CHAPTER 5
IMPACT ASSESSMENT AND
MITIGATION MEASURES
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5. IMPACT ASSESSMENT AND MITIGATION MEASURES

This chapter describes the methodology used in the assessment of the potential impacts environmental resulting from anthropic changes applied to the environment and to the social-economic means as a result of the Laúca dam construction activities, within the territorial limits of the provinces of Malanje, Kwanza North and Kwanza South.

5.1. METHODOLOGY CONSIDERATIONS

The analysis of the potential impacts and environmental risks arising from the Laúca dam construction was carried out in a multi and interdisciplinary way based on the diagnoses submitted for the studied area (in the several influence areas of the project), presented in Chapter 4 of this study, as well as the proposed enterprise activities presented in Chapter 2. This chapter emphasizes the directly affected and direct incidence areas defined in Chapter 1, pursuant the Executive Decree no. 92/12 of March 1st.

Therefore, a comprehensive approach took place covering all the involved aspects and their possible interactions, so no potential impact regarding the enterprise implementation and operation phases was left without consideration.

The analysis covered the enterprise actions capable of generating potential environmental and social-economic impacts; the preparation of an impact interaction matrix and the qualification and assessment of the identified impacts.

The generating actions are directly related to the enterprise’s planning, implementation and operation activities, and in order to identify the impacts it is necessary to analyze the power plant characteristics.

After the definition of the impact generation factors, an interaction matrix was prepared, which has as basic structure the components of two sets of variables: the necessary actions for the dam implementation and operation and the environmental components, regarding the physical, biotic and social-economic means, which can suffer the effects of these actions. By means of this matrix it is possible to associate the impacts on the studied means with their generating actions.

After this, an individual assessment of the impacts was carried seeking their qualification and, when possible, their quantification. After the potential impact assessment was concluded, it was possible to establish mitigation measures and configure the necessary environmental programs to be implemented by the entrepreneur, which will ensure that the undesirable damages to the social-environmental means are
corrected, compensated or prevented. Additionally, actions intended to boost the positive impacts will be defined, as a means to leverage the region’s social-economic development and to bring benefits to the population.

For the assessment of the Laúca dam’s potential environmental and social-economic impacts, the criteria presented in Table 5.1 were adopted, which will be transcribed to the impact identification matrix, when all impacts will be described in an individual way.

**Table 5.1: Criteria and Assessment of Potential Impacts**

<table>
<thead>
<tr>
<th>Classification</th>
<th>Criterion</th>
<th>Qualification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase</td>
<td>Phase of the enterprise implementation when the potential impact takes place</td>
<td>Planning</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Implementation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Operation</td>
</tr>
<tr>
<td>Nature</td>
<td>Impact effects</td>
<td>Positive</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Negative</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Undetermined</td>
</tr>
<tr>
<td>Form</td>
<td>Assess how the impact takes place</td>
<td>Direct impact, resulting from an action</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Indirect impact</td>
</tr>
<tr>
<td>Duration</td>
<td>Persistence time of the impact</td>
<td>Permanent</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cyclic</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Temporary</td>
</tr>
<tr>
<td>Reversibility</td>
<td>Assesses the capacity of the mean to return to its natural state after the end of the impact generation action, considering the mitigation measures</td>
<td>Irreversible</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Reversible</td>
</tr>
<tr>
<td>Coverage</td>
<td>Places where the impact effects are felt</td>
<td>Global (exceed the AH limits, the impacts take place in a specially disseminated way)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Regional (the impact also reflects in the AH)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Localized (its occurrence area is very clear and restricted to the AID and ADA)</td>
</tr>
<tr>
<td>Magnitude</td>
<td>Refers to the transformation intensity of the impacted environmental factor regarding the preexisting situation</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Medium</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Low</td>
</tr>
<tr>
<td>Importance</td>
<td>Interference degree of the environmental impact over different environmental factors</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Medium</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Low</td>
</tr>
</tbody>
</table>

The generating actions are indicated for each impact and also the respective measures to be adopted for their mitigation/correction or leverage (for positive impacts). The adoption of such measures was deemed adequate in time and space, according to the importance, intensity and duration of each one. Similarly, the compensatory measures were identified in the case of potential impacts with no possible mitigation or those actions that have their compliance mandatory by law.
5.2. IMPACT IDENTIFICATION

Table 5.2 presents the matrix resulting from the interaction among the potential impacts studied for the Laúca dam project. The potential impacts were quantified according to the project phases (planning, implementation and operation) and identified by means of acronyms to provide a better understanding.

The first phase of the enterprise that corresponds to the project planning consists on carrying out the activities related to viability and the planning of the actions necessary for its implementation, including the environmental studies that resulted in the preparation of the present document.

In the building of the interaction matrix acronyms were used according to the impacted means and environmental process. Therefore, for the processes related to the physical means, the letter F was adopted, followed by A for water, Ar for air and S for soil; the letter B is used for the biotic mean, followed by the letters corresponding to the processes related to the vegetation cover (V), land fauna (FT) and water fauna (FA); and finally, letter A was adopted for the anthropic mean, followed by the letters P (population), E (economy), OT (land classification) and PMI (historic, cultural and archeological assets).

5.2.1. PLANNING PHASE

The first phase of any project corresponds to that of planning. It consists in carrying out the activities related to the viability study and to the planning of the necessary actions for their implementation, including the environmental studies that have originated the present document. The interactions identified in this phase were:

- **Physical, biotic and anthropic means:** increase in the technical-scientific knowledge about the region under the environmental and social-economic points of view, with the formation of important collections associated to an information bank and photographic registers of the influence areas studied (FA1, FAr1, FS1, BV1, BFT1, BFA1, AE1 AOT1 and APMI1).

- **Anthropic means:** creation of expectations within the population due to the news published about the enterprise during the performance of the environmental studies, particularly those related to employment offer, improvement of living conditions and social-economic leverage (AP1).
Table 5.2: Interaction Matrix of the Laúca Hydroelectric Power Plant’s EIA.

<table>
<thead>
<tr>
<th>Enterprise</th>
<th>Physical Means</th>
<th>Biotic Means</th>
<th>Anthropic Means</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Water</td>
<td>Air</td>
<td>Soil</td>
</tr>
<tr>
<td>Phases</td>
<td>Actions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Planning</td>
<td>Execution of studies</td>
<td>FA1</td>
<td>FAR1</td>
</tr>
<tr>
<td></td>
<td>Labor hiring</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Implementation of the workers village and the work quarters</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Readequacy and/or expansion of the region’s system access</td>
<td>-</td>
<td>FAR4</td>
</tr>
<tr>
<td></td>
<td>Transport of materials and equipment to the work quarters</td>
<td>-</td>
<td>FAR5</td>
</tr>
<tr>
<td></td>
<td>Mine exploration for civil construction and the formation of the desired area</td>
<td>FA6</td>
<td>FAR6</td>
</tr>
<tr>
<td></td>
<td>Excavation for the foundation and power house, penstocks, ducts and water intake</td>
<td>FA7</td>
<td>FAR7</td>
</tr>
<tr>
<td></td>
<td>River deviation, construction of cofferdams, and civil works</td>
<td>FA8</td>
<td>FAR8</td>
</tr>
<tr>
<td></td>
<td>Cleaning of the reservoir areas</td>
<td>-</td>
<td>FAR9</td>
</tr>
<tr>
<td></td>
<td>Labor demobilization</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Reservoir filling</td>
<td>FA11</td>
<td>FAR11</td>
</tr>
<tr>
<td>Operation</td>
<td>Dam operation</td>
<td>FA12</td>
<td>-</td>
</tr>
</tbody>
</table>
5.2.2. IMPLEMENTATION PHASE

The enterprise implementation phase considers the period since the labor hiring until the reservoir filling, passing through the necessary work adequacy activities, construction of accesses, work quarters, etc. The interactions identified in this phase were:

- **Physical means**: loss of soils (FS3, FS4, FS6, FS7, FS8 and FS11); risk of triggering or increasing erosive processes and landscape changes (FS6, FS7 and FS9); soil compacting (FS5); instability of the river bank slopes (FS8); changes in the water table and possible changes in the soil dynamics (induced seismicity) and loss of large land extensions (FS11); generation of dust, noise and gas emissions (FAr2, FAr4, FAr5, FAr6, FAr7, FAr8, FAr9 and FAr11); possible climatic changes and changes in the local hydrologic balance (FAr11); changes in the water flow and quality (FA2, FA6, FA7, FA8 and FA11).

- **Biotic means**: suppression of the vegetation with the consequent loss of vegetation individuals and species and the loss and fragmentation of habitats (BV3, BV4, BV6 and BV7); loss of the natural and genetic assets and of vegetation individuals (BV9); changes in the vegetation communities bordering the reservoir (BV11); fauna disturbances (death and/or frightening) (BFT3, BFT4, BFT5, BFT6, BFT7, BFT8, BFT9 and BFT10); water fauna disturbances and risk of fish deaths (BFA7 and BFA8); changes in the reservoir’s fish fauna composition and structure and in the hydrobiologic communities (BFA11); changes in animal communities due to the reservoir filling (FAT11).

- **Anthropic means**: increase in the population’s anxiety due to the desire of being hired (AP2); changes in the population dynamics (AP4); risk of accidents with the local population (AP5 and AP6); disturbance in the local population’s extraction activity, in addition to increased risks to its health (AP9, AP10 and AP11); leverage of the local and regional economy (AE2); shipping feasibility of the local production (AE4); increase in the local income due to the availability of timber (AE9); generation of pressure over the local and regional, social and economic infrastructure (AOT2 and AOT3); increase in the leverage of the land use and occupation process (AOT4); risk of losing the archeological assets (APMI3, APMI4, APMI6, APMI7 and APMI8); risk of losing the local population’s sacred sites (APMI9 and APMI11);
5.2.3. OPERATION PHASE

With the enterprise operation the following interferences are expected:

- **Physical means**: changes in the water quality upstream and downstream of the reservoir (FA12). Gas generation and emission (FAr12). Depleting of the reservoir, thus causing changes in the soil close to the margins of the future reservoir (FS12).

- **Biotic means**: risk of fauna disturbance downstream (BFA12) and changes in the biotic communities in the reservoir depletion zone (BV12 and BFT12).

- **Anthropic means**: higher energy offer, making viable the country’s social and economic development, resulting in a higher quality of life for the national population (AP12 and AE12).

5.3. IMPACT ANALYSIS

For the assessment of the environmental impacts caused by the construction of the future Laúca dam, the criteria presented in Table 5.1 were adopted, which results are described below, individually and at the end of the present item, summarized in Table 5.3.

The generating actions are indicated for each impact, followed by the respective recommended mitigation measures, whose adoption was deemed adequate, in time and space, according to importance, intensity and duration of each one. Similarly, compensation measures were identified in the case of impacts with no possible mitigation and leverage measures for positive impacts.

5.3.1. PLANNING PHASE

5.3.1.1. GENERATION OF EXPECTATIONS IN THE LOCAL POPULATION

**Generating action**: Direct contact of the study teams with the local population.

**Description**: The expectations of the population regarding the enterprise are a result of a set of factors, among which are the initial actions regarding the enterprise, as the technical studies and the first news about it in the region.
The local population’s anxiety, caused by the contact with the technical teams during the field work visits conducted for the engineering projects and the environmental studies, has contributed to increase the expectations, mainly in the villages situated in the ADA and the AID. Such expectations or apprehensions can be either negative or positive. According to the interviews carried out, they are related to the hope by part of the population of finding jobs during the implementation phase of the enterprise and of ending their present isolation by getting in contact with all the social and economical dynamics that will be introduced during this period, as well as the possibility of having electric power in a near future.

Some local authorities have demonstrated good acceptance of the enterprise implementation, believing in the perspectives of economic and social development for the region, resulting from the existence of such a large dam construction project and, at medium term, the benefits of its operation.

As unemployment is one of the main economic problems in the region, the generation of work places is seen with great expectation by part of the population, mainly by the younger people that are eager for jobs. This fact was acknowledged in the cities of Malange, N’Dalatando, Dondo and Lucala, where the young people asked about the enterprise and about the necessary procedures to find jobs in the construction works. In all the villages interviewed and heard, this concern was also found, although a difficulty was also found, which is the lack of the interested people’s identity cards, a fact that prevents the hiring.

Part of the non-qualified labor, necessary for the enterprise works, can be found by hiring the population in the ADA and AID villages, provide they are duly trained to perform the necessary activities, since they consist of traditional peasants, totally unqualified for the functions that will be offered in the enterprise implementation and operation.

As mentioned above, the lack of an identity card is another problem that affects almost all the people living in the AID, making their hiring impossible. The issuing of this document demands a slow and costly process that, combined with the destitute conditions of the population, makes it very difficult. There is an expectation that Odebrecht, together with the governmental authorities, will help the population to solve this problem.

The generation of expectations can be considered of a negative nature when it is related to the implementation of the project and to changes in the population’s way of life, particularly the rural one, and positive, when associated to the perspective of offering new jobs due to the construction works, the offer of energy and improvements in the economy.
Assessment: Takes place in the planning and implementation phases, and has a negative impact effect resulting from the anxiety that it causes on the population due to the disclosing of inadequate information, making difficult a clear understanding about the new situation and bringing many uncertainties that are; direct; temporary, because it is only present during the implementation phase; reversible, because with the hiring the negative expectations tend to subside, affecting not only the ADA and AID population, but also has some global significance due to the high national unemployment rate. It is of high magnitude and great importance because the possibility of hiring local labor is a unique opportunity for its social and regional insertion, as the population residing in the AII and the AAR also suffer the consequences of unemployment.

Measures to be adopted: Social communication plan, to be implemented by the entrepreneur to make the enterprise implementation clear to the community and fulfill the community’s demand for the disclosure of the selection criteria, in addition to the local population’s qualification actions so it may participate in the enterprise implementation, whether directly or indirectly.

5.3.1.2. INCREASE OF THE TECHNICAL–SCIENTIFIC KNOWLEDGE ABOUT THE REGION

Generating action: Development of environmental studies and engineering projects for the areas under the influence of the dam construction.

Description: The environmental studies about the enterprise’s areas of influence, as well as the engineering works, will contribute to increase the technical–scientific knowledge of the medium section of the Kwanza River basin, generating important diagnoses, sometimes unheard of, about the same.

Assessment: This is a positive; direct; permanent; irreversible; global influence impact; with high magnitude and great importance, regarding the present scarcity of general data.

Measures to be adopted: In order to leverage them, the announcement of the studies carried out is recommended, together with the promotion of events, the publication of the study results and making the information available to the public.

5.3.2. IMPLEMENTATION PHASE

5.3.2.1. WORKPLACE GENERATION

Generating action: Labor hiring.
**Description:** For the enterprise construction, around 4,000 workplaces will be made directly available. With the leverage of the local economy, more employment opportunities will show-up in an indirect way regarding the enterprise. Based on the Brazilian experience, the number of indirect workplaces generated by the execution works in the implementation of hydroelectric enterprises may reach 2.5 times the number of direct employment, in the present case representing approximately 10,000 workplaces in activities supporting the construction actions, as those of services for the workers directly hired.

**Assessment:** This is a positive, direct, temporary, reversible, localized impact, with great importance and high magnitude.

**Measures to be adopted:** A professional insertion effort shall be prepared and implemented by the entrepreneur for the local population, including professional qualification, which shall be widely announced in the social communication plan, moreover for the ADA and AID population.

Since the important problem of lack of documentation in the AID population was revealed, with a negative effect on the possibility of employment for the population directly affected by the enterprise, citizen support actions could be carried out to make possible the issuing of identity cards for the ADA and AID population, together with the local administration.

**5.3.2.2. GENERATION OF POPULATION MIGRATION**

**Generating action:** Labor hiring.

**Description:** The disclosure of the hiring of labor for the enterprise implementation will generate expectations in the entire AAR population, mainly in the ADA, AID and AII, due to the possibilities of finding jobs and income, stimulating the migration to the ADA and the AID, in higher number than the workplaces offered.

Based on the precarious quality of living conditions observed in the affected population and the almost inexistent basic minimum support for the social infrastructure, it is possible to declare that the conditions shall become worse for the local inhabitants and will not be better for the migrants.

**Assessment:** This is a negative impact, because it will overload the precarious local social infrastructure, whether temporary or permanent, because the possibility of establishing homes, even after the end of the works, will prevail strongly precisely in the city do Dondo; localized influence; high magnitude and great importance.
Measures to be adopted: Social communication plan, informing the population of the AII/AAR cities and the ADA villages about the exact labor-hiring conditions, the number of workplaces available, the regional living conditions, etc. The adoption of education actions for the interested population is also recommended, specifically to fulfill the indirect jobs that will show-up, as well as to support the implementation of the necessary basic infrastructure.

5.3.2.3. ECONOMIC LEVERAGE

Generating action: Increase in the circulation of vehicles and people due to the works.

Description: The Laúca dam construction shall stimulate the local economy, mainly with respect to the increase in demand for services and products by the workers, even if almost all the supplies have to come from Luanda.

Therefore, the employment offer and the new work opportunities shall attract new investments, even if they are small, generating the circulation of goods and income.

In this context, the city of Dondo, that already receives the impacts of the Cambambe dam elevation works, will be the main focus, since it has commercial and service establishments that fulfill the existing present demand. This economic leverage will take place as a result from the migration of the population seeking employment and income opportunities.

The villages along the Capanda dam road that connects to Dondo shall also start to offer services and market products, although in small scale and more suited to the food sector, to fulfill the needs of these migrants and workers. This is already a reality as it was ascertained by social research.

The strongest influences of the economic leverage will occur in the short and medium terms, having their peak in the enterprise implementation phase and then receding in the operation phase.

Assessment: This is a positive, indirect, temporary, reversible impact, with local influence, with higher reflections in Dondo, of high magnitude and great importance.

Measures to be adopted: To ensure the optimization of the benefits from the stimulation of the economic dynamics for the local population, actions shall be adopted to boost the generated benefits, as qualification and training for the production of goods and services, etc., having entrepreneurship in mind, in order to
qualify it for income generation, thus strengthening the social tissue and the local economy, so the economic leverage will acquire a long-lasting effect.

5.3.2.4. INCREASE IN THE PRESSURE OVER THE LOCAL INFRASTRUCTURE

Generating action: Increase in the circulation of vehicles and people due to the works.

Description: The circulation of vehicles and people engaged in the enterprise works, as well as the increase in the flow of the population attracted by them, will generate a demand for social equipment to face the more specific assistance to health and safety problems, and the infrastructure of accesses, communication and environmental sanitation. In this context, the city of Dondo shall receive the higher pressure, but also in the “sanzalas”, the population’s quality of life shall suffer as a consequence this pressure.

The precarious health network in the region counts with few assistance stations in some “sanzalas”, lacking adequate equipment and trained professionals. The Dondo Municipal Hospital has 60 internment beds, a capacity already occupied, since it receives patients from three provinces. It is important to point out that malaria is endemic in this region, with seasons of high incidence of the disease.

Assessment: This is a negative, direct, temporary, reversible and local impact. It is of high magnitude and great importance due to the lack of proportion between the allocated contingent and the lack of existing infrastructure capacity to meet the local demand.

Measures to be adopted: Actions that support the territorial arrangement of the city of Dondo, as well as to the ADA and AID, communities, shall ensure that these will guarantee the local conditions, incorporating the benefits arising from the process.

