be developed that encourages visitors to minimize importing to the area packaging and waste that must be disposed of.

Materials Reuse:
The ecotourism industry can minimize the generation of disposable materials by:

- **Purchase Ban:** The ecotourism industry may opt to ban the purchase and use of products / materials that are designed for one-time use and then must be discarded. Primary examples are styrofoam cups, plates, soft-drink containers, etc. Other such items include disposable cameras and paper towels.
- **Reuse Policy:** In tandem with the purchase ban, materials that can be reused can be emphasized. Permanent dishware, and the use of cloth towels, are examples of waste minimization techniques that can minimize waste litter and disposal volume.

Recycling:

Recycling from a remote and isolated location can be costly and labor intensive. Therefore, maximum effort should be placed on waste minimization techniques and materials reuse. However, recycling of selected materials is an important component of the waste management hierarchy. Some techniques that can be employed include:

- **Source Separation:** As emphasized under waste minimization, recycling is a life-style component that is consistent with the ecotourism concept. Visitors can be encouraged to separate their waste materials into containers made for biodegradable and non-biodegradable materials. Materials such as newspapers, tissue, and paper can be placed in a container specifically designated for that purpose. Other materials, such as used shaving utensils, non-recyclable plastic packaging materials, etc. would be placed in a disposal container. Restaurants would be expected to collect food waste and other biodegradable materials for waste treatment.
- **Processing:** Materials collected for recycling can be either processed on location into specific material types, i.e. HDPE, PET, glass, newsprint, etc. As an option, all comingled recyclables can be transported to a more urbanized area for processing and marketing of the final products. The manner by which these materials are handled will be dictated by the quantity, the success of waste minimization efforts, availability of markets, etc. Processing on location may require hand-sorting and baling / crushing of materials. These techniques require machinery that may not be compatible in a remote location where servicing will be difficult and power availability inconsistent with the ecotourism concept.

Treatment:

Several forms of treatment can be employed. The most common are composting and incineration / waste-to-energy (WTE).

- **Waste-to-energy:** Waste incineration utilizes the process combustion at temperatures high enough to convert waste materials to primarily ash and carbon dioxide. Waste To Energy (WTE) utilizes the waste heat from the incineration process to create steam that is

in turn used for heating, industrial production or electrical generation (with the addition of an electrical generator). Incineration is often considered a waste treatment technique instead of final disposal, since it reduces the volume of waste to approximately 15% of its original mass. However, the remaining residue requires final disposal. While incineration (waste to energy) may be economically viable in areas with high energy costs or in urban regions where energy markets exist and large waste volumes are generated, the lack of an economy of scale in remote regions escalates the costs of treatment of waste in this way. Further, this method require the design, construction and operation of sophisticated facilities, with smoke-stack technology that may be incompatible with the concept of ecologic preservation.

- **Composting:** Biodegradable materials such as chipped wood, wastewater sludge, food wastes and paper products can be composted into a material that can be used as a soil amendment. The amendment can be placed on land in a variety of areas, including landscaped areas, pastureland, cropland, and in areas suffering from soil erosion. Composting can use in-vessel or windrow technology, which range from sophisticated and mechanized processes to low-technology and low-cost processes. The type of system employed would be based on the end-use, costs and location of the operation to the ecotourism facilities. It is envisioned that a significant component of the waste stream could be managed using this technology.

Disposal:

All economically viable waste management strategies include landfilling as a final disposal requirement. Current landfill technology calls for an impervious containment system, composed of a base liner made of natural and/or manufactured materials, and a system of drainage materials and piping that can collect and convey moisture inherent to the waste mass or added from external sources. The classification of landfill is based on the type of final cover placed over the waste fill.

- **Landfill Options:**
  - **Dry Tomb:** In addition to a base liner system, the waste mass is encapsulated by an impervious cover. The concept is to isolate the waste from the environment in perpetuity.
  - **Bioreactor:** The decomposition of the waste mass is accelerated by creating conditions that enhance biological activity within the waste. The bioreactor is envisioned as the ecologically responsible disposal method of choice, in that the waste mass is stabilized as rapidly as possible. The bioreactor landfill is opposite in concept to the dry tomb landfill. Its benefits are that the waste mass is rendered inert while the containment system is still functioning reliably. It also allows reuse of former disposal space, and can produce usable end-products such as compost / soil amendment, and methane gas for spot heating / electrical generation. It may be used in lieu of a formalized compost system and can generate many of the same products.

The landfill technology employed would be based on the waste minimization and treatment techniques employed prior to disposal. The landfill used could be located on

site, or in a remote location where a larger waste volume could result in an economy of scale and cost benefit. Transportation costs of the residue waste remaining after use of other waste management techniques, such as waste minimization, recycling and treatment would be compared with the cost of localized facility development and operation. The transportation technology used would be based on the volume of waste, road access and distance to the receiving facility.

8.0 WASTEWATER MANAGEMENT

To mitigate any potential impacts to ground or surface water resource, site specific wastewater treatment plans will be developed for each hotel site. Based on the nature of the soils, the quantity of the influent needed to treated, and proximity to ground and surface water resource, treatment systems designed will be de signed and constructed to meet discharge standards. The objective of any system will be to minimize water consumption and maximize the potential for reuse.

Several options are available for wastewater treatment. These include:

- Small packaged treatment plants to be installed;
- Septic tanks with leach field systems;
- Oxidation ponds with duck weed for odor control;
- Mound and low pressure pipe/septic tank treatment systems for low permeable soils;
- Sand filters; or
- engineered wetlands may be appropriate.

In addition, composting or incinerating toilets may be considered as ecologically friend but costly.

Leaky septic lines, seepage for the ponds, and improper handling of septic tank sludge may pose a threat to surface and ground water resources at the site. To minimize these impacts, with the final design of the system most a wastewater management plan will be developed and implemented. The plan will call for schedule maintenance of the facility, periodic sludge removal, and a monitoring program to ensure the design system is operating effectively. Should leakage occurred every effort will be made to correct the problem.