5.3.2.5. INCREASE IN DWELLING DEMAND

Generating action: Population migration.

Description: As with the infrastructure, the demand for new dwellings will also suffer strong pressure. The inadequacy of the already existing houses and deficiencies in the urban structure in the areas of influence may become a serious social problem, with the possibility of disorganized occupation on the strips along the road and on the slopes. The spontaneous density increase foreseen will turn the problems more serious due to the lack of basic sanitation, garbage collection and public safety.
**Assessment:** This is a negative, indirect, temporary, because it will prevail only in the implementation phase, localized impact, with medium magnitude and importance.

**Measures to be adopted:** The social communication plan that informs the affected population about the exact labor-hiring conditions, the number of workplaces available, the regional dwelling conditions, etc., must be efficient, thus, preventing the arrival of a large number of workers that cannot be incorporated to the works. Additionally, support actions shall be implemented for the population that unavoidably will migrate to the ADA and the AID attracted by the opportunities that the enterprise will provide, to make the communities capable of arranging the necessary basic infrastructure.

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**5.3.2.6. TIMBER GENERATION**

**Generating action:** Deforesting of the areas of dam construction, living quarters, work quarters and accesses, supporting and cleaning infrastructure in the reservoir area.

**Description:** The construction area deforesting will make available a great quantity of timber that can be offered to the village population, because charcoal is the main energy source used by such population, and the surplus production can be marketed.

**Assessment:** This is a positive, direct, temporary and localized impact, with low magnitude because it can generate income for a few families being, therefore, of low importance.

**Measures to be adopted:** Announcement actions and the planning and organization of the cut timber transfer to the village dwellers. This material will be collected by Odebrecht for use in the work quarters and also used in the production of saw dust for emergency *Kits* (oily residue spills). Some of this material will be mixed, but passing first by a crusher.

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**5.3.2.7. RISK OF HARMING THE LOCAL POPULATION’S SOCIAL STRUCTURE**

**Generating action:** Increase in the circulation of vehicles and people as a result of the works.

**Description:** The population migration may promote a relatively delicate social impact, because the villages are formed by family organizations governed by a traditional authority (soba), with peculiar rules and habits, linked to community structures formed by small groups. The flow of foreign people will certainly interfere on this organization, affecting its way of life and habits.
The strong neighborhood and family relationships, which is an important factor that reflects positively on the social structure, can be affected. This impact may generate uncertainty and even contempt, mainly in the villages closer to the enterprise.

The population’s concern is that with the increase of expatriates an increase in prostitution will also take place in the areas affected by the enterprise.

**Assessment:** This is a negative, direct impact, because it is the result from the contact with migrants, and a permanent one, because the change in habits and behaviors are irreversible, localized and of medium magnitude and medium importance.

**Measures to be adopted:** In order to mitigate this impact, the social communication plan will take actions intended for the ADA and AID communities, including previous information about the expected migration perspectives and its consequences, in order to reduce the population’s uncertainties before the arrival of the future workers. Additionally, the ADA and AID population will be benefited by specific qualifying actions that will include, in addition to the technical aspects that favor the formation intended for income generation, orientations regarding the relationship with the workers, activities intended to value local habits and behaviors, development of a calendar for traditional cultural activities and support to the promotion of events that value the local culture, effectively promoting an improvement in the local population’s quality of life.

### 5.3.2.8. INCREASE IN THE RISK OF ACCIDENTS

**Generating action:** Increase in the circulation of vehicles and people as a result of the works.

**Description:** The increase in the traffic of heavy vehicles on the road that connects the Capanda AH to the city of Dondo, the main access way to the enterprise’s work quarters, is a concern factor due to the presence in the villages along the road. Most of these villages are located besides the road, half of the times with occupation on both sides of the road, thus creating the need for constant people crossing and the constant presence of animals on the road. Some villages were closed with fences, but the presence of animals is constant (goats on the road) and people as well.

**Assessment:** This is a negative, direct and permanent impact, because once the works are finished, there will still be the traffic of workers to the plants, from the ADA and AID. It is irreversible, of high magnitude and medium importance.

**Measures to be adopted:** Application of preventive measures together with the village populations, and the implementation of signaling and safety elements on the roads, as adequate speed reducers, in addition to
social communication actions and the formation of the drivers engaged in the works, including periodic recycling, the monitoring of risk situations caused by them and an infraction penalty system, intended to guarantee the safety and the life of the people living in the villages adjacent to the road.

5.3.2.9. INCREASE IN THE INCIDENCE OF DISEASES

**Generating action:** Increase in the circulation of vehicles and people

**Description:** The migratory flow and the precarious basic sanitation conditions, added to the environmental changes due to the works, will bring favorable conditions for the proliferation of vectors and pathogenic agents. In this context, it is important to point out that malaria is the main disease in the region, making it the main internment reason in Dondo’s Municipal Hospital and the main cause of death in the AAR.

The sleep disease (*Trypanosoma brucei*) is another infirmity that concerns the local authorities therefore the region is now under epidemiologic surveillance, with the capture of the Tsé-Tsé fly (*Glossina*) that transmits the disease being made. According to the administration of the São Pedro da Quilemba community, in an interview carried out in August 2008, 20 cases of the disease were recorded, placing the community under alert status, because in recent years no cases of the disease were registered.

Due to the almost absence of basic sanitation and the precarious situation of the health infrastructure and the rapid population growth caused by the expected migration, there is also the possibility of the increase of water-transmission diseases, as cholera, a problem that already affect the region, mainly in the rainy periods, and infectious and parasite diseases that affect mainly children.

Another situation to be considered is the fact of the increase in Sexually Transmitted Diseases (DST), with the risk of the increase in contamination by AIDS.

The increase in respiratory diseases can also be increased by the intense vehicle traffic in Dondo and the villages, caused by particles in suspension and dust, and the emission of polluting gases into the air, affecting mainly children and aged people (population more sensible).

It is important to consider the possibility of increase in the cases psychosocial disturbances in the population due to the generation of expectations and eventual social conflicts that may arise to the arrival of migrants.

**Assessment:** This is a negative, indirect, local, temporary and irreversible impact, with high magnitude, due to the epidemiologic character and the risk to public health, and is of great importance.
Measures to be adopted: The support actions for the AID communities shall instruct the population with respect to the cares regarding basic and environmental sanitation, the identification and elimination vector concentrations, in addition to the intensification of the epidemiologic actions, improvement in the health system, improving and increasing the care capacity in the hospitals and health centers, specially in Dondo and the ADA and AID villages. Actions for the announcement of preventive measures, holding of orientation and information lectures for the communities, shall also be carried out within the social communication plan context.

As this situation is of extreme importance and considering that the high circulation of workers in the region may increase the risk of the occurrence of the sleep disease cases, it would be important to intensify the entomologic studies in the region to establish the degree of risk for its occurrence. The use of repellants and insecticides in the lodging is also recommended.

5.3.2.10. OCCURRENCE OF OCCUPATIONAL ACCIDENTS

Generating action: Construction of the enterprise in different phases.

Description: Due to its magnitude and complexity, the enterprise implementation works will involve thousands of people and will require many specialties in different areas. Therefore, the risks of accidents associated to the type of work required is significant and involves, besides occupational risks, the risk of accidents with poisonous animals and many others. It must be pointed out, having in view the significant number of workers involved, that the existence of alcohol and drug consumption is a real possibility and is an intensification factor for the risk of accidents in the work environment.

Assessment: This is a negative, direct, temporary impact, with localized effect, reversible, not being possible to estimate magnitude and importance.

Measures to be adopted: Permanent actions for worker formation shall be implemented, with preventive and corrective character, linked to occupational health and safety, including periodic recycling. The company shall provide and make the workers aware of the use of personal protection equipment.

5.3.2.11. RESETTLING OF THE FISHERMEN VILLAGE OF KISSAQUINA

Generating action: Reservoir filling.
**Study of Environmental Impact of Laúca Dam Construction Project**

**Description:** The area of the fishermen village of Kissaquina, in the South Kwanza province, will be totally flooded by the filling of the Laúca dam reservoir. Close to the Kwanza River banks, there are some straw houses belonging to around 25 fishermen that live in this place together with their families.

**Assessment:** This is a negative, direct, permanent, localized and irreversible impact, with high magnitude because it will change the way of life of the affected families, having great importance.

**Measures to be adopted:** On the community resettling, actions to define the settling’s place and territorial project with the participation of the community, of the implementation of the complete infrastructure (water, sewage, adequately prepared place for residue disposal, accesses) shall be implemented to promote the improvement of the dwellers’ quality of life.

**5.3.2.12. RESETTLING OF PLANTATIONS AND FARMS**

**Generating action:** Reservoir filling.

**Description:** There are two farms in the village, belonging to the Kissaquina village dwellers and located at approximately 12 km from the village on the Kwanza River’s right bank. Such farms belong to the Jackson and Zé Boy brothers and are only a few meters from the Kwanza River bank. The farms are productive and employ young people in the region. Most of the products sold, specifically manioc, sweet potatoes and corn, are delivered to customers in Cacuso and Malanje.

On the Kwanza River left bank, in the Kissaquina South village, on the banks of the Luinga River, there are around six (6) plantations with areas between 0.5 a 1 hectare. These will be flooded by the filling of the reservoir. The owners of these plantations and farms showed concern with the filling of the reservoir and with losing their production, which is important for their subsistence and as an income source.

**Assessment:** This is a negative, direct, permanent, localized, irreversible impact, with high magnitude, because it will affect the way of life of the families involved, and is of great importance.

**Measures to be adopted:** On the farm resettling, actions to define the settling’s place and territorial project shall be implemented with the participation of the parties involved, together with the implementation of the basic infrastructure (water, sewage, adequately prepared residue disposal place), shall be implemented to promote the improvement of the dwellers’ quality of life. The farms should be located in fertile soil and close to the river to provide easy access to irrigation water. If this is not possible, means for irrigation and water supply to the farm in an adequate and sufficient manner shall be implemented.
5.3.2.13. RESETTLING OF THE SOBA CEMETERY

Generating action: Reservoir filling.

Description: The Kissaquina South’s sacred cemetery located on the left bank, where 11 Sobas of the Kissaquina village are buried, is located on the Laúca dam flooded reservoir area. As this place is considered a sacred site by the entire population of the Ambundu tribe, involving rituals and symbology still strong among the communities, it will be necessary to provide its resettling, regarding the pre-established measures, in order to comply with certain local traditions and habits. It is important to point out that the Soba of the Kissaquina village did not favor the flooding. The community suggests that the elderly people from the two villages and others from the neighboring villages are contacted to find a solution.

The population keeps the habit of holding a party during the annual cleaning of the soba cemetery, locally known as “Jindambu” and located at approximately 7 Km from the Kwanza River. The old Jindambu still exists and is located on the Kwanza River left bank. To reach the cemetery site it is necessary to cross the river by canoe and flatboat, or by the land way passing by Libolo-Kwanza South. It is important to point out that the old cemetery called Jindambu stays at approximately 1,000 meters from the fishermen district.

The Kirinji village soba cemetery still exists, located on the right bank at approximately 6 Km from the Kwanza River bank, in the Fuxi Ya Lemba zone. This one could be on a risk area that will be subject to flooding in case the reservoir is full. Due to access difficulties, it was not possible to reach the place and therefore it was not possible to determine exactly this possibility. The Soba of the Kirinji village showed his agreement with the possible resettling of the cemetery, provide their traditions are followed and the purification rituals carried out. Another concern raised by the participants during the meeting is connected to the place where the first village hunter was buried. According to the population’s reports the first hunter of the Kirinji village was buried at approximately 1 km to the north of the place where the Laúca project work quarters is located. The place could not be visited by the social survey team.

Assessment: This is a negative, direct, permanent and irreversible impact, of high magnitude, because it will interfere in the community’s beliefs and religion, therefore of great importance.

Measures to be adopted: The resettling of the sacred cemetery shall be carried out through actions that call for the participation of the community and the soba because these are sacred soils defined by the local authorities, with respect to the entire transfer rituals in order to minimize any type of conflict with the population.

5.3.2.14. RISK OF LOOSING ACCESS TO THE VILLAGES

Confidential
**Generating action:** Reservoir filling.

**Description:** In the Kissaquina South village there is a bridge that connects the village to the pastures, which is normally flooded by the floods of March and April, and is located in a zone that will be subject to permanent inundation with the filling of the reservoir. The village population also crosses the Kwanza River (through the access to the Kissaquina fishermen village) to visit their families in the villages of Kissaquina and Dala Kiosa. In the Calombe village there is also a bridge over the Luinga River that will also be subject to permanent inundation.

**Assessment:** This is a negative, direct, irreversible and permanent impact, and it is not possible to estimate its magnitude and importance.

**Measures to be adopted:** Recovery of the affected areas through the construction of new accesses connecting the right and left banks. New surveys shall be carried out in the villages to confirm the problems with the accesses and verify whether they can be used for displacement between the villages.

### 5.3.2.15. RISK OF LOOSING ARCHEOLOGICAL SITES

**Generating action:** Installation of the work quarters, works supporting the dam construction, deforesting and cleaning of the reservoir area, formation of the reservoir.

**Description:** The dam implementation works and the formation of the reservoirs will affect old human settlings and sacred areas. As there is no ethnological study and neither the identification of possible areas with archeological interest, the implementation process of the works will possibly find important sites and artifacts for the reconstruction of Angola’s history.

**Assessment:** This is a negative, direct, irreversible and permanent impact, and it is not possible to estimate its magnitude and importance.

**Measures to be adopted:** Identification and rescue of archeological sites and sending of the materials found to museums and institutions capable of classifying them for later study.

### 5.3.2.16. LANDSCAPE CHANGES

**Generating action:** Formation of the reservoir
Description: With the formation of the reservoir changes in the local landscape will take place, with the transformation of the running water environment into a still water environment, loss of rapids and possible changes in the vegetation cover, when a new ecosystem situation will prevail.

Assessment: This is a negative, direct and permanent impact, with irreversible character, localized influence, high magnitude and great importance.

Measures to be adopted: Recovery of the degraded areas and environmental compensation, focused on the recovery of equivalent areas.

5.3.2.17. SOIL CHANGES

Generating action: Implementation of access roads, land cleaning, other structures supporting the works and the formation of the reservoir.

Description: This impact, arising from the implementation of the supporting infrastructure, consists in the turning the soil impermeable due to compacting and covering with another type of material with the purpose of creating a regular soil with good resistance, making it unsuitable as substrate for the development of vegetation and water absorption.

With the formation of the reservoir, more important impacts will affect the soil, because of the total inundation of the soil in these areas and, consequently, its definitive loss. It is not possible to establish either preventive or corrective measures for this impact. Changes in the soil characteristics due to the elevation of the water table must also be considered, causing the formation of humid and flooded zones, which can modify or render impossible its utilization in farming.

According to the enterprise’s technical characteristics, with reservoir level fluctuations according to the local seasons and power generation demands, it is possible that the soil in the reservoir banks, in the depletion zone, will be subject to cyclic changes.

Assessment: This is a negative, direct, permanent, irreversible, localized impact, with medium magnitude and great importance.

Measures to be adopted: Implementation of monitoring programs for the lack of stability on the shore and marginal slopes, recovery of degraded areas and hydro-geologic monitoring, which can provide important information to minimize the impacts.
5.3.2.18. CHANGES IN WATER TURBIDITY

Generating action: River deviation and dam construction.

Description: Modifications in the slope shapes caused by earth movements (borrowing of materials and deposit areas for surplus materials), which have caused changes in the slopes, the mechanic disaggregation of soils and slopes, as well as the removal the vegetation cover, will intensify the material transport processes, with the possibility of river aggradation and changes on the fluvial dynamics.

Assessment: This is a negative, direct, cyclic, reversible, localized impact, with medium magnitude and medium importance.

Measures to be adopted: Implementation of environmental actions to the works intended to reduce the entrance of sediments into the river, besides monitoring the water quality to minimize the consequences, including aggradation.

5.3.2.19. RISK OF INDUCING EROSIVE PROCESSES

Generating action: Execution of cuts, landfills, underground and open air excavations, cleaning and deforesting in the construction and reservoir areas.

Description: The erosive processes are started and/or intensified by morphologic land changes that result from activities associated to the enterprise implementation, as well as to cyclic environmental phenomena.

Assessment: This is a negative, direct, temporary, reversible, localized impact, with medium magnitude and importance.

Measures to be adopted: Adoption of measures during the works that minimize the areas to be deforested out of the reservoir area, restricting them to the minimum necessary areas for building the infrastructure, with the purpose of preventing the intensification of the erosive processes. After the conclusion of the infrastructure works, the areas shall be recovered and measures shall be taken to prevent erosion. The degraded areas shall be recovered (soil and vegetation) with permanent maintenance.
Engineering techniques shall be adopted for the containment of slopes and prevention of erosive processes, as works of superficial draining conduction. Additionally, the adoption of monitoring in places that favor the starting of erosive processes is recommended, for the implementation of the necessary preventive measures.

5.3.2.20. ELEVATION OF THE WATER TABLE

Generating action: Reservoir filling.

Description: The filling of the reservoir triggers changes on the base level, starting changes and the redistribution of hydraulic gradients and elevating the water level.

This change may bring an increase in the aquifer productivity, which increases the availability of underground water in the areas closer to the reservoir. However, this condition depends on the type of underground aquifer found in the ADA and the AID, because the type of rock substrate interferes directly on the underground flows.

Another possible effect resulting from the water table elevation is the pollution of the underground aquifers due to the presence of septic tanks, cemeteries or other contamination sources of anthropic origin.

Another group of effects originated by the water table elevation refer to changes on the soil conditions. This is an important impact having in view that it presents a significant magnitude, and there is no possibility of establishing corrective or preventive measures. Depending on the pedology characteristics, such changes may render impossible the use of the affected soil for farming. Another important change refers to changes in the composition of the marginal forests, because some vegetal species cannot stand the water table elevation, what may lead to their death and replacement for species adapted to the new humidity conditions.

Assessment: The water table elevation effects are ambiguous regarding their nature, since they will benefit the creation of shallow aquifers, increasing the water availability for the population, depending on the type of existing aquifers. On the other side, its effects are negative when one considers the possibility of the formation of humid and flooded areas, thus interfering with the soil characteristics. The impact is direct; permanent; irreversible; with regional influence and medium magnitude and importance.

Measures to be adopted: Actions of monitoring the water table elevation and the quality of the underground water shall be conducted, to verify eventual negative effects and encourage corrective measures, as well as increasing the benefits. Cleaning and decontamination of the reservoir area (septic tanks, cemetery and plantations).

5.3.2.21. CHANGES IN LIMNOLOGY CHARACTERISTICS AND WATER QUALITY

Generating action: Reservoir filling
Description: The formation of reservoirs normally brings impacts to the water quality, of which the most important are related to the inundation of the vegetation on the reservoir area and the further degradation of the phytomass. This phenomenon is related to several processes of physical, chemical and biological nature. The excessive presence of vegetal biomass in the aquatic means releases organic compounds and nutrients that, when decomposed may bring changes to the reservoir’s water, as color, turbidity and eutrophication. The chemical and biological oxidation of organic compounds can also create the consumption of the dissolved oxygen available in the water, and may also generate anaerobiosis conditions (absence of dissolved oxygen). These areas with absence of oxygen are more developed in the deeper layers, where there is no more incidence of solar light.

Impacts on the water quality may occur, not only in the reservoir area, but also in the first sections of the Kwanza River, downstream of the dam axis. The first impact occurs during the filling phase and is significant just after the filling of the reservoir, periods in which there is the incorporation and biodegradation of the flooded biomass and the consequent release of nutrients and organic compounds that may bring significant impacts to the aquatic species.

The water quality in the downstream section is conditioned to the levels and characteristics observed on the reservoir body, mainly in the portion of the reservoir located close to the axis. Starting on this point and proceeding downstream, a progressive recovery of the dissolved oxygen levels shall be observed, which will be promoted by the natural reaeration and the consequent drop in the CBO rates. After this transition phase (which cannot be estimated), the dissolved oxygen levels shall be reestablished within the natural limits that are normally observed in this water body.

In the incoming flows that form the reservoir, due to the newly established hydrodynamic balance, the occurrence of an eutrophication process may be favored, with a magnitude that will be conditioned to the residence times and the concentration of nutrients present in the liquid mean.

The inundation of the vegetation area also contributes to this impact, causing the consumption of the oxygen dissolved in the water used to feed the biochemical reactions associated to the decomposition of the underwater organic matter, which may affect the aquatic life, particularly the development of fish. The most critical phase of this impact can be considered temporary, which is the decomposition process of the more easily degradable phytomass that takes around 30 days, after this period, the remaining timber material presents a slow decomposition that is not more critical for the water quality. However, the water quality will have its characteristics permanently modified.
Assessment: This is a negative impact directly caused by the formation of the reservoir. Its magnitude is high and of great importance, however, it can be controlled and monitored through preventive measures.

Measures to be adopted: The mathematic modeling of the water quality must be carried out to be used as basis for the selective removal of the phytomass existing in the area of the future reservoir, and also in the forecasting of the future reservoir’s water quality characteristics, as well as the possible influence of the bottom discharger. As a complement, the water quality monitoring (before and after of the reservoir formation) and the limnology follow-up shall be carried out since the start of the filling, in order to validate the modeling and detect, in a timely manner for correction, eventual deviations regarding the foreseen behavior.

5.3.2.22. LOSS OF NATIVE VEGETATION

Generating action: Implementation of the work quarters and other supporting structures, and the formation of the reservoir.

Description: The work quarters implementation area and the one that will be flooded by the reservoir, will represent the loss of native vegetation individuals, reducing the local vegetation’s genetic pool. The diagnosis has not revealed the existence of rare species, either threatened or in danger of extinction, however, the possibility that such species exist cannot be dismissed.

Additionally, the loss of vegetation area, with the subsequent elimination of the habitats used by the fauna, which is forced to move to adjacent areas, is another consequence of this impact.

Assessment: This is a negative, direct and permanent impact, the loss of individuals is irreversible. It presents localized influence, high magnitude and great importance.

On the other side, the loss of area in the work quarters and in other supporting infrastructure is reversible, by applying the measures foreseen in the degraded area recovery program.

Measures to be adopted: Consist of compensation measures foreseen in the flora conservation program, like the execution of the area’s flower and forest inventory that seeks the definition of the priority species for germoplasm rescue (seeds, seedlings and other propagation structures), and the assessment of the existing timber potential; planning of the removal of the species for an ex situ conservation, thus ensuring the maintenance of the genetic asset of species with potential commercial and medicinal value, implementation
of seedling beds and the recomposing of degraded areas with native essences. The implementation of the Degraded Area Recovery Plan is of paramount importance.

5.3.2.23. CHANGE IN THE ICHTHYOFUAINA MIGRATION FLOW

Generating action: Dam construction.

Description: The river deviation has an impact on the fish species that make great displacements during the reproduction season, which coincides with the high water season, a stimulating event. Therefore, in the rainy period, such fish, also called reophylic, migrate upstream, while their gonads are reaching maturity. When arriving to the upper and more favorable river regions, the fish finally spawn. With the river deviation, the annual reproductive cycle of these species is affected by the restriction or impediment of these displacements and even the change of the place for spawning and mating.

In the specific case of the enterprise under study, part of the impact was already consolidated by the construction of the Cambambe dam, downstream of the works and of the upstream Capanda dam that already regulates the Kwanza River natural flow in the area being studied. However, during field expeditions, some migratory species were collected and, therefore, this change must be considered in the implementation of the river deviation and, with additional data, in the dam construction phase.

Assessment: This is a negative, direct, permanent, irreversible, regional impact, with high magnitude and great importance.

Measures to be adopted: Execution of an ichthyofauna inventory in the medium Kwanza River basin and the limnology and water quality monitoring, including the immediately downstream tributaries.

5.3.2.24. CHANGE IN THE VEGETATION COMMUNITIES AT THE RESERVOIR MARGINS

Generating action: Reservoir filling.

Description: With the water level elevation up to places with essentially non-hydromorphic characteristics and the consequent water table elevation, changes in the physical and biological conditions of these environments will take place. The more perceptible change, on the long term, will be the structural modification of the vegetation communities found in the areas around the reservoir. This change will occur mainly due to the different adaptation capacity of the vegetation species living there. The species with higher...
adaptation capacity to different environments will suffer less or can even be favored, while others will have their survival and natural regeneration conditions restricted. This condition will result in the change of the original vegetation community structure. With respect to changes in the flower composition, it is likely that some species may extinguish locally while other new ones may establish. It is worth pointing out that structural and flower modifications shall occur only on a narrow strip along the reservoir margins.

**Assessment:** This is a negative, direct, permanent, irreversible, localized impact, with high magnitude and great importance.

**Measures to be adopted:** Consist of compensation measures, like the execution of the area’s flower inventory for the definition of the priority species for germoplasm rescue (seeds, seedlings and other propagation structures).

5.3.2.25. REDUCTION IN HABITAT DIVERSITY AND SIZE

**Generating action:** Suppression of the native vegetation.

**Description:** The removal of the native vegetation represents an area reduction and the loss of specific habitats for the land fauna species in the region. It is not possible to assess the adequacy of the displacement of the individuals of some species to neighboring areas, where there still are similar habitats, due to the lack of specific studies. Additionally, the reduction in the native vegetation cover will affect the flow of species in the affected ecosystems, thus creating a possible unbalance in their populations due to the reduction of genetic exchange.

**Assessment:** This is a negative, direct, permanent, irreversible, localized impact, with medium magnitude and importance.

**Measures to be adopted:** There are no mitigation measures for this impact. Flora inventory and fauna monitoring actions shall be carried out.

5.3.2.26. LOSS OF INDIVIDUALS AND LAND AND BIRD FAUNA DISPLACEMENT

**Generating action:** Civil works, displacement of machines and people, loss of habitats and filling of the reservoir.
Description: The presence of a higher number of people in the work quarters area, deforesting and sound pollution are factors that induce the local fauna to a displacement to areas away from the works. Such displacement will cause changes in the reception areas due to the competition for shelter and food. Birds and mammals tend to displace to closer vegetation formations, but, therefore, they shall cross open areas where they can easily predated. The displacement of other fauna components that constitute the nutrition basis of amphibians and reptiles, as insects and small mammals, determines the dispersion of different species of serpents and lizards.

As a consequence, the displacement of animals due to the filling of the reservoir will take place, when many of them, mainly birds and mammals, will be capable of escaping the advancing waters, seeking shelter in areas still emerged. However, as these areas will be soon occupied by their own animal population, a super population situation may occur, creating a more intense than normal competition among them.

Among other consequences we can point out that small mammals with restricted living areas and short flying birds, reptiles and amphibians will have difficulties to accomplish the displacement to the more distant remaining areas.

Assessment: This is a negative, direct, temporary, irreversible, regional impact, with high magnitude and great importance.

Measures to be adopted: Consist of compensation measures, like the execution of a fauna inventory in the area to define the priority species for rescue, when necessary, and monitoring.

5.3.2.27. INCREASE IN THE RISK OF ACCIDENTS WITH POISONOUS ANIMALS

Generating action: Displacement of the land fauna and habitat invasion by workers.

Description: As a result of animal displacements and the frequent presence of people in the area, a higher number of encounters with poisonous animals is expected, mainly ophidians. In such occasions, the contact of these animals with the local human population and the consequent accidents may occur.

In addition to displacements caused by environmental changes during the construction, the filling of the reservoir may cause the retreat of poisonous animals to higher grounds, which can favor the accidents involving them.

Assessment: This is a negative, indirect, temporary, reversible, localized impact, with low magnitude and great importance.
Measures to be adopted: Social communication actions and worker orientation, with warning about the problem and the risks of accidents. For the treatment of eventual accidents, besides establishing an agreement with institutions that produce the anti-ophidian serum, an infrastructure must be created to ensure the adequate storage of this material and increase the stored volume in the local health care facilities, also human resources must be qualified to perform the treatment.

5.3.2.28. RISK OF FISH DEATH

Generating action: Downstream water depletion during the filling and in the reservoir area due to changes in the water quality.

Description: The water falling on the spillway and/or the pressure in the turbines results in gaseous saturation in the areas adjacent to the dam, hydraulic turbulence and/or high pressures. In consequence, there is the possibility of fish death caused by gaseous embolism and by predators attracted by injured fish. During the reservoir formation period, a reduction in the dissolved oxygen may still occur and, therefore, bring death to the less resistant species in this new situation.

Assessment: This is a negative, direct, temporary, irreversible, localized impact, with high magnitude and great importance.

Measures to be adopted: Implementation of a barrier system, ichthyofauna monitoring and either the transport to the river of the fish captured in the downstream section of the cofferdam, during the construction, or leaving them in place for scientific studies.

In order to avoid significant water quality changes during the filling phase, the removal of the vegetation indicated in the modeling shall be carried out to prevent reduction in the oxygen levels.

5.3.2.29. CHANGE IN THE ICHTHYOFAUNA MIGRATION FLOW

Generating action: Dam construction.

Description: The dam construction interrupts the routes of the migratory fish species and reduces the river flow speed in the reservoir area. These species make displacements for food or for reproduction, stimulated by the high water season. Therefore, in the rainy period, these fish species, called reophilic, migrate upstream while their gonads mature. When they reach the upper and more favorable regions of the river, the finally
spawn. Therefore, the annual reproduction cycle of these species is affected by the restriction or impediment of such displacements.

Additionally, the downstream river flow regulation will reduce the flooding peaks and the necessary stimulus for the fish displacement from downstream to upstream.

In the specific case of the Laúca enterprise, part of the impact already was already consolidated by the construction of the Cambambe dam, downstream, and the Capanda dam upstream, which already regulate the natural Kwanza River flow in the area under study.

The existence these dams without transposition mechanisms has isolated ichthyofauna populations, however, there is not sufficient knowledge about the situation of these fish populations within the area of influence of the proposed enterprise. During the field expeditions, some migratory species were collected, so this change cannot be dismissed.

**Assessment:** This is a negative, direct, permanent, irreversible, regional impact, with high magnitude and great importance.

**Measures to be adopted:** Execution of an ichthyofauna inventory in the medium Kwanza River basin and the limnology and water quality monitoring, also in the immediately downstream tributaries.

### 5.3.3. OPERATION PHASE

#### 5.3.3.1. RETENTION OF SEDIMENTS

**Generating action:** Formation of the reservoir

**Description:** The reservoirs act as sedimentation basins due to the reduction of the water flow speed. The sediments deposit in an irregular way along the reservoir, so in the reservoir entrance the coarser and heavier are deposited while the finer sediments proceed downstream, being deposited in the same measure as the water speed subsides. The deposition of these sediments means a significant reduction in the reservoir’s water storage capacity and may compromise the enterprise’s operation and service life.
Study of Environmental Impact of Laúca Dam Construction Project

Sediment retention may bring important consequences, as operation difficulties, adverse effects on the equipment performance and the intensification of the slow water effects, with the gradual elevation of the water level in the region upstream from the reservoir. In the case of the Laúca dam, changes in the water level will be attenuated by the existence of the Capanda dam that retains the major part of the sediments originated in the high Kwanza River, and is capable to regulate the flows. However, considering that the retention capacity along the reservoir is estimated in 94.6%, it can be forecast that little sediment will be made available upstream.
**Assessment:** Of a negative nature, the impact is direct, permanent, localized and irreversible, and shall take place after the filling. Its magnitude and importance are low, having in view that there are no tributaries of great importance in the section between the Laúca AH and the Capanda AH, as well as because of the characteristics of the land use and the Kwanza River waters. However, only hydro-sedimentology studies may provide the exact dimensions and the importance of this impact.

**Measures to be adopted:** The amplitude of this impact will be sized during the continuation of the hydro-sedimentology studies that will detect the need or not to take direct control actions, as the dredging of the sandy sediment. The bottom discharger may collaborate in reducing the sediment build-up in the reservoir area.

### 5.3.3.2. CHANGE IN THE HYDRAULIC BALANCE AND CLIMATE CHANGES

**Generating action:** Formation of the reservoir.

**Description:** The atmosphere and the climate have interaction with liquid bodies, whether of sweet water or oceans. In the case of reservoirs, this interaction takes place mainly through the evaporation process. Therefore, there is the possibility that climate changes originated by the formation of reservoirs will influence the micro-climate around the reservoir. The formation of clouds by the water droplets produced by the Kwanza River rapids can be observed. Some change in the rain regime may happen due to the dam construction on the river. The total annual rainfall will not undergo significant changes, because the impacts on the micro-climate will be limited to the immediate reservoir surroundings.

Effects on the regional climate are not likely, because the macro-scale atmospheric systems that control the climate in the medium Kwanza River have their origin in very distant areas. Eventually, the regional changes that might occur will be based on the combined effect of the future enterprise with the existing Capanda AH and Cambambe AH.

Temperature is the climatic element with the highest potential to undergo changes resulting from the formation of reservoir, due to an effect very similar to that exerted by the sea on sea shore regions. This change shall spread up to the upper part of the limit layer, mainly in the same direction that the wind blows. Therefore, a reduction in the daily, monthly and annual thermal range may occur. The light reflection on the water surface will increase.

Changes in the circulation pattern and in the local wind may occur, since there will be a significant change in the valley region with the reservoir construction.
In global terms, the reservoir will act as an emission source of small quantities of greenhouse gases, particularly methane and carbon dioxide.

**Assessment:** This is a negative, indirect, permanent impact, with irreversible character. The major effects will be local, on the bottom of the valleys. The magnitude and importance are low.

**Measures to be adopted:** Implementation of rainfall and meteorological stations in the direct influence area, for a continuous follow-up of the climatic conditions.

### 5.3.3.3. PROLIFERATION OF AQUATIC MACROPHYTES

**Generating action:** Formation of the reservoir (transformation of the lotic environments into semi-lentic or lentic and longer water residence time).

**Description:** With the formation of the reservoir, a considerable increase in the water’s nutrient contents may take place due to the lixiviation of the flooded soil and the decomposition of the flooded land vegetation. Such nutrients encourage the growth of the aquatic macrophytes. Although they present great ecologic importance, their excessive growth may compromise the multiple uses of the aquatic ecosystems and obstruct the water entrance flow into the dam turbines, thus causing water quality problems.

**Assessment:** This is a negative, direct, temporary, reversible, localized impact, with low magnitude and medium importance.

**Measures to be adopted:** Control of the processes that may lead to the eutrophication of the reservoir, as the use of the soil in its surroundings, thus, preventing the appearance of pollution sources with nutrient concentration above the water body’s absorption capacity; water quality monitoring.

### 5.3.3.4. CHANGE IN THE BENTHONIC DYNAMICS

**Generating action:** Formation of the reservoir.

**Description:** The structure of the benthonic macro-invertebrate community in the enterprise’s area of influence is subject to changes due to the formation of the reservoir, with the suppression of rapids and high oxygen content environments, as well as by the reduction of the downstream flow.
The ecosystem degradation, promoting the development of undesirable species as the aquatic macrophytes and the growth of aquatic plants in the reservoir area, may create favorable places for the proliferation of vectors with medical-sanitary importance.

**Assessment:** This is a negative, direct, permanent, irreversible, localized impact with medium magnitude and medium importance.

**Measures to be adopted:** Integrated monitoring action of the water, health and vector control.

### 5.3.3.5. CHANGE IN THE DOWNSTREAM AQUATIC ORGANISM COMMUNITIES

**Generating action:** Reduction in the river flow.

**Description:** The flow reduction brings changes in flow, temperature and the water’s chemical composition, and the retention of solids and nutrients, leading to several limnological changes, which can affect the aquatic fauna in this section of the river. The retention of material in suspension in the reservoir changes the nutrient distribution downstream. Additionally, the reduction and regulation of the water flow may cause the formation of ponds that, with the temperature elevation and the reduction of dissolved oxygen may generate the death of fish and of macro-invertebrates retained in such ponds by drying or predation.

**Assessment:** This is a negative, direct, permanent, local, irreversible impact, with medium magnitude and great importance.

**Measures to be adopted:** Integrated monitoring actions of the water and ichthyofauna, in addition to the maintenance of the minimum ecologic flow that guarantees the ecosystem reproduction.

### 5.3.3.6. RISK OF INCREASE IN DISEASE VECTORS

**Generating action:** Formation of humid and swamp areas.

**Description:** With the filling of the reservoir the formation of humid and swamp areas will occur. The appearance of these areas creates a favorable environment for the reproduction of disease vectors.
Assessment: This is a negative, direct impact, with temporary duration, regional coverage and reversible. Its magnitude is low, having in view that the affected areas are not occupied. The importance is high because the proliferation of vectors can trigger the increase in the cases of malaria and sleep disease.

Measures to be adopted: Survey, monitoring and intervention in these flooded areas as part of the vector and disease control program.

5.3.3.7. INSTABILITY AND EROSION OF MARGINAL SLOPES

Generating action: Formation of the reservoir and plant operation

Description: The dam construction and the filling of the reservoir will cause modifications in the topographic characteristics of the area directly affected and, consequently, in the acting geomorphologic processes.

The action of winds, waves and water level variations in the reservoir margins is an important factor for the development of the abrasion margins, where, depending on the slope characteristics and the type of soil and vegetation, gravitational processes may be favored.

Downstream of the dam, the river regime suffers modifications due to the artificial control of the liquid discharges, leading to changes in the fluvial processes, as cuts in the bed, erosion of the margins and downstream deposition, which can reach long distances. These impacts are normally perceived in the medium and long terms.

During the plant operation, the erosion of the unprotected margins may take place due to the water level oscillation and waves, also considering the depletion of 50 m foreseen in the project. There is also the possibility of instability in the slopes with higher declivity.

Assessment: This is a negative, direct and irreversible impact, acting permanently around the enterprise. Its magnitude and importance are medium.

Measures to be adopted: Identification and qualification of the critical areas (by mapping the areas that are susceptible to erosion) for monitoring and the adoption of preventive solutions of stabilization and protection of slopes and marginal areas.
Additionally, with the purpose of mitigating and, mainly, preventing the mentioned impacts, it is recommended that after the conclusion of the works, the degraded areas shall be refilled with soil and vegetation and be subject to permanent maintenance. The reservoir margins shall be refilled with vegetation in order to attenuate the impacts of the reservoir waves.

5.3.3.8. INDUCED SEISMICITY

**Generating action:** Mine exploration, use of explosives, excavations and formation of the reservoir.

**Description:** The possibility of the occurrence of seismic waves results from the use of explosives for the exploration of mines for the dam construction, underground excavations and the formation of the reservoir. In the first case, the result is “artificial” seismic waves having reduced impact significance; the other is “natural” seismic waves, although they are induced by the reservoir and present high significance as potential impacts.

The area where the enterprise is located is a region of deep fractures that reflect on the landscape morphology. Tectonic activity, although rare, was already recorded on the site. Magnitudes of 4.4 and 4.8 were observed in 1968 and 1976, respectively, and were associated to intense seismic activity in 1914, with magnitude of 6.54 in the MSK-64 scale.

There is no consensus about the causes, epicenter localization or forecasting methods regarding induced seismicity. The own problem of the classification of eventual shocks or tremors related to massive engineering works, as seismic ones, has no consensus, although most of the technicians in the area consider them as so.

Induced seismicity is usually associated to large reservoirs, but it has been also reported in a significant number of small works. Hydroelectric power plants were the first type of engineering works where effects on the earth’s crust were detected, and where induced seismicity was associated to stress modifications due to the formation of reservoirs.

Whether through a clear seismic effect, or due to the elevation of the hydrostatic pressure on the reservoir walls and bottom, generating the superficial accommodation of layers, or due to small displacements related to soil collapse, that is the rearrangement of particles due to the filling, the appearance or the intensification of tremors and shocks constitutes an impact already reported in several situations and environments in the world.

Confidential
In general, every reservoir is capable of generating seismic waves, but their intensity reach destructive effects only eventually. The maximum magnitude and intensity values due to the filling of the reservoir must not exceed the region’s natural seismicity levels.

**Assessment:** This is a potential impact of negative and indirect nature, with the possibility of occurrence during the construction, the filling of the reservoir or in the operation phase. It has a local influence with temporary duration and irreversible effect. It presents medium to low magnitude, varying with the tremor intensity, and medium importance because of the possibility of affecting the population and the axes.

**Measures to be adopted:** Artificial seismic waves will certainly occur and can be mitigated by the introduction of the usual controlled explosion techniques, natural waves are not certain and their mitigation is very difficult. Since seismic tremors get out of control and are difficult to forecast, seismic monitoring shall be developed to record eventual induced seismic activity due to the filling of the reservoir and the repair of any damage that may result from such activity.

5.3.3.9. THERMAL STRATIFICATION OF THE RESERVOIR

**Generating action:** Formation of the reservoir.

**Description:** The onset of thermal stratification normally occurs more easily in very deep reservoirs. The stratification results in the formation of water mass layers with different temperatures and densities. In the deeper reservoir layer, called hypolimnion, the water has the worst quality, and may reach anaerobiosis under the most critical conditions, with the consequent release of methane and hydrogen sulfide. In the epilimnion, the dissolved oxygen concentrations of are relatively higher, and aerobic-type reactions and good quality water prevails.

**Assessment:** This is a negative, direct, permanent, irreversible, localized impact, with high magnitude and great importance.

**Measures to be adopted:** Execution of stratification studies that will allow the preparation of recommendations that will guide the power plant operation, seeking the mitigation of this potential impact.

5.3.3.10. CHANGE IN THE ICHTHYOFANA COMPOSITION

Confidential
Generating action: Modification of the fluvial regime from lotic to semi-lentic and lentic.

Description: This change leads to a significant modification in the aquatic communities, not only in the ichthyofauna, with an expected depletion in the population of reophilic species and those adapted to fast flows, and with relative implementation in the communities adapted to the lentic regimes. The elimination of the lotic environments, with the consequent increase in lentic areas, brings changes in the ichthyofauna richness and abundance.

A drastic change in the local hydrological regime frequently causes dramatic changes in the niches available to the aquatic communities. The drop in the water flow speed leads to a higher deposition of particles, which normally causes the gradual change of the substrate with a natural increase in the deposition of finer sediments. Therefore, many reproduction and feeding sites are eliminated, bringing changes in the structuring and dynamics of the communities.

Aspects related to the feeding tactics get changed and the increase of some species may occur, as those that choose substrates, for example, while others, as those that practice the active hunting of moving benthonic macro-invertebrates.

Certain species in the Kwanza River that are already found naturally in environments with lentic characteristics, will find in the future reservoir the ideal conditions to accomplish their life cycles. From the species that live mainly in lotic environments, those having great ecological value are those that have the greater possibilities of surviving and prospering in reservoirs. On the other side, populations of the typically reophilic fish species, shall decline in the region to be occupied by the reservoir. Other species, although not migratory, but adapted to the lotic conditions, can also suffer reduction in their population.

Assessment: This is a potential impact of negative, direct, permanent, irreversible and regional nature, with high magnitude and great importance.

Measures to be adopted: Ichthyofauna monitoring and studies of the upstream water courses, with the purpose of establishing a fauna conservation area (aquatic reserve) in the tributaries of this section and guarantee possible alternate routes for the migratory fish.

5.3.3.11. BENEFITS TO THE COUNTRY

Generating action: Power generation with the construction of the Laúca dam.
Description: The country is presently undergoing a strong economic transition and the revitalization of sectors that remained paralyzed during decades. In this context, the construction of the dam is of extreme importance to give sequence to the power generation necessary to meet the demand that is starting to grow, both to boost the industrial sector and too supply the population that still depends on the use of biomass as the main energy source.

Assessment: This is a positive, direct, permanent impact, with national influence (global), high magnitude and great importance.

Measures to be adopted: Because it is a positive impact, no measures are foreseen.

5.3.4. WORK CONCLUSION PHASE

5.3.4.1. GENERATION OF EXPECTATIONS AND UNCERTAINTIES

Generating action: End of the construction works in the dam, filling of the reservoir and labor demobilization.

Description: Despite the temporary nature of the hiring, the end of the works generate expectations and uncertainties in the local and the migrant population, mainly because new employment opportunities will be scarce, due to the high unemployment rate prevailing in the region, worsened by the lack of specific programs for transferring the workers.

As the regional market does not offer many employment options, it is likely that part of these migrants will return to their places of origin. At the same time, with the demobilization, the workers coming from the ADA and AID villages will probably return to the unemployment situation existing before the beginning of the enterprise.

This impact will bring the increase of the unemployment rate in the region and probably the slowing of the local economy, mainly in the city of Dondo, with the consequent reduction in the family income, followed by the increase in poverty.

The exit of the workers will cause the reduction of the demand for goods and services, leading to an economic retreat and the closing of commercial establishments.
Assessment: This is a negative impact, because it will bring unemployment, with temporary duration and local influence. It is irreversible and of medium magnitude because part of the migrants will return to their places of origin, therefore this impact is considered of medium importance because it may result in the possibility of redirecting to other works, having in mind that some workers will have acquired their first professional qualification.

Measures to be adopted: Social communication actions, and the establishment of agreements with other enterprises in the region, which will stimulate and make possible the recruitment or redirecting of the available labor.
Table 5.3: Impact Analysis of the Laúca dam construction EIA.

<table>
<thead>
<tr>
<th>Description</th>
<th>Phase</th>
<th>Causing Agent</th>
<th>Reception Mean</th>
<th>Nature</th>
<th>Form</th>
<th>Duration</th>
<th>Reversibility</th>
<th>Influence</th>
<th>Magnitude</th>
<th>Importance</th>
<th>Measures to be adopted</th>
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<tbody>
<tr>
<td>Generation of expectations in the local population</td>
<td>P/I</td>
<td>Direct contact of the study teams with the local population</td>
<td>MA</td>
<td>N</td>
<td>D</td>
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<td>A</td>
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<td>Social communication and support actions to the local population</td>
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<tr>
<td>Increase in the technical-scientific knowledge about the region</td>
<td>P</td>
<td>Studies and projects</td>
<td>MA</td>
<td>P</td>
<td>D</td>
<td>P</td>
<td>I</td>
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<td>A</td>
<td>G</td>
<td>Availability of the generated knowledge</td>
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<td>Workplace generation</td>
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<td>Hiring of labor</td>
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<td>D</td>
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<tr>
<td>Population migration</td>
<td>I</td>
<td>Hiring of labor</td>
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<td>N</td>
<td>I</td>
<td>T/P</td>
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<td>A</td>
<td>G</td>
<td>Social communication and support actions to the local population and to the city of Dondo</td>
</tr>
<tr>
<td>Leverage of the local economy</td>
<td>I</td>
<td>Increase in the income and in the circulation of people and vehicles</td>
<td>MA</td>
<td>P</td>
<td>I</td>
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<td>Support actions to the local population and to the city of Dondo</td>
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<tr>
<td>Increase in the pressure over the local infrastructure</td>
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<td>Population migration/economic leverage</td>
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<td>N</td>
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<td>Support actions to the local population and to the city of Dondo</td>
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<tr>
<td>Description</td>
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<td>Planning/ Implementation/ Operation/ Conclusion</td>
<td>Causing Agent</td>
<td>Reception Mean</td>
<td>Nature</td>
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<td>Maintenance of the minimum ecologic flow, water and ichthyofauna monitoring</td>
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<td>Risk of the increase of disease transmission vectors</td>
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<tr>
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<td>Global/Regional</td>
<td>Magnitude/High/Medium/Low</td>
<td>Importance/Great/Medium/Small</td>
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<td>Support actions for the local community</td>
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<td>Without measures</td>
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<tr>
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<td>M</td>
<td>Social communication and agreements to support the unemployed population</td>
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</table>
5.4. PRONOSES
As shown above, two alternatives for the definition of the environmental prognosis were analyzed, the first one without the enterprise and the second with the enterprise.

5.4.1. WITHOUT THE ENTERPRISE
The overall trend is that the social-economic conditions of the municipalities inside the enterprise insertion area will remain as they were in the medium and long terms. The opening process, the improvement of the access infrastructure and the future energy production and transmission shall encourage the implementation of several projects of farming and industrial nature in the medium Kwanza River basin. The appearance of agro-industrial hubs with the purpose of making Angola a self-sufficient country concerning food is a bet of the Government of Angola.

However, this process shall concentrate in the Malanje / Cacuso / Dondo / Luanda axis, whereas the Dondo / Capanda AH axis will remain the present situation, out of the development dynamics and the accelerated development process now in progress in Angola.

Therefore, the village populations shall continue their survival based on subsistence farming and extraction activities, following the present pattern and worsened by the fleeing of young people in the search for better opportunities and education. Due to the many social emergencies present in the country and the lack of human and material resources, in the short and medium terms little will be accomplished in terms of the implementation of infrastructure and social equipment intended to improve the living conditions of this population.

With respect to the biotic mean, in a prospective picture, it can also be stated that it will remain stable, with the continuation of hunting for survival and illegal, as well as the execution of land burning for several purposes and charcoal production. Probably, the fauna will continue its slow recovery process after the war period.

5.4.2. WITH THE ENTERPRISE
The implementation of this enterprise in the medium Kwanza will create leverage in the region under the social-economic point of view, affecting essentially the population of the municipalities and villages in the areas of influence analyzed in this study. The most significant aspects will be the following:

- Generation of doubts and expectations in the population surrounding the project site;
• Increase in the local attractiveness and the consequent increase of the population seeking employment opportunities;

• Offer of fixed and temporary employment in the enterprise’s implementation and operation phases, with the creation of income generation opportunities and the development of small businesses.

The approximate number of workers in the so-called “peak period of the works” will be of approximately 3,700 people, totaling around 5,800 workers, including the direct and indirect services (support, administrative, laboratories, etc.). This peak is foreseen to take place between the 2\textsuperscript{nd} and 3\textsuperscript{rd} year of the dam construction, approximately in the month of October 2015.

The arrival of such a contingent of workers, added to the migrants and to the busy traffic of vehicles and cargo, will cause potential impacts on the way of life and on the social structure of the villages, a fact that will possibly give way to some conflicts and tensions, should the measures for process accommodation and strengthening of the community social structure in the surrounding villages are not taken.

Once the construction period has passed, the retreat of the process will take place, possibly bringing negative consequences to the region, should measures and specific cares are not taken when the works are demobilized.

With respect to the physical mean, to the geologic and geomorphologic and water quality characteristics, the foreseen impacts are predominantly associated to the enterprise implementation phase, due to the transformations arising from excavations and explosions in the Kwanza River banks and bed, and the filling of the reservoir as well.

With respect to the biotic mean, the enterprise implementation will affect the original vegetation areas, with the loss of vegetation species and habitats. The vegetation suppression will affect the fauna, due to the forced displacement of animals. The aquatic fauna will also suffer with the changes on the mean, with the likely reduction and/or disappearance of some species. The bird fauna will be affected during the period of the bank slope explosions and excavations, where a great number of swallow individuals and other species are found, being this place used for mating and nest making. The potential impacts will have priority and are related to the filling of reservoir.
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# Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>AAR</td>
<td>Regional Influence Area</td>
</tr>
<tr>
<td>ADA</td>
<td>Directly Affected Area</td>
</tr>
<tr>
<td>AID</td>
<td>Direct Influence Area</td>
</tr>
<tr>
<td>AII</td>
<td>Indirect Influence Area</td>
</tr>
<tr>
<td>AH</td>
<td>Hydroelectric Power Plant</td>
</tr>
<tr>
<td>BCR</td>
<td>Concrete Compacted with Roll</td>
</tr>
<tr>
<td>CNRF</td>
<td>National Center for Phytogenetic Resources of Angola</td>
</tr>
<tr>
<td>CCD</td>
<td>Convention for Fight against Desertification</td>
</tr>
<tr>
<td>CDB</td>
<td>Convention on Biological Diversity</td>
</tr>
<tr>
<td>DEC.</td>
<td>Decree</td>
</tr>
<tr>
<td>EFB</td>
<td>Rock Construction with Concrete Coating</td>
</tr>
<tr>
<td>EIA</td>
<td>Environmental Impact Study</td>
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<tr>
<td>ENE</td>
<td>National Energy Company</td>
</tr>
<tr>
<td>FAO</td>
<td>United Nations Organization for Food and Agriculture</td>
</tr>
<tr>
<td>GAMEK</td>
<td>Office for the Medium Kwanza Power Plant</td>
</tr>
<tr>
<td>LBA</td>
<td>Environment Basis Act</td>
</tr>
<tr>
<td>LBRA</td>
<td>Aquatic Biological Resources Act</td>
</tr>
<tr>
<td>LGT</td>
<td>General Labor Act</td>
</tr>
<tr>
<td>LOTU</td>
<td>Territorial Arrangement and Urbanism Act</td>
</tr>
<tr>
<td>MINAGRI</td>
<td>Ministry of Agriculture</td>
</tr>
<tr>
<td>MINAMB</td>
<td>Ministry of the Environment</td>
</tr>
<tr>
<td>NBSAP</td>
<td>National Strategy and Action Plan for Biodiversity</td>
</tr>
<tr>
<td>OIT</td>
<td>International Labor Organization</td>
</tr>
<tr>
<td>OP</td>
<td>World Bank Operational Policy</td>
</tr>
<tr>
<td>OMS</td>
<td>World Health Organization</td>
</tr>
<tr>
<td>SADC</td>
<td>Community for Southern Africa Development</td>
</tr>
<tr>
<td>SEA</td>
<td>State Secretariat for Water</td>
</tr>
<tr>
<td>SONEFE</td>
<td>National Society for Study and Financing of Overseas Enterprises</td>
</tr>
<tr>
<td>TIRFAA</td>
<td>International Treaty on Phytogenetic Resources for Food and Agriculture</td>
</tr>
<tr>
<td>ZCIT</td>
<td>Intertropical Convergence Zone</td>
</tr>
</tbody>
</table>
6. Environmental Management Programs

The plans presented in this chapter have the purpose to preventing, minimizing or compensating the potential impacts of the Laúca AH project. These impacts were previously identified in Chapter 5 of this study, which also contains the recommended mitigation or compensatory measures for the same.

The mentioned plans and programs follow a specific organizational structure, as shown in Figure 6.1 below.

**Figure 6.1:** Organizational Structure of the Environmental Programs Proposed for the Laúca Dam EIA.

<table>
<thead>
<tr>
<th>Programs for Support to the Works</th>
<th>Social-Environmental Programs</th>
<th>Monitoring and Control Programs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction Environment</td>
<td>Support to the AID Communities</td>
<td>Climate-related</td>
</tr>
<tr>
<td>Slope instability monitoring</td>
<td></td>
<td>Seismological</td>
</tr>
<tr>
<td>Community resettling</td>
<td></td>
<td>Hydro-geological</td>
</tr>
<tr>
<td>Rescue of archeological assets</td>
<td></td>
<td>Limnology and Water Quality</td>
</tr>
<tr>
<td>Recovery of degraded areas</td>
<td></td>
<td>Ichthyofauna</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Flora</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Land fauna</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Vectors</td>
</tr>
</tbody>
</table>

The structure above is headed by the Environmental Management and Monitoring Plan that will carry out the coordination of the inter-institutional actions necessary for the good functioning of the other programs. The follow-up of the actions foreseen for all the other environmental programs will be carried out by means of this plan, keeping integrated the different agents that will be responsible for its implantation.

The Social Communication and Environmental Education Programs will act as the axes from which the information flow and the actions that will be implemented by the other company environmental programs will be spread all over the proposed enterprise, thus ensuring the communication between the entrepreneur, the public agencies involved and the population in general.
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The implementation and development of these programs are the responsibility of the entrepreneur who, when carrying out the programmed actions, will be benefited by the lower expenditures in the implementation and operation phases, thanks to the control of the significant environmental elements and, moreover, due to less conflicts with the population and communities either affected or involved by the enterprise.

The application of these environmental programs will also count with the participation, whenever possible, of the country’s universities and research institutions, so the information and data in this report will be published and used in other researches in order to benefit the population.

**6.1. ENVIRONMENTAL MANAGEMENT AND MONITORING PLAN**

**6.1.1. JUSTIFICATION**

The enterprise implementation requires a management structure that guarantees that the execution of the environmental programs will be conducted in an adequate and integrated manner. To this end, the *Environmental Management and Monitoring Plan* shall establish efficient mechanisms to guarantee the execution and control of all planned activities in all the environmental programs, and the adequate execution of the enterprise works, during both the implementation and operation phases.

This Plan will define a management structure that will ensure that the environmental protection measures established in the EIA are correctly implemented, and that will make feasible the follow-up of the implementation of the environmental programs not directly associated to the works, thus providing a better integration among the different agents, companies, consultants and public and private institutions involved in the process.

**6.1.2. OBJECTIVES**

**6.1.2.1. GENERAL OBJECTIVES**

This plan for the management of the other programs has as main purpose to guarantee the elimination, mitigation or compensation of the environmental impacts foreseen in the surveys and studies that were conducted.

**6.1.2.2. SPECIFIC OBJECTIVES**

- Promote the development of the environmental programs;
- Mitigate or prevent the interferences generated by the works;
- Promote the integration among the proposed programs;
- Signature of agreements for carrying out the environmental programs.

**6.1.3. METHODOLOGICAL PROCEDURES**

As activities that compose this Plan are, briefly, the following:
• Allow permanent communication with the people responsible for the development of the environmental programs foreseen in the present study;
• Promote the integration of the professionals involved in the preparation and execution of the programs;
• Plan the development of the necessary activities for the program implementation;
• Follow-up and access the results of the program implementation;
• Review and adequate to the proposed activities/actions, when necessary;
• Follow-up the works and issue periodic progress reports;
• Coordinate the compliance with the environmental license restrictions;
• Develop a schedule that integrates all programs;
• Issue periodic monitoring and follow-up reports.

6.2. SOCIAL COMMUNICATION PROGRAM

6.2.1. JUSTIFICATION

The Social Communication Program is a very important support tool for the relationship between the people responsible for the implementation of the works and the other environmental programs, and the several social segments affected and/or holding stakes in the enterprise. This Program guides the negotiation procedures that shall be placed in practice together with the discussions that will follow the work programming, and that will extend during the whole dam implementation and operation period. It implies in the creation of efficient information communication channels regarding the announcement of the environmental and social interest projects and programs foreseen in this study.

The Program will be directed to the AID communities, traditional authorities, municipal representatives and neighboring communities, and can also cover the population of the closest cities, thus contributing for the reduction of uncertainties and doubts related to the enterprise implementation.

It is worth pointing out that the actions foreseen shall also benefit the population from the cities and communities that may be attracted by the announcement of the works and, consequently, by the announcement of the workplaces that will be made available.

The communities from the villages located on the side of the road that connects the city of Dondo to Laúca will be affected by the traffic of vehicles and people involved in the works, which will have access to the work quarters through a road that runs between the villages of Dumbo ya Pepe and Muta in the south direction. Some people in the Kissaquina village will be directly affected by the formation of the Laúca dam.

The population in these villages still favors the works because they expect to be hired for paid workplaces, even when it was ascertained that, when the survey was carried out in the communities, not all will have this desire fulfilled. This hope is already creating expectations in the population and, if there is not an efficient communication mechanism regarding the availability and the form of hiring, such expectations tend to transform into anxiety, and can generate significant population displacements, with all the negative consequences inherent to them.
In addition to the absence of professional qualification, the majority of the people do not have identity cards. This problem must be discussed, to make possible the hiring of the local labor, because identification is fundamental for the hiring by the contractors.

Another important expectation of the local population is the improvement in living conditions, infrastructure, services, as well as accesses and roads. Therefore, in addition to information about the works and the workplaces available, the information about and the participation of the communities in other environmental programs also require permanent communication with the village populations. Actions for the formation of the population are foreseen, as described in the Environmental Education Program, which will benefit them and, in order to accomplish their purposes, they will require much effort by the people responsible toward involving the communities.

In the case of the affected population in the village of Kissaquina (farms and the fishermen village), which shall be resettled, the Program will develop specific communication and follow-up actions for each preparation phase intended for the resettling, which must include the sacred site that exists there.

The village sobas will act as permanent contacts with the people executing this Program and the Administrators of the Pungo Andongo and São Pedro da Quilemba communities, to which the sobas report, and will also participate through the established instruments. This process shall be comprehensive since the beginning of the works, in order to guarantee the inclusion of all the people during the project, in all its phases, since the construction of the river deviation tunnels (already in progress) until the dam construction, the purpose of this report.

6.2.2. OBJECTIVES

6.2.2.1. GENERAL OBJECTIVES

The main purpose of the Program is to establish communication channels that will allow a permanent flow of information about the enterprise and its implementation and operation, as well as about the associated programs that shall be implemented in the region. The purpose of this Program is to mitigate the impacts regarding the creation of expectations in the population due to employment generation and the implementation of structural improvements in the ADA and AID communities. It will also allow to keeping the population informed about the implementation process of the social and environmental programs foreseen in this document and others developed under the contractor’s initiative.

The Communication Program also seeks to provide information and orientation regarding the demobilization phase of the works, when the number of workplaces fall and, consequently, the economic activities associated to them will be significantly reduced.

6.2.2.2. SPECIFIC OBJECTIVES

- Keep the population correctly informed about the enterprise, the project characteristics, its impacts and the programs proposed to mitigate them, thus avoiding divergent information from the several agents;
- Minimize the population suspicions and uncertainty with respect to the enterprise;
Prevent information distortions making it more transparent;

Promote the local population’s involvement in specific programs, as a way to make their implementation more efficient, following-up and continuing the necessary actions;

Allow the affected population to manifest its expectations, apprehensions and problems related to the execution of the works and the assessment of the procedures adopted to mitigate their potential impacts, by opening a permanent dialog channel;

Approximate the relationship between the entrepreneur and the several social sectors affected and interested in the enterprise; and

Carry out institutional articulation between the entrepreneur, the contractor, the local institutions, the church and NGO’s.

6.2.3. METHODOLOGICAL PROCEDURE

This Program shall explain to the village population the project characteristics, the period foreseen for the dam construction and the filling of the reservoir, the work phases, the foreseen impacts and as measures attempted to mitigate or compensate them; therefore, it shall be permanent and maintained after the demobilization das works and the beginning of the Laúca AH operation, providing assistance to the displacement of the temporary workers within the enterprise area.

The target public for this program includes the village population living and working in farms in the region (this means all the villages visited and heard in the EIA); All’s institutional agencies; enterprise workers; and recently arrived immigrants from several parts of the world. The villages capable of supplying localized work force along the road will also be included, specifically Kissaquina, Ngola Ndala, Kibenda, Nhangue Ya Pepe, Kibenda, Kirinji, Cassula, Kiangulungo, Dumbo Ya Pepe and Dala Kiosa.

As activities composing this program are:

- Formation of the team responsible for the program implementation;
- Creation of the reference center;
- Organization of the relevant information about the enterprise characteristics and the environmental measures proposed for the mitigation of the impacts that can be generated by the same;
- Selection and production of the material that will convey the information about the enterprise, according to each target public defined, as well as the definition of the strategies for this announcement;
- Publishing of the enterprise characteristics, the environmental studies and the work schedule;
- Holding meetings with the sobas to discuss the general guidelines of this Program, with emphasis on the ADA and AID communities;
- Distribution of the information and illustrative material about the soba activities;
- Assistance to the ADA and AID villages for the issuing of the identity documents;
- Elaboration of bulletins and strategies for insertion into the media of information to the AAR and All, regarding the actual demand for workplaces, in order to prevent migratory movements to the enterprise region.

6.3. ENVIRONMENTAL EDUCATION PROGRAM
6.3.1. JUSTIFICATION

The environmental education is considered part of a comprehensive participation process, where the environmental problems affecting individuals and communities are highlighted, seeking the establishment of a balanced and, above all, healthy family environment. The main point to be dealt with in the environmental education processes is the focus on the building of attitudes and values. To be effective, an environmental education program shall promote, besides the knowledge about the social, environmental and health problems and dynamics, the mastering of procedures, the development of attitudes and the building of values. These are the necessary conditions for the training carried out to will be able to generate health and adequate ways of relationship with the environment. Another fundamental aspect is related to the knowledge about the local social-environmental reality. Therefore, the region where the people live shall be the subject and context of the work, so the environmental problems can be effectively solved.

Among the several definitions of environment, this work holds as premise that the environment is the set of (physical, biological, political, social-cultural and economical) conditions involving living beings in a certain place, allowing their survival. And among these living beings are, logically, the human societies.

The basis of the Environmental Education Program for the dam project’s areas of influence here presented, considers that the environment comprises the relation between the human beings and their mean, in an intrinsic way, and seeks to stimulate the development of sustainable alternatives for the activities of the communities living there, also providing solutions for the serious social and environmental problems which they presently face, as well as to promote the minimization of the negative effects arising from the enterprise implementation and the leverage of its positive consequences.

This population contingent that shall be attracted to the AID will exert pressure on both the environment (local fauna and flora) and the population (on its culture, health and its production means) and also over the local infrastructure, already very deficient.

Disturbances as accidental fire, illegal hunting and environmental degradation can be avoided under the correct orientation and inspection of the appropriate agencies. Therefore, it is necessary a program that clarifies the workers about the cares with the environment, specially regarding hunting, fishing and its importance for the neighboring communities, about the need for respect with the community culture, about the risks inherent to sexual relationships and the precautions to be taken.

However, as important as the worker awareness, is that of the local population and the immigrants, since they will be directly affected in its living conditions, already very precarious. Therefore, the Environmental Education Program that will cover economic, social-cultural and of health problems, shall be split into two sub-programs, with specific methodologies: one intended for the construction workers and another for schools, churches and the local population.

Another important feature of this program is to warn the target public about possible risks involving fauna elements, specifically wild and poisonous animals, or those that transmit diseases, and how to avoid them.
6.3.2. OBJECTIVES

6.3.2.1. GENERAL OBJECTIVE

The Environmental Education Program has as main purpose taking relevant formation and information to the ADA and AID population and to the enterprise workers, seeking the improvement of their quality of life and the environment preservation.

The program actions intend to mitigate impacts such as the risk of accidents (outside and inside the works), health risks, as the transmission of sexually transmissible diseases (Sexually transmissible diseases – STDs, HIV/SIDA and others), valorization of the community relationships and the sociability and orientation with respect to the social relations, taking into account the arrival of migrants, etc.

6.3.2.2. SPECIFIC OBJECTIVES

The purposes of the Environmental Education Program for workers are the following:

- Create awareness in the workers about adequate environmental procedures with respect to the works, the health and safety and to the relationship with the neighboring communities;
- Create awareness in the workers about the seriousness of prostitution, particularly the infantile kind;
- Warn and create awareness in the workers about possible disease transmission vectors, with emphasis on the risk of STDs and forms of prevention;
- Provide adequate knowledge to the workers about a possibility of the occurrence of accidents involving the environment and their own safety;
- Warn about the possibility of accidents with poisonous animals and a need to use protective equipment;
- Warning about the risk of fire, indicating the most common causes of such accidents, and orientation about the measures to be adopted;
- Guide the workers, during the enterprise operation, by means of adequate signaling and inspection, about the dangers of accidental fire and the legal provisions that forbid hunting and govern fishing;
- Create sensibility and awareness in the workers regarding the importance of protecting wild life, giving emphasis to illegal hunting and the sanctions foreseen in the legislation in force in the country;
- Create sensibility and awareness in the workers about environmentally adequate procedures related to the works, the health and safety and to the relationship with the neighboring communities;
- Guide the workers about the behavior to be adopted with respect to the local cultural characteristics, in order to promote their valorization and establish absolute respect to them;

The purposes of the Environmental Education Program for the population are:

- Contribute to the prevention and minimization of the environmental and social impacts arising from the enterprise;
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• Inform the population about the foreseen environmental changes and the mitigation and compensation measures to be implemented;
• Create sensibility in the population about the importance of the conservation and recovery of the environment;
• Integrate and turn compatible several project actions involving environmental education;
• Carry out a general diagnosis of the environmental domestic, sanitary and health conditions, seeking the development of appropriate prevention and orientation campaigns about the possible disease transmission vectors, with emphasis on the STDs, and how to avoid them;
• Spread knowledge and techniques that contribute for the improvement of the environmental conditions around the residences and districts;
• Spread techniques that stimulate the sustainable use of natural resources and income generation;
• Guide the population, during the enterprise operation, by means of adequate signaling and inspection, about the dangers of accidental fire and the legal provisions that forbid hunting and govern fishing.

6.3.3. METHODOLOGICAL PROCEDURES

In order to accomplish the purposes established in this Program, which will assist both the workers engaged in the works and the local population, a coordination structure will be established, as follows:

• Formation of the team responsible for implementation and technical support team;
• Definition of the technical structure necessary for the program implementation (specific space, infrastructure, equipment and supplies);
• Establishing of a training/formation methodology for the different themes to be covered in the courses;
• Preparation of the lecture program, recycling periodicity, definition of the use of media (television and radio, among others) and the creation of basic materials as leaflets, posters, didactic material for schools, audiovisual material, etc.;
• Monitoring of the results obtained, re-adequacy and updating of the program themes;
• Establishment of partnerships with governmental entities and NGOs, whenever necessary and possible, to make possible the optimization of the program results.

6.3.3.1. WORKERS

Periodic formation actions will be carried out, composed by lectures and other interactive activities for the workers, intended to present and discuss the Workers’ Behavior Code and the environmental standards and construction techniques adopted in the enterprise.

The worker orientation and formation program will start already during the integration of the worker by the contractor, just after the hiring of each group, before starting their activities in the works, and will include periodic recycling, when specific activities and actions will be carried out should problems be identified during the works.

Didactic posters will be prepared and posted in the lodging building and around the works, with clarifications about the region (for example, map with the Kwanza River path, indicating the existing species shall not be hunted, the localization of the villages, medicinal plants, the road system and the work quarters and workshop location), information about the Ambundu culture, information about STD prevention, etc.
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A monthly report shall be prepared by the monitor, about the registered notifications and the way they were dealt with, whether through interviews, warnings or other disciplinary measures.

The actions here foreseen will be taken as support and with complete integration with the formation planning established in the Construction Environmental Program.

6.3.3.2. POPULATION

The educational activities have the purpose of introducing and strengthening the environmental preservation notions and increasing the quality of life of the families by disclosing relevant information about the region and the technical assistance to the communities, intending the improvement of the farming activities in a sustainable manner.

Several activities will be carried out seeking the spreading of domestic economy knowledge and techniques; maintenance of health and family hygiene; improvement of adequate environmental conditions in the residence surroundings (construction, maintenance and cleaning of septic tanks, appropriate disposal and launching of residential waste, etc.) and the valuation of local experiences.

Such actions will be carried out as far as possible in a participative way, integrated to the communities, always promoting their actual involvement in the program, thus incrementing their results. In principle, the following themes will be considered:

- Identification of the main problems and the potential local social-environmental advantages;
- Identification of the effects and consequences (positive and negative) of the enterprise in the region;
- Presentation of technologies and sustainable and alternative uses of the natural resources seeking the improvement of the environment and the population’s quality of life; better practices regarding construction, sanitation, etc.;
- Health protection and prevention against disease transmission, being the main focus on STDs, AIDS, endemic diseases, and diseases associated to water distribution and family health and hygiene.

In addition to these basic themes, new themes to be developed together with the communities can be introduced during the program, whenever relevant.

Formation actions seeking the qualification of teachers and monitors will also be carried out, covering environmental problems in the schools attended by the ADA and AID population. Together with the formation, specific didactic material will be provided for the teaching of activities associated to environmental education, where priority is given to the importance of healthy environments for the quality of life of the people and environmental preservation, focusing the local reality.

Specialized centers can be created for the qualification of spreading agents in some strategic villages, as a way of leveraging and spreading the program results.
6.4. PROGRAMS SUPPORTING THE WORKS

6.4.1. CONSTRUCTION'S ENVIRONMENTAL PROGRAM

6.4.1.1. JUSTIFICATION

The region where the Laúca dam will be built, in the medium Kwanza, had lived an economic and demographic depletion due to the war, like other regions in the country. A significant population contingent will be attracted to the area in the search for new employment and income opportunities and will exert pressure on the local environment.

The fact that traditional populations living in the neighborhood use the mean where they live as raw-material source that is collected for consumption and sale, in addition to complementing the food supply, makes even more important the preservation of the existing natural resources. For this reason, efficient environmental control actions shall be established, which will take place during the entire period of the works.

Therefore, some preventive practices as, for example, the adoption of environmental criteria for selecting the areas for the implementation of the work quarters, the storage of the organic soil removed for the installation of the work quarters, or the establishment of the Worker Behavior Code, can reduce significantly the impacts caused by the works on the environment and the local population. Previous measures intend to prevent or reduce the environmental impacts, in addition to turn economically feasible the later recovery posterior of the area used and its integration to the new landscape.

On the other side, regarding the workers, besides concerns about their relationship with the local communities, additional cares with their work, hygiene and health conditions shall be part of the work quarters installation program, with respect to the improvement of the quality of life and well-being of the employed population, as well as also avoiding damages to the surrounding communities.

The worker’s village (administrative work quarters) shall offer lodging, nutrition, health services, water supply services, treatment of effluents and solid residues, leisure equipment, recreation and cultural entertainment to the workers. This policy intends to reduce the anthropic pressure exerted by the workers’ contingent on the environment that will receive the works.

In the case of the dam construction project, several impacts are foreseen during the construction phase, capable of generating degradation phenomena, which result from the following actions:

- Cleaning of the land and removal of the existing vegetation;
- Earthmoving for the installation of the work quarters;
- Cuts and landfill for the implementation of the access ways;
- Mine exploration for the obtainment of construction materials;
- General excavations;
- Intense traffic of heavy machines on the area and the surroundings;
- Use of the installations by thousands of people, during a long period;
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- Explosive detonation for slope excavations.

Such actions configure a considerable and quick intervention on the region where they take place. And they would leave consequences after the implementation, if an environmental control program were not adopted. Respect for the implementation region and its natural resources is, therefore, the justification of this program.

6.4.1.2. OBJECTIVES

**General Objectives**
This program seeks to provide technical elements to make the works feasible with the lowest environmental cost possible and, after this, value the landscape aspects around the dam and work quarters’ construction. It shall provide the contractor with all the environmental criteria to be followed during the several construction phases and, to the workers, the standards for an environmentally correct behavior.

**Specific Objectives**
The program has the specific purposes of mitigating the impacts arising from the starting and/or increment in the incidence of erosive processes on the soil; landscape changes; vegetation suppression in the civil works and work quarters area; atmospheric emissions and noises produced by vehicle engines; utilization of heavy machinery and the use of explosives, causing stress on the population; emission of effluents.

6.4.1.3. METHODOLOGICAL PROCEDURES

The development of the environmental control program in the construction phase foresee the following activities:

- Analysis of the basic project’s technical and execution specifications regarding the aspects of the works that may bring environmental risks;

- Installation, operation and demobilization of work quarters:
  - Susceptibility to erosive processes;
  - Soils subject to physical instability;
  - Jagged topography;
  - Floods and inundations;
  - Water table surfacing;
  - Proximity of areas with vegetation in good condition;
  - Forms of soil use and occupation, according to the legislation in force;
  - Hours for the works and vehicle movement;
  - Signaling system;
  - Water supply;
  - Sanitary sewage;
  - Collection and disposal of solid and liquid residues;
  - Procedures for labor mobilization control;
  - Traffic of machines and equipment;
  - Healthcare and occupational medicine facilities;
  - Occupational safety;
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- Opening of access roads:
  - Susceptibility to erosive processes;
  - Soils subject to physical instability;
  - Strict purpose for the normal operation of the equipment running on them;
  - Specific drainage system;
  - Special characteristics for the road design and execution;
  - Interference in the sacred places of the traditional communities.

- Land deforesting and cleaning:
  - Criteria and special cares for deforesting and land cleaning in the work quarters area.

- Installation and exploration of mine, borrowing areas and disposal areas:
  - Removal and storage of the fertile soil layer;
  - Terrace building;
  - Declivity reducing;
  - Soil management and compacting;
  - Drainage orientation;
  - Vegetation recovery.

- Earthmoving services:
  - Geologic and geotechnical factors;
  - Vegetation cover;
  - Drainage;
  - Noise generation, where applicable;
  - Interference with the roadway system;
  - Risk of accidents and running of machines and equipment;
  - Excavations;
  - Boulder removal;
  - Superficial drainage system;
  - Material transport.

- Operation of machines and equipment:
  - Generation of effluents from the fueling, washing and maintenance of machines and equipment (fuel, oil, grease, etc.);
  - Noise generation (when applicable);
  - Generation of particulates;
  - Movement of machines and equipment;
  - Signaling devices for the operation;
  - Risk of accidents.

6.4.1.4. INFORMATION COLLECTION

The collection of information about the work quarters and its installations, the number of workers and living place, labor health (to size the healthcare facilities), place of extraction and quantity of
construction materials, land use and occupation in the work quarters area, need and design of access ways, foreseen movement of machines and equipment.

6.4.1.5. PREPARATION OF ENVIRONMENTAL CRITERIA AND GUIDELINES FOR THE EXECUTION OF THE WORKS

Twelve aspects were identified in the enterprise implementation that are environmentally affected: drainage; geotechnical actions and earthmoving; design of roads and access ways; water supply; domestic and industrial sewage draining; garbage, residue collection and disposal; traffic, signaling and operation of machines and equipment; deforesting and vegetation recovery; sound pollution; labor mobilization; hygiene and health; soil use and occupation. Regarding each one of these aspects, criteria and guidelines that shall guide the contractor will be developed.

6.4.1.6. WORK QUARTERS

The work quarters shall include buildings for administration and services; warehouse; canteen; healthcare facilities; vehicle washing and oil change station; crushing center, concrete center; yard for rock, sand, crushed stone, gravel and surplus material storage; yard for steelwork and pre-molded pieces; carpentry; locker rooms, toilets, watch station and parking lot.

All discharge points from the flow of soil channels and drains shall receive protection against erosion, using crushed stone layers, and grass or energy dissipation boxes. In the cases where the transport of sediments is likely, retention boxes for solids shall be foreseen, which will receive periodic maintenance. In case of steep declivity, channels shall be built in the shape of stairs, with intermediate dissipation boxes if necessary. In no case, the rainwater drainage systems and the sanitary drainage systems shall be interconnected; these shall have their own drainage systems. Regardless of the requirement for an absolute separator system, oil and grease separation boxes shall be foreseen in the drainage network, in strategic points along the system before the final disposal, so the water originated from the washing of machines and vehicles will collected and separated.

Flat platforms that favor water ponds shall always be avoided by guaranteeing a minimum declivity of 1% to 2% in any place within the works. As theses are temporary installations, the work quarters may use simplified drainage systems, therefore dismissing sophisticated works in concrete, as discharges and others of a permanent nature. The occurrence of erosion or sediment transport to water springs and reception trenches shall be avoided. Additionally, the work quarters drainage shall be equipped with structures that stand the traffic of machines and equipment.

With respect to earthmoving services, the environmental criteria refer mainly to the mandatory inclusion, in the planning and execution of these services, of prevention techniques against erosion, of the maintenance of the implemented protection systems and the monitoring of their efficiency.

Additionally, the area for any earthmoving service that might be carried out on the work quarters shall be subject to a future recovery program for degraded areas, where the separate removal, transport and appropriate storage will be necessary, including a program for the future reutilization of the material removed from the land’s fertile layer. The contractor will be responsible for conserving the material characteristics until the moment of reutilization.
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The internal circulation accesses between the several work quarters elements shall be kept under in permanent traffic conditions for the construction, erection and inspection equipment and vehicles, until the conclusion of the works.

In the specific case of the warehouse areas for the open air material storage, the land shall not undergo earthmoving, the shallow vegetation will be conserved and only the existing shrubs will be removed. The storage of the material shall be made over metallic or wood blocks to avoid direct contact of the material with the soil.

In order to guarantee an adequate water supply to the work quarters, special cares shall be taken against contamination. In case any chemical product is used for treatment or disinfection, its storage and handling shall be made in a safe way and by trained people, thus preventing risks to people, animals and the environment.

For oil, grease and other contaminant materials, separation and accumulation tanks shall be foreseen, in addition to adequate removal procedures. The effluents resulting from an eventual treatment process shall be directed to the industrial sewage system, in this case required. The whole supply system shall be protected against contamination, particularly water tanks and wells, by choosing an adequate localization, fences, elevation, etc. Treatment of domestic effluents in septic tanks shall be foreseen in the work quarters. The use of open air trenches or tanks without adequate cover is not allowed.

Residue management shall cover the work quarters and all of its installations, including the temporary ports for access and assistance to the both margins of the works and, as far as possible, using the same area should there be the need to store the residues. Detailed information about residue management is presented in Attachment IV –Residue Management Plan.

The collection, transport and final disposal of residues shall be carried out in adequate ways and places. All residues produced in the work quarters and other places of the works shall be frequently collected, in order to prevent odors or the proliferation of insects, mainly the tsé-tsé fly. Food waste and empty bottles shall be totally removed from the drums, and no disposal of residues will be allowed in field areas.

The industrial residues that will be generated during the Laúca dam construction activities shall be subject to mandatory management in terms of collection, disposal and adequate destination.

Residues so classified exist only in the Brazilian legislation; the best solution is to call them industrial residues that shall be stored in an isolated place, covered and with impermeable floor, so, in case of leaks, no infiltration will occur with the possibility of contaminating the soil. Additionally, a concrete dike shall be built around the hall (nave), so any spill would not reach the external environment.

Oil and grease shall be placed in cylindrical containers or similar recipients, in PVC or PP, and kept hermetically closed. Such recipients shall be provided with labels attached to a visible place on their walls, with a text indicating their contents.

Used oil can be delivered to third parties to be re-refined for use in less demanding processes. Should this service not be available in Angola, the industrial residues will be sent to an industrial landfill or to a duly licensed incineration unit. However, continuity shall be given to the permanent
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maintenance procedures of vehicles to prevent their oil from leaking and its excessive consumption, as well as keeping hygiene in the workshop installations, by in no case disposing the residues on the atmosphere, soil and water springs.

The final destination of the residues will depend on the possibility of reutilization, reprocessing or recycling carried out by third parties, duly licensed or authorized by the appropriate environmental control offices, or of delivery to a licensed receptor for final disposal, whether by means of a controlled industrial landfill, co-processing or thermal destruction.

The local population will have priority in hiring. Therefore, the workers will able to keep their homes, thus reducing the concentration of the contingents of foreign population in the region and the consequent social and sanitary problems.

All workers shall be vaccinated against yellow fever, tetanus and other diseases endemic in the region. The contractor shall carry out the vaccination upon the hiring medical examination of the employees, in addition to preventive campaigns against sexually transmissible diseases, ingestion of contaminated water and accidents with poisonous animals, as foreseen in the social communication and environmental education programs.

The employees shall be oriented regarding the procedures for the utilization of the canteen, healthcare facilities and the overall work quarters area and, also, regarding their displacement, consumption and leisure, in order to reduce relationship problems with the local population.

The hiring procedures and the later demobilization of workers shall be informed to the community as part of the Social Communication Program. In the same way, the institutions participating in the forum to be created, as well as the communities, shall be informed about all events scheduled for the construction phase.

Where necessary, food should be stored in facilities subject to permanent cleaning and refrigerated, in the case of perishable food. Screens and protective screens should be used to prevent access by animals and insects. Dining hall facilities should include screens, ventilation systems, and a sufficient number of restrooms with adequate capacity. Transport of meals into the field should be accomplished, when necessary, in sterilized airtight containers.

The medical unit for treatment of illnesses, injuries, and accidents should include the following facilities and offer adequate space for workers, as per the table below (Table 6.1).

Table 6.1: Minimum Recommended Area for Ambulatory Facilities at the Project Work Site

<table>
<thead>
<tr>
<th>Facilities</th>
<th>Area (m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waiting Room</td>
<td>16</td>
</tr>
<tr>
<td>Immunization Room</td>
<td>9</td>
</tr>
<tr>
<td>Examination Room</td>
<td>9</td>
</tr>
<tr>
<td>Pantry, Utilities, and Cleaning Supplies</td>
<td>4</td>
</tr>
<tr>
<td>Medical Bandage, Sterilization, and Pharmaceutical Supply Room</td>
<td>9</td>
</tr>
<tr>
<td>Public Restroom</td>
<td>2</td>
</tr>
<tr>
<td>Employee Restroom</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>51</strong></td>
</tr>
</tbody>
</table>

*Source:* Intertechne Consultores S.A.
The Environmental Construction Program will include the establishment of an Internal Accident Prevention Committee (CIPA) at the project site, training for first responders, and tracking and follow-up of endemic diseases.

Health and safety education measures will be provided to address the following issues: traffic safety; prevention and control of infectious diseases and parasites; smoking and alcohol consumption controls; prevention of accidents involving poisonous animals; prevention of physical, chemical, and biological workplace risks; and use of Individual Protective Gear (IPG).

6.4.1.7. ACCESS HIGHWAYS AND ROADS

All access roads should be executed, preferentially, for their specific designated purpose. However, access roads may be shared or reconfigured for use by local communities, provided the pertinent safety measures are met. The removal of vegetation to open access highways and roads constitutes a significant environmental impact with indirect repercussions on local wildlife, water resources, and soil structures. As such, special attention should be given to the strategies adopted, with a view to attenuating the corresponding impacts on the ecosystem.

All protective elements and structures required for the supervision and safety of access road use should be executed and specified in the project’s executive design. The vertical and horizontal project designs for access roads should minimize environmental disruptions, with a view to facilitating drainage and preventing unnecessary erosion or deforestation.

When possible, access roads should follow the contours of the terrain, circumventing these smoothly where necessary. In cases in which it is not possible to avoid steep inclines, stone or gravel covering should be used to facilitate traffic flow and prevent erosion. Intersecting slopes should be included on platforms and shoulders to ensure proper drainage of roadways. The execution of new access roads or modification of existing roadways should incorporate accompanying drainage systems to prevent erosion. All cut or fill slopes should be drained by means of pipes using steps or terraces and energy dissipation boxes, when required.

The contours of existing roadways executed for tunnel excavation activities will be adapted to the characteristics of the pertinent construction equipment and dam project design. This process may require earth-moving services.

To reduce or eliminate the possibility of environmental degradation arising from earth-moving services executed for purposes of the construction and adaptation of access roadways and routes, all project design criteria governing access road drainage systems and the respective cuts or landfills to be avoided must be strictly applied during the planning stage and by virtue of the geological and geotechnical characteristics of the region’s soils and their susceptibility to erosion. All cut or fill slopes designed and scaled to the pertinent stability criteria adopted in the project must be protected by grass (recovery of vegetation) immediately upon completion of the respective earth-moving services.

Existing access roadways that intersect areas subject to flooding and were improperly executed must be modified, with a view to re-establishing the natural conditions of the drainage network through implementation, for example, of storm drains, galleries, cross bridges, etc.
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pavement should be maintained so as to ensure the continuous flow of construction and assembly equipment and vehicles, as well as privately owned vehicles used by local residents.

All permanent signage required for the safety and operation of the Laúca Hydroelectric Unit will be executed in accordance with the executive project design. During the construction phase, signage should be installed at all locations that intersect with local communities or are situated near these, ensuring traffic stops where necessary and the safety of pedestrians in relation to the flow of heavy vehicles, trucks, etc. Additional safety measures may be adopted in relation to traffic and signage in areas located near villages. Heavy machinery and equipment operators must adhere to appropriate traffic measures in areas of high risk for humans and wildlife.

In the light of the characteristics of the region of the dam project, the transportation of workers on flatbed trucks is prohibited. All workers must be transported in automobiles or vans. The project executor must establish rules, with a view to minimizing the harm caused to the environment by heavy vehicle traffic, preventing unnecessary destruction of roadside vegetation and barring the discharge or disposal of materials or substances such as fuel, oil, parts, or components in the surrounding countryside.

Any damages caused by human, vehicle, or other traffic to roadways, crossings, or other existing resources, including crop fields and additional community property, must be compensated and repaired by the project executor. Repairs should be executed immediately in the case of accidental and unnecessary damage to ongoing work or during regular maintenance, in the case of damage to roadways and other resources affected by normal heavy use during work activities.

Appropriate speed limits should be enforced at crossings, with a view to preventing accidents of any type involving project personnel or others. The project executor will be responsible for preventing accidents and adopting the respective safety measures, which will be subject to periodic inspection.

**6.4.1.8. LOAN AREAS AND EXCESS MATERIAL STORAGE FACILITIES**

Earth-moving services for implementation and development of loan areas must be properly planned to prevent erosion during use and subsequent recovery. Techniques must be adopted during use and control of loan areas that give priority to moderate declivities, terracing between excavation banks, and vegetation recovery on slopes following completion of services.

All slopes generated in loan and excess material disposal areas must be adequately protected from erosion caused by runoff until permanent recovery of these areas. Upon conclusion of construction on the hydroelectric units, all excavated slopes in the area must be protected with crawling vegetation or shrubs, in accordance with the degraded area recovery subprogram set forth in the plant conservation program. In disposal areas, all other excavated material deriving from surface soil rich in organic material should be distributed and preserved (not used). Basic structures may be used for temporary facilities, although appropriate measures should be taken to prevent sediment carriage to nearby water courses and waterways.

With respect to earth-moving services, the environmental criteria refer principally to the mandatory inclusion of planning and execution of the related services, erosion control techniques, maintenance systems for implemented protection systems, and monitoring of those systems. In addition, if earth-moving services are performed in areas located at a distance from the project site and the construction site, these services should be encompassed in a future degraded area recovery program,
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providing for removal, transport, and proper storage, separately, and for future reuse of the removed fertile sediment.

6.4.1.9. JOINT WORK BETWEEN THE ENGINEERING AND ENVIRONMENTAL UNITS

The environmental criteria and guidelines cited above and those founded on consolidated technical specifications and environmental plant construction experiences in other countries should be discussed by the engineering and construction units and adopted by mutual agreement. During execution of the project, experts in the environmental and engineering areas should engage in ongoing monitoring and follow-up and maintain continuous exchanges, with a view to minimizing the attendant environmental impacts to the extent possible.

6.4.1.10. INCLUSION OF ENVIRONMENTAL GUIDELINES IN PROJECT CONTRACTS

Once the technical specifications of the project contracts have been prepared with the inclusion of the respective environmental criteria and guidelines, these will serve as a code of conduct for all project developers.

6.4.1.11. DEVELOPMENT OF A WORKER CODE OF CONDUCT

The objective of the code of conduct is to safeguard the health and hygiene of workers and, by extension, local communities, and the environmental conditions of the project work site and surrounding areas. It should include the rules below, which should be disseminated and incorporated in the training measures provided for in the communication and education programs described in this report.

- All workers must undergo a physical exam and receive the required vaccinations at the time of hiring;
- Appropriate conduct will be expected during transfer from project lodging facilities to the work site to ensure the peace and quiet of local communities;
- Water from rivers or streams may not be used for individual consumption;
- All waste generated at the work site or dining hall facilities must be disposed of in appropriate containers;
- Restrooms must be used appropriately to ensure proper hygiene;
- Under no circumstances may trees be cut down by individual initiative without the authorization of the responsible party;
- Under no circumstances will hunting or collection of wildlife be permitted, nor the collection of local plant species;
- Drivers of heavy machinery and equipment must adhere strictly to the established itineraries.

The operational procedures set forth in this program must be incorporated in the project work contracts to ensure the price quotes submitted by proponents include the recommended environmental precautions.
6.4.2. MARGINAL HILLSIDE AND SLOPE DESTABILIZATION MONITORING PROGRAM

6.4.2.1. JUSTIFICATION

Based on their specific characteristics, hillsides located along the banks of the reservoir may be subject to instability due to interventions in the area, including erosion and landslides. This possibility raises the need for implementation of a hillside monitoring and containment program.

Saturation of soil and rock due to filling of the reservoir is yet another factor underlying the instability of hillsides, due to increased demand on solid or rocky ground (neutral pressures), thus reducing resistance. Generally, in granite areas erosion processes predominate due to greater soil thickness, low density of plant coverage, and lower fracturing of granite, while in metasedimentary rocky domains conditions are more favorable to the movement of large masses and boulder blocks.

The destabilization of marginal hillsides is related to erosion, which at the time of the formation and operation of the reservoir are reactive, primarily as a consequence of the removal of plant cover. The occurrence of water “surges” and lapping of waves on reservoir banks are the principal causes of erosion and are capable of forming ravines and gullies, in particular along the reservoir bank. These effects, in conjunction with the partial submersion of hillsides, may cause landslides due to saturation of the soil and subsoil.

Filling of the reservoir during the implementation phase will elevate the hydraulic loads on the margins, temporarily creating water flows from the reservoir toward hillsides that will be progressively submerged until complete filling of the reservoir. Reduced resistance to shearing of the soil due to saturation generated by vertical hydrostatic thrust in lower sections of submerged hillsides and elimination of surface cohesion will cause deterioration of hillside stability and increase the potential for movement of large masses and erosion.

These phenomena are exacerbated or minimized based on the declivity of the area. The problem is more severe on steep hillsides and those marked by soil use and occupation, as removal of natural vegetation cover is a contributing factor to erosion processes.

Detailed mapping of those areas susceptible to erosion and landslides will enable proper channeling of mitigation measures to contain marginal hillsides around the reservoir.

Hillsides may also be destabilized due to explosions and drilling activities in connection with dam construction. Work performed during construction should aim to minimize land and rock slides and prevent accidents.

6.4.2.2. OBJECTIVES

General Objectives

The specific objective of the program is to mitigate impacts arising from erosion on marginal hillsides of the reservoir through monitoring and prevention, through the containment of hillside destabilization and erosion processes, in order to ensure, above all, the safety and useful life of the
reservoir, as there are virtually no constructions along the margins requiring protection for foundations or other types of interventions.

An additional objective of the relocation of access roads is the application of controls on the physical environment in connection with soil movement during implementation.

**Specific Objectives**

- To map and monitor areas susceptible to erosion;
- To train specialized human resources in Angola to ensure continuity of the academic and scientific research in connection with the monitoring programs;
- To contribute to planning of direct intervention measures, with a view to protecting hillsides from erosion.

**6.4.2.3. METHODOLOGICAL PROCEDURES**

The Program involves the following activities:

- To contract a technical team for implementation;
- To map areas susceptible to erosion;
- To execute field research, install instruments, and conduct laboratory tests;
- To perform photo-interpretation and geological-geotechnical mapping, follow up field research studies, and interpret the respective results;
- To assess the stability of hillsides and scope of control and containment solutions;
- To assess protection measures against superficial laminar erosion, deep erosion, and lapping of waves against tunnels;
- To monitor stability conditions and erosion along the margins and hillsides used for construction of the dam, in addition to elevation of groundwater and corresponding variations during filling.

Geological and geotechnical description encompasses the use of information collected in the inventory and specification phases plus the following activities:

- Photo-interpretation;
- Field mapping and execution of manual augur surveys, inspection pits, and percussion surveys, with a view to identifying the pertinent geological-geotechnical features;
- Execution of laboratory tests to determine the geotechnical characteristics of the representative materials for the various soil and rock types;
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- Topographical marks installed to control materials subject to instability;

- Determination of critical areas and their respective order according to a specific priority scale.

The frequency of installed reading instruments varies over time and should be determined following geological and geotechnical mapping and description. In the event of heavy rainfall, inspection of the pertinent stability and erosion conditions is recommended.

6.4.3. COMMUNITY RESETTLEMENT PROGRAM

6.4.3.1. JUSTIFICATION

A portion of the village of Kissaquina (on the left bank of the river), Kwanza Sul, is located in the Laúca Hydroelectric Unit reservoir flooding area. According to residents, the territory occupied by the population of Kissaquina encompasses a vast area delimited by the Kwanza River to the north, the Serra M’Bango Mountains to the southeast, and the Serra de Cassango mountains to the northeast. The community is divided by the Kwanza River, occupying areas on both banks. It is important to understand the Kissaquina people’s view of territoriality, as this factor is critical for establishing the parameters applied to select a new territorial area for settlement and identify a solution with the smallest impact possible on the community following transfer to another location.

Based on the social surveys and public consultations conducted with the population, two productive farms occupying approximately 2 hectares were identified, each owned by the Boy brothers. The farms employ youth in the region. A fishing village is located 12 km from Kissaquina, in an area inhabited by 25 individuals and occupied, further, by a soba cemetery. In addition, the habits and cultural expressions directly tied to the target territory will be affected.

Inhabitants circulate in an extensive area, principally for purposes of hunting. Territorial borders are based on natural features of the landscape, among them hills, streams, and plains. According to Mr. Luis N’golombole (Personal Communication 2009), territorial limits between the communities are respected by the sobas and are established on the basis of areas used by their ancestors. It is important to underscore that the sobas and hunters interred in the forest are considered guardians of the respective territories, who ensure fruitful hunts and protect current hunters.

Kissaquina soba Mr. Casimiro António, located near highway EM 322, reports having relatives of the former village of Kissaquina on the left bank of the Kwanza River. The population uses the fishing settlement’s access to the river for crossings. The village is a typically rural settlement, with plantations arranged radially from a central core of rudimentary adobe and wattle and daub huts distributed outward, extending to a cemetery housing sobas and their malombes located on a hillside near the Kwanza River. The cemetery will be flooded by the reservoir. The village soba on the left bank (Mr. Ngunza Canhanga) is opposed to flooding of the cemetery, as is the other soba of Kissaquina, and has requested that alternatives be found to prevent the removal of the interred.

There is no basic infrastructure or essential public utility equipment, including schools or health clinics, in Kissaquina or in the majority of villages consulted. There are no water or electric power supply services either, and local populations live in significant poverty.
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Based on this setting, the interviews held as part of the human environment analysis set out in the study revealed that the local population was supportive and had positive expectations with respect to resettlement, by moving them closer to the river, and the potential benefits and improvements to quality of life, as described above.

The key challenges reported by local residents are the lack of transportation, schools, health care facilities, and jobs. Very few local residents have birth registrations or identification cards. With regard to their expectations in connection with the project, they point to the possibility of less isolation, access to schools, health care, and the opportunity to sell their surplus farm production.

In this light, to ensure the welfare of local residents and preservation of the cultural and archeological heritage of the area, the resettlement of some Kissaquina residents will be guided by a detailed resettlement program, which will encompass the basic needs of the population identified for resettlement during implementation of the new site and adhere to the rituals demanded by local leaders for the proper removal and relocation of the sacred soba cemetery.

6.4.3.2. OBJECTIVES

**General Objectives**

The specific objective of the community resettlement program is to mitigate impacts arising from the resettlement of potentially affected populations (including Kissaquina); crop fields and the fishing settlement; the village sacred soba cemetery on the left bank; and the destruction of potential archeological and historical sites.

**Specific Objectives**

- To develop alternatives for a new physical and spatial organization of the Kissaquina village population subject to removal from its current areas of utilization and occupation;

- To identify new farmland areas (crop fields);

- To promote a new territorial organization accompanied with basic infrastructure and access structures;

- To supply new social equipment – education and health;

- To introduce enhanced techniques and procedures for the construction of new traditional dwellings;

- To promote environmental education and coordination with other specific programs designed for the area;

- To implement technical training programs for affected populations; and

- To stimulate and instruct local groups on strategies for increasing household income, including best practices of agricultural production.

The principles of the program center on ensuring the target population:
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- Equivalent or better standards of living than that registered prior to implementation of the project;
- Access to registered property, natural resources, and basic services (potable water, sanitation, infrastructure, education, and health);
- Full recovery of losses arising from challenges encountered during the transition process, that is, difficulties arising from resettlement;
- Recovery of the social networks of project affected populations;
- Recovery of job opportunities;
- Recovery of production capacity;
- Access to economic and social development activities;
- Direct benefits for project affected populations;
- Customary rights fully recognized and fairly compensated;
- Ensuring the resettlement process includes compensation through land for land swaps;
- Consent of project affected populations for resettlement and compensation measures;
- Acceptance, where applicable, by the host community.

6.4.3.3. METHODOLOGICAL PROCEDURES

The program is organized based on technical guidelines and methods capable of enabling development of the project, which take into account the socio-cultural, economic, and environmental factors of the target communities.

In this light, the program will encompass solutions for the community’s new spatial organization, supplying the area with basic infrastructure, new dwellings, and the necessary social equipment. With a view to mitigating project impacts, the program will also adopt mechanisms for community participation, promoting environmental education and technical training for inhabitants, with a view to boosting household incomes.

Based on the physical and spatial diagnostic analysis and study of the current settlement, formulation of the project stages for the new settlement will be executed. To this end, the program will need to determine the selection criteria for the new site, preferably one near the existing settlement chosen with the collaboration of community residents, followed by development of an intervention program and a basic and executive project design for the new area. As part of the selection process, meeting and consultations should be held with government officials and cultural representatives of the Kissaquina villages.
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The work will proceed methodically in sequential and consecutive stages for purposes of planning and direct and indirect analyses, and encompass the consolidation of information on the occupied area and the new settlement area. Subsequently, the content analyzed by the project team and noted by the project executor will guide the procedures for management of families and households and occupation of the new area.

The analyses of the research studies will be consolidated in a single product, in which the respective sources and methods adopted will be set, formalizing submission of the document in digital and print format (texts, graphic materials, tables, illustrations, and others) and the Specifications of the resettlement projects.

In this light, development of the program will proceed methodologically and be organized into specific stages and moments, as follows:

**Stage I**

1. **Mobilization of the Work Team**

   **Objectives:** to determine the bases for organizing the respective work and structuring a project management plan to guide execution and control of the project, in addition to facilitating communications between stakeholders.

   **Activities:** to hold expert meetings for the purpose of setting out the project management plan with an accompanying organization chart, schedule of activities, and qualification structure of local technicians for the pertinent territorial organization policy planning activities, as well as specifying additional contracts and/or agreements with related entities executed by the government and its policymaking bodies.

2. **Coordination**

   **Objectives:** to establish priorities with the local Chieftancy, which serves as the Kissaquina government authority’s political representative and has primary responsibility for forging ties with other government bodies, academic institutions, and NGOs to ensure the success of the work conducted.

   **Activities:** to develop a registry of sectoral entities and other representative bodies; to prepare a document with basic inputs for the project executor.

**Stage II**

1. **Strategic Prospecting**

   **Objectives:** to confirm the territorial delimitations of Kissaquina as a whole, the areas occupied by the farms, fishing village, and cemetery, identifying the relevant physical and territorial features and determining the scope of the program.

   **Activities:** to perform technical and scientific anthropological, socioeconomic, and environmental studies on the territorial organization of the related spaces; to collect official information on the communities within the respective Chieftancy; to prepare a physical and territorial registry
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(altimetry and planimetric surveys) of the current settlements and develop a document with the necessary cartographic bases; to execute a detailed population survey; to establish a work schedule; to hold meetings with sobas and residents.

2. Mobilization of Sectoral Bodies and Local Leaders

Objectives: to disseminate the work to technical staff of the relevant sectoral bodies and the village of Kissaquina.

Activities: to organize direct and indirect meetings between participating stakeholders and executing personnel; to monitor all work stages.

Stage III

1. Description of Human Occupation

Objectives: to describe the forms of human occupation and distribution of dwellings and to establish the parameters for selecting the new settlement area.

Activities: to prepare technical reports and thematic cartographic bases, detailing how the soil is appropriated by residents, the predominant types of dwellings, water supply characteristics, sanitation and sewage related issues, and others.

2. Prospective Analysis

Objectives: to identify and list the principal physical and spatial challenges found in Kissaquina and describe the territorial resources in the area, with a view to ensuring these features and elements transferred to the new settlement.

Activities: to systematize and classify the community’s principal challenges, developing future scenarios to guide implementation of the new rural settlement.

3. Selection of Resettlement Area

Objectives: to determine the areas where project affected populations will be resettled.

Activities: to select resettlement areas through consideration of the characteristics of the populations subject to resettlement and the impacts on the host community. Selection of resettlement areas should consider the pertinent environmental aspects, preventing impacts in relation to:

- Infrastructure development;
- Increased population density in host area;
- Pressures on natural resources and ecologically sensitive areas.

An environmental impact survey of the host community should be performed. The study should consider the capacity of the areas targeted for resettlement to support the populations affected by resettlement (host and resettled communities).
4. Development of a Project for the New Settlement Area

Objectives: to outline the project guidelines based on data collected in prior studies.

Activities: to determine the physical and spatial organization of the new sites established for Kissaquina fishing village and the two farms; to determine the territorial analysis procedures employed to select alternative sites; to prepare preliminary studies for each thematic project, incorporating the pertinent illustrations, tables, graphic materials, and other components; to align the respective proposals with the expectations of residents and government representatives.

5. Development of the Preliminary Project and Basic Project

Objectives: to adapt the set of proposals listed in the preliminary studies to the new project stages.

Activities: to develop the preliminary project and basic project, including the alternative water supply, sewage, runoff drainage, road system, public lighting and electric power, and waste disposal solutions adopted; to develop environmental education procedures with the residents of Kissaquina, with a view to ensuring adequate use of the new settlement’s proposed infrastructure.

6. Development of the Executive Project

Objectives: to develop the executive project, including detailed description of the alternatives adopted for water supply, sewage, runoff drainage, road systems, public lighting and electric power, and waste disposal, adapting these as necessary; to incorporate the respective specifications, graphic materials, and budgets in the projects.

Activities: to prepare the final report, namely the Community Resettlement Program, accompanied by the executive project and respective appendices.

During execution of the work, the identification of alternative engineering solutions is recommended to ensure preservation of the malombes located along the territorial boundaries of Kissaquina. In addition, a landscaping project should be included within the program’s scope as part of the natural landscape conservation project.

7. Monitoring and Evaluation

The Resettlement Plan should be evaluated based on fulfillment of the respective obligations and agreements, with a view to ascertaining the social and economic conditions of the resettled and host populations.

Qualitative and quantitative indicators will be established to assess these conditions at critical intervals, as determined according to the status of the project’s general execution. A date will be set for final evaluation upon completion of the plan, specifically defined as the moment when the projected standards of living are expected to have been achieved.

6.4.4. ARCHEOLOGY HERITAGE PROTECTION PROGRAM
6.4.4.1. JUSTIFICATION

The regions in which the access points from the road connecting the city of Dondo to the project site and the respective construction and work sites are located lie within an area inhabited by traditional communities for thousands of years.

The archeological sources reveal the presence of human beings in the Middle Kwanza River Basin in the Stone and Iron Ages, while other anthropological and historical evidence points to areas dating to the Kingdom of N’dongo in the 16th and 17th centuries. There is the possibility that remains of this human presence could be found in archeological sites subject to impact and/or destruction by the movement of heavy machinery, soil, and rocks, excavations, and construction of the coffer-dams and the principal dam, which could submerge as of yet undiscovered archeological sites of substantial value to Angolan history.

Based on these sources, there is the possibility archeological sites from different periods could be discovered containing polished stone and ceramic tools and artifacts from the Stone and Iron Ages, in addition to remaining evidence of human settlements, markets, fishing encampments, etc. from the N’dongo kingdom period, factors justifying the proposed archeological investigations and recovery efforts.

6.4.4.2. OBJECTIVES

General Objectives
To perform an archeological study in dam construction areas prior to the respective earth-moving, rock removal, and excavation phases. In the event archeological sites are discovered in the area, the studies will enable the preservation of archeological heritage sites before completion of the construction work and filling of the reservoir.

Specific Objectives

• To identify and analyze archeological and paleontological sites in the Directly Affected Area of the Project;

• To document and preserve archeological and paleontological material found in the area prior to authorizing the commencement of construction work in the target locations.

6.4.4.3. METHODOLOGICAL PROCEDURES

• Designated expert team designated to conduct studies;

• Perform cartographic analysis of the area and reconnaissance of the project site and areas subject to flooding using orthophotography, with a view to verifying implementation of the required encampments, construction sites, and other structures necessary for dam construction;
6.4.5. DEGRADED AREA RECOVERY PROGRAM

6.4.5.1. JUSTIFICATION

The implementation of construction sites, loan areas, excess material storage depots, access ways, and some marginal areas along the future reservoir will cause environmental degradation, causing harm to local vegetation, soil deterioration, erosion, and silting of waterways and reduced aquifer recharging.

As such, planning of recovery measures in degraded areas during project construction phases is essential, both during use of these in the construction period and recovery following exploitation of the respective areas.

6.4.5.2. OBJECTIVES

General Objective

To establish a program for the recovery of areas degraded by virtue of project activities, including temporary protection during the respective construction work and permanent recovery following implementation of the Laúca Hydroelectric Unit.

Specific Objectives

- To identify and map priority replanting areas using criteria in connection with the selection of existing vegetation coverage, soil use, susceptibility of local soils to erosion, and pertinent factors relating to the tunnel operation system;
To determine the recommended plant species and optimal planting techniques and methods;

To specify the criteria for the recovery of loan areas and others degraded by construction work, taking into account soil conditions, the characteristics of the terrain, and adaptation of the plant species introduced in the area.

**6.4.5.3. METHODOLOGICAL PROCEDURES**

Initially, surveys will be performed on the areas targeted for intervention, recording, to this end, information on the location and pertinent descriptions, the type of intervention executed, description of soil use, status of natural regeneration, and identification of erosion processes. The information is necessary to determine the scope of the required conservation measures.

The type of management system adopted in the area must be determined based on three recommended lines of action, specifically:

- **Recovery of vegetation:** this measure should be adopted in areas without the capacity for natural regeneration but which, by virtue of their location, are conducive to connecting autochthonous vegetation fragments. The recovery of vegetation may be aimed at the formation of ecological corridors to enable the movement of wildlife and gene flows between populations. Similarly, this effort may be aimed more simply at the natural landscape, an important factor for human settlement, consisting of revitalizing areas near local settlements and work sites;

- **Enrichment:** areas with the capacity for natural regeneration should be enriched through the introduction of native species to attract pollinators and seed dispersers, with a view to boosting the area’s biodiversity;

- **Natural Regeneration:** in areas with a solid capacity for natural recovery, presenting resprouters and seedling and seed banks in sufficient quantity to eliminate the respective degradation factors.

Following identification of the areas and determination of the management strategy, the study will then indicate the measures recommended for each stage of the construction project. **Error! The reference source was not identified.** Below, the key implementation measures recommended are summarized.

**Table 6.2:** Principal measures adopted for the Laúca Dam project.

<table>
<thead>
<tr>
<th>Measures</th>
<th>Characteristics</th>
<th>Measures Implemented</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biological</td>
<td>Use vegetation cover capacity to protect against erosion in initial phases</td>
<td>Planting of grasses and forage legumes. Planting of native bush and tree species in mixed cultures</td>
<td>Registers results following establishment of plant vegetation cover. Prevents degradation in a sustainable manner over the long term</td>
</tr>
</tbody>
</table>
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<table>
<thead>
<tr>
<th>Measures</th>
<th>Characteristics</th>
<th>Measures Implemented</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical</td>
<td>Use constructions (containment structures) to slow degradation</td>
<td>Construction of drainage and runoff channels, protective wall structure, and other measures</td>
<td>Immediately reverses degradation. Provides for emergency prevention of degradation</td>
</tr>
<tr>
<td>Physical-Biological</td>
<td>Use a combination of the two measures above, through which the physical measures are employed, preferably, with the adoption of biodegradable materials</td>
<td>Planting of grasses and forage legumes. Planting with cushion system</td>
<td>Immediately reverses problem, but does not prevent degradation. Intermediate solution</td>
</tr>
</tbody>
</table>

Source: Intertechne Consultores S.A.

The implementation stages for the program’s principal activities are described below.

- **Identification and Delimitation of Area:**

  This stage involves precise identification and scaling of areas subject to recovery. Based on this, the quantities of required native species seeds and seedlings will be determined and include grasses and forage legumes, where necessary.

- **Preparing the Terrain:**

  In this stage, the primary measures for preparing the terrain are specified, including:

  - **reshaping of terrain and/or manual smoothing of slopes**: prepare the terrain to lay groundwork for introduction of plant cover;

  - **implementation of “cushions”**: introduce vegetation tiles to reverse degradation process;

  - **implementation of channels**: channels will serve to divert drainage from runoff and containment structures;

  - **soil collection and analysis**: the analysis is the basis for the recommendations on corrective and fertilization measures (Lemos and Santos, 1984).

- **Species Selection:**

  For purposes of vegetation recovery, species selection should encompass, above all, the intensive use of pioneer plants, with a view to the rapid formation of a canopy and the premature ageing of leaves, with the accompanying formation of litter or debris, so as to provide immediate protection to the soil and foster the survival of species in different stages of succession. Plants in other stages of their life cycle should also be used in the proposed model.

  For enrichment of the remaining material and recomposition of the respective areas, essential native species recovered from project affected areas will be used, thereby ensuring the use of
autochthonous species to reconstitute the natural ecosystem and reestablish the region’s original phytophysiognomy.

Species selection should take into account adaptability and growth rates in humid and/or dry environments, the rate of propagation and production of important fruits and berries for local ichthyofauna and avifauna, so as to contribute to the successful planting and rapid establishment of plant species.

In this light, the current physical and chemical conditions of the soil in which the respective plant species will be planted must be considered; the largest possible number of species should be planted to stimulate diversity; combinations of fast growing species (pioneer plants) and slower growing plant species (secondary and climax plants) should be used; species capable of attracting wildlife should be employed; and species adapted to each specific soil condition should be planted.

- Implementation of vegetation:

  Implementation of vegetation cover in locations used to supply materials employed in the project or degraded by virtue of the project encompass the following:

  - **grass tiles**: in locations where immediate recovering of soil is required and in locations in which the terrain’s declivity limits the planting of species using seeds/seedlings;

  - **dispersal of grass and forage legume seeds**: planting of some species will be performed through the dispersal of seeds in 1-5 cm deep grooves arranged in contours and separated by a distance of approximately 1.5 m between grooves;

  - **native species seedlings**: this activity will be performed in locations marked by brush/arboreal vegetation suppression, in locations without restriction on the establishment of arboreal species. The distribution of species based on a vegetation succession model (Figure 6.2) is proposed. Recovery of vegetation in affected areas is accomplished by inducing vegetation succession through a combination of species of different ecological succession groups (Budowski 1965, 1970; Gomez-Pompa, 1971; Denslow, 1980; Carpanezzi et al., 1990; Ibama, 1990; Cetesb, 1992; Rodrigues et al., 1992; Kageyama et al., 1992, 1994; Crestana et al., 1993; Rodrigues e Gandolfi, 1993; Ferreti, 1995; Cordovil-Silva e Walter, 1997; Corrêa e Melo-Filho, 1998). Planting of species groups will be conducted simultaneously in the field using seedlings.
Figure 6.2: Proposed distribution of seedlings for planting of recovery vegetation in affected areas

Legend:

3, metros = 3.0 meters
1,5 metros = 1.5 meters

Legenda:

- Pioneiras = Pioneer Plants
- Secundárias = Secondary Plants
- Clímax = Climax Plants

- Maintenance and Monitoring:

Following implementation and establishment of seedlings, a number of measures will be required to ensure their full development, with a view to contributing to the project’s success. Similarly, the physical measures implemented to halt/reverse erosion processes should be tracked until the related problems are effectively resolved. The respective measures are set out below:

  o Monitoring and control of erosion processes (aimed at interventions and reviews of the proposed methodology);
  
  o Cropland measures (soil correction, maintenance fertilization, pest and disease controls);
  
  o Replanting of failed areas and densified planting.
6.5. SOCIO-ENVIRONMENTAL PROGRAMS

6.5.1. COMMUNITY SUPPORT PROGRAM IN THE DIRECT AREA OF INFLUENCE

6.5.1.1. JUSTIFICATION

As discussed above, the villages located on the road connecting the Capanda Hydroelectric Unit and the city of Dondo to the Laúca hydroelectric facility project sites will be subject to a number of adverse impacts arising from the increased flow of light and heavy vehicles, the arrival of migrants in search of work, and others. However, residents in these villages will also benefit from positive impacts, namely job opportunities and improved living conditions by virtue of the measures prescribed in the environmental programs laid out in this study and greater economic dynamism generated by the project.

The expected impacts on the local socioeconomic and demographic dynamics justifies the implementation of a support program for resident communities along the main road used during project execution, with a view to mitigating the projected adverse impacts and leveraging the opportunities for better living conditions arising from the project.

6.5.1.2. OBJECTIVES

General Objectives

The program is aimed at supporting, restructuring, and strengthening village communities through new measures to boost and build capacity in local farm and artisanal production activities and worker training to meet the region’s new demands.

Specific Objectives

- To provide guidance and support to the participation of social groups in the implementation of basic sanitation and sewage systems;
- To provide guidance to the introduction of new techniques and procedures to enhance and stimulate farm production on small plots;
- To support capacity building for workers with a view to ushering in new economic and social dynamics in villages;
- To stimulate diversified farm production for consumption in a sustainable manner;
- To stimulate sustainable fishing activities;
- To support the organization of local farmers, with a view to enabling surplus farm production and subsequent sale;
- To increase the production of domestic and artisanal goods for sale;
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- To present alternatives for improvements in nutrition;
- To stimulate and incorporate social groups in formal and environmental education programs;
- To train local workers in civil construction activities;
- To strengthen cultural, sport, and recreational/leisure expressions and activities;
- To introduce personal hygiene and care practices by stimulating cleaning of physical spaces.

6.5.1.3. METHODOLOGICAL PROCEDURES

Based on the findings on living conditions and production arising from the socioeconomic surveys, and supplemented by analyses prepared within the scope of the Environmental Education and Public Relations Program, the curricula for course and training programs offered to communities will be developed and the respective needs in connection with infrastructure, support materials, and inputs identified.

The measures and activities provided for in this program will be executed through a coordinated effort with the Environmental and Public Relations Programs.

6.6. MONITORING AND CONTROL PROGRAMS

6.6.1. CLIMATE MONITORING PROGRAM

6.6.1.1. JUSTIFICATION

A real assessment of climate change is only possible by comparing conditions prior to and following completion of the project. The primary recommendation involves the implementation of temperature and rainfall and meteorological stations prior to filling of the reservoir, given the small number of stations in the region.

Implementation prior to the project will supply a series of data on the phase prior to locking of the reservoir for subsequent comparison with data collected during the operational phase, with a view to identifying climate changes in the transition period. In addition to tracking potential changes to the micro-climate and the local climate, this measure will allow for studies on local climate effects on the reservoir.

In addition to micro-climate observations, meteorological stations are useful for modeling climate interactions in the ecosystem, such as recording wind action, an important factor for determining the thermal and erosion instability of a reservoir and consequent recycling of nutrients and vertical distribution of phytoplankton and zooplankton. In this light, implementation of automatic meteorological stations is recommended at the Laúca Dam.

6.6.1.2. OBJECTIVES

General Objective
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To monitor the potential impacts of changes in water balance and climate change.

Specific Objectives

- To assess potential climate changes arising from filling of the reservoir;
- To offer contributions to impact studies on the respective changes, as well as the development of climate and environment interaction models.

6.6.1.3. METHODOLOGICAL PROCEDURES

The program provides for the following activities:

- Contracting of expert personnel for program implementation;
- Description of program actions;
- Acquisition and installation of the meteorological and temperature and rainfall stations;
- Monitoring and interpretation of results.

Preferably, analysis of the data should be performed jointly with the National Institute of Hydrometeorology and Geophysics of Angola (INAMET).

Temperature and rainfall stations or micro-meteorology stations should be installed in areas near the reservoir at variable distances, preferably in the vicinity of the Laúca Hydroelectric Unit. Other sites will be chosen according to the local relief at distances of not more than 5 km from the reservoir, based on accessibility.

The automatic station installed at the Laúca Dam should include a data acquisition system, in addition to temperature, humidity, wind, atmospheric pressure, rainfall, solar radiations, and soil temperature sensors, and, if possible, temperature gauges for water in the area of the future reservoir.

6.6.2. SEISMOLOGICAL MONITORING PROGRAM

6.6.2.1. JUSTIFICATION

The project reservoir areas are located in a region with a history of seismic activity resulting from two deep regional fault lines. The studies on the Capanda Hydroelectric Unit indicated that the region is an area of natural seismic activity warranting attention. Records register a magnitude 6.54 earthquake and two smaller magnitude 4 to 6 tremblers in the area in 1914. In 1968 and 1976, two additional seismic events were recorded, a magnitude 4.4 and 4.8 trembler, respectively.

6.6.2.2. OBJECTIVES

General Objective
The objective of the seismological monitoring station is to monitor the potential impacts of induced seismic activity.

**Specific Objectives**
The objective of the seismological monitoring is to assess natural and induced seismic activity in the reservoir’s area of influence, beginning at least one year prior to closing off of the reservoir and extending for an additional two years or more during operation of the unit. The purpose is to allow for a comparative analysis of seismic activity prior to and following filling of the reservoir, with a view to assessing the existence of impacts by virtue of the reservoir’s implementation, in addition to providing guidance on the adoption of future procedures.

The program is also aimed at detecting the occurrence of induced seismic events, obtaining a correlation between seismic activities and the geological and tectonic features of the area and determining respective epicenters, intensity, magnitudes, seismic acceleration, and area of influence.

### 6.6.2.3. METHODOLOGICAL PROCEDURES

The program provides for the following activities:

- Contract expert staff personnel for implementation;
- Perform a detailed description of the monitoring program and specifications;
- Acquire and install a seismographic station; and
- Track the program and interpret results.

Seismic activity should be monitored continuously through seismographs. Fire excavations at the Laúca Dam construction site and other locations within the area of influence of the future reservoir should be monitored and recorded.

A seismograph station equipped with a recorder, seismometer, and data radio-transmission equipment should be installed in a selected location and housed in a protected facility. Operation of the station will require a technician to perform periodic maintenance on the equipment and collect data generated by the seismographs, in the case of equipment without radio-transmission systems.

Data analyses will be performed on a bimonthly basis. According to the results of the initial analyses, the need for installing addition seismographic stations will be determined for the purpose of locating the epicenters of seismic events.

### 6.6.3. HYDROGEOLOGICAL MONITORING PROGRAM

#### 6.6.3.1. JUSTIFICATION

Changes in groundwater levels due to formation of the reservoir are important and require more precise description of the projected impacts, and may correspond to increased productivity of
aquifers, the formation of humid and flooded areas, increased susceptibility, and destabilization and erosion of marginal hillsides.

The variety of impacts caused by a rise in groundwater levels has an ambiguous effect, at times positive, at times adverse. In both cases, the factors and parameters influencing changes in groundwater levels and confined aquifers vary considerably, as do the initial conditions. In this light, hydrogeological monitoring enables planning of preventive and mitigation measures, adverse impacts, and strategies for leveraging positive impacts.

6.6.3.2. OBJECTIVES

The objective of the program is to monitor, control, and mitigate the impacts arising from a rise in groundwater levels, retention of sediments, and formation of humid and flooded zones.

6.6.3.3. METHODOLOGICAL PROCEDURES

The program involves the following measures:

- Formation of team;
- Detailed description of monitoring program measures;
- Detailed study of existing aquifers in project areas of influence;
- Determination of monitoring points;
- Measurement of levels, collection of samples, and analysis of underground water;
- Field research and measurement facilities;
- Monitoring of results interpretation program.

For purposes measuring the depth of water levels, monitoring wells should be drilled at the locations indicated in the program description. The depths should be converted into absolute levels to obtain the potentiometric surface of the free aquifer and confined areas. Surveys executed for the implementation of piezometers will be performed for sample collection and geological, geotechnical, and hydrogeological description of crossed materials and, further, determination of parameters such as hydraulic conductivity.

The frequency of water level readings adheres to different patterns according to the project phase. During the construction phase, bimonthly readings must be performed at least. Two months prior to filling of the reservoir through two months following filling of the reservoir, readings should be executed every two weeks. In the operational phase, bimonthly readings should be resumed for a period of at least two years. After this, monitoring may be performed on a six-month basis.

In addition, sample collections and analysis of water drawn from the monitoring wells should be performed on a six-month basis in the construction and operational phases and monthly during the six-month period designated for filling of the reservoir.
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In locations with underground water designated for human consumption, sample collection and analyses should be conducted of the parameters established to determine water potability, as listed below: aspect, smell, color, turbidity of the water, dry residues, pH, alkalinity, presence of hydroxides, carbonates, and bicarbonates, total hardness, oxygen consumed, ammoniac nitrogen, albuminoids and nitrous, iron, chloride, fluoride, arsenic, copper, lead, zinc, barium, selenium, manganese, cadmium, chrome VI, cyanide, organic waste, and microbiological characteristics. Other parameters may be included in the program description.

6.6.4. LIMNOLOGY, WATER QUALITY, AND SEDIMENT MODELING AND MONITORING PROGRAM

6.6.4.1. JUSTIFICATION

Implementation of the project will cause a number of changes to the aquatic environment in the Kwanza River region due to the transition from a lotic regime to a lentic regime. These changes are expected to be similar to those occurring during implementation of the Capanda Hydroelectric Unit, given the similarities between the two reservoirs.

The environmental analysis performed in this study indicated that the waters are naturally low in nutrient content, clear, and pH neutral, for the most part. Samples collected immediately downstream from the Capanda Hydroelectric Unit reveal low nitrogen levels, a product of the reservoir’s trophic stability and the absence of farming activities and urban areas in the vicinity. Phosphate analyses suggest the presence of phosphorous on the reservoir bottom. In addition, 0.05 mg/L of sulfate was detected, indicating an anaerobic environment, in which phosphorous dissolves in the water column. Transferred downstream by turbines or, where applicable, discharges from the bottom, phosphorous has the potential to cause eutrophication, for which preventive measures should be adopted.

In addition, the area targeted for flooding includes sections of vegetation coverage. The selective and partial removal of existing phytomass should be performed in the area of the reservoir to prevent significant water quality issues, primarily during and immediately following filling of the reservoir.

In this light, water quality models should be executed to simulate the various vegetation removal scenarios. In addition, mathematical models will serve to forecast water quality during operation of the reservoir, identifying with greater precision potential problems and critical regions and contributing to determination of water quality monitoring locations. Mathematical models may also be used to project thermal stratification phenomena in the reservoir.

Following the pertinent modeling activities, a program should be established to monitor water quality, as provided by Odebrecht, prior to and following formation of the reservoir and for the purpose of contributing to the adoption of preventive, mitigation, and/or offset measures. Physical, chemical, and biotic data will be analyzed (phytoplankton and zooplankton). The samples collected will contribute to the studies performed during the environmental analysis, enhancing knowledge and understanding of the factors impacting on the dynamics of water quality, including the presence of fecal coliforms, chlorophyll, oxygen, ammonia, phosphorous sediments, temperature, water
turbidity, and others. The study of these parameters will contribute to managing water quality in the reservoir.

6.6.4.2. OBJECTIVES

General Objectives

The objective of the program is to describe through mathematical models and monitoring of the limnological behavior of the Kwanza River waters and those of its principal tributaries prior to damming, nutrient balances, trophic potential and thermal stratification, and anoxia of the planned reservoir, in addition to assessing the respective physical and chemical conditions and temporal variations, bacteriological conditions, and hydrobiology of the waterway, as well as the transportation of sediments. Further, the program includes studies upstream from the Capanda Hydroelectric Unit due to its direct impact on areas of the proposed project.

Specific Objectives

The specific objectives of the program are to monitor and mitigate the impacts arising from changes in local limnological characteristics and water quality, both upstream and downstream from the project, due to changes in the river’s lotic characteristics; increased water turbidity; flooding of land vegetation on the river’s margins, accelerating the deterioration of aquatic systems; stratification of the reservoir; changes in communities of aquatic organisms downstream from the dam, potential proliferation of aquatic macrophytes, and retention of sediments in the reservoir.

6.6.4.3. METHODOLOGICAL PROCEDURES

Based on the results obtained from the field surveys conducted for purposes of the environmental studies, in conjunction with previous experiences of this nature, the program was divided into four distinctive stages:

Stage 1: Mathematical Hydrodynamics and Water Quality Modeling During and Following Filling of Reservoir

Mathematical modeling tools are the most modern method for providing forecasts on future environments. The following modeling analyses are recommended for the reservoir:

- Water quality modeling during filling of the reservoir based on the various scenarios of vegetation removal, with a view to selecting those areas in which the related activities should be prioritized;
- Hydrodynamic modeling to study the thermal stratification of the reservoir and identify potential areas of greater stagnation susceptible to eutrophication processes and sediment deposits;
- Water quality modeling of the reservoir and downstream sections;
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- Stratification models will take into account all the relevant parameters of the phenomenon, including: incident solar radiation and wind speed, in addition to inherent parameters of the reservoir in connection with geometry, air and water temperatures, and flow velocity, etc.

- Water quality models may contribute to the re-selection of locations within the reservoir identified for monitoring.

**Stages 2 and 3: Monitoring Before and During Construction**

The recommended monitoring program should be initiated immediately following environmental licensing with bimonthly samples. Water samples should be collected in locations at least 1 meter in depth and with current flows. Backwater deposits without water flow or inverted water flow should be avoided. The points previously established in the EIA should be employed. Monitoring should follow the existing Odebrecht water monitoring plan.

**Stage 4 and 5: Monitoring During and Following Filling of the Reservoir**

This procedure refers to the stage in which the respective impacts occur due to changes in the aquatic environment. As such, more detailed monitoring is required, initially at smaller time intervals, with a view to creating a database for future analyses. Therefore, during filling of the reservoir and in subsequent months, samples should be taken on a monthly basis, followed by bimonthly samples the following year, and, finally, quarterly samples beginning the third year following filling of the reservoir.

Monitoring measures at the future reservoir, as well as maintenance of the collection points at the Capanda Dam, should be ongoing and permanent.

- **Sampling strategies**

  The same field survey protocol should be adopted for all the stages described in the program, specifically:

  - During collection, the pertinent environmental data should be entered in a log and the data supplied via a multi-parametric probe: water temperature, dissolved oxygen, and conductivity;

  - The pH and turbidity parameters should be submitted to a sensor calibration evaluation before beginning routine recording of the respective readings;

  - The water samples may be stored in previously washed and labeled water bottles, which should be completely submerged to avoid the interference of supernatants; and

  - Backwater deposit areas should be avoided and preference given to areas of running water, as these more accurately describe the fluvial environment. Following collection, all samples should be cooled and stored in coolers packed with ice through delivery to the laboratory, where they should be stored in refrigerators until processing of the analyses, which will be executed within a period of up to 24 hours.
For purposes of collection and biological analyses of phytoplankton and zooplankton, the procedures below should be adopted:

- In the case of quantitative phytoplankton samples, 200 mL of raw water should be collected using a 25 μm mesh net and set in 2 mL of formaldehyde;
- For quantitative zooplankton samples, 100 L of water should be filtered through a 68 μm mesh net, resulting in a 200 mL sample and set in 20 mL of formaldehyde;
- Qualitative samples should be filtered to enable more precise identification of organisms;
- Nets may be arranged against the river current and placed in position for approximately 3 minutes. Filtered matter should be set according to the procedure described for quantitative analysis samples; and
- Plankton samples may be stored in 300 mL water bottles. The volume limit, however, should be demarcated, with a view to ensuring the preservative dosage level is adequate.

6.6.5. ICHTHYOFAUNA INVENTORY AND MONITORING PROGRAM

6.6.5.1. JUSTIFICATION

Implementation of an artificial lake environment by damming of the Kwanza River will cause changes to the composition of ichthyofauna, as the system will be transformed from a lotic to a lentic regime in some areas, thus altering environmental conditions.

The original composition of fish fauna in the Kwanza River was modified by implementation of the Cambambe and Capanda plants, facilities located on the Kwanza River downstream and upstream, respectively, from the proposed Laúca Hydroelectric Unit. In this light, Cambambe and Capanda created irreversible artificial obstacles to the flow of migratory species on the Kwanza.

The original ichthyofauna of the Kwanza River is virtually unknown. The only available information is a descriptive and scientific summary of fish fauna in Angola (Poll, M., 1967, Contribution à la faune ichthyologique de l'Angola). However, the work is both outdated and principally addresses fish fauna in the Congo River Basin and Cubango/Zambeze complex, which flow north and southeast, respectively. Fish species on the Kwanza River and other coastal basins, which flow primarily west, were only studied partially by Max Poll.

The Middle Kwanza River Basin presents a fit geographic profile, which cuts through the valley without major tributaries along the middle and high sections and with a substantial number of lotic environments, among them rapids. This profile suggests some degree of endemism, which although not necessarily threatened by the implementation of an additional dam warrants scientific attention.

With a view to establishing protection measures for fish communities in the Kwanza River Basin from impacts caused by construction of the project, a series of actions should be adopted, beginning with an inventory of the Middle Kwanza River Basin through an extensive ichthyofauna collection and monitoring program.
6.6.5.2. OBJECTIVES

General Objective

The principal objective of the program is to describe the ichthyofauna, in particular those specimens occurring in direct areas of influence, including organisms present in the principal tributaries. This description should include a detailed comparison of the composition of ichthyofauna prior to and following implementation of the dam. The program also includes ichthyofauna monitoring studies during filling of the reservoir and operation of the project.

Specific Objectives

- To supplement existing data and prepare a comprehensive diagnostic analysis on the diversity of the ichthyofauna in the Middle Kwanza River Basin and describe the status of conservation in the current setting, that is, prior to implementation of the project;

- To identify reproductive (migratory periods) and feeding (diet) habits of ichthyofauna in the Middle Kwanza River Basin region;

- To understand fishing activities in the project area;

- To identify the potential impacts to ichthyofauna arising from implementation of the projects in the construction and operational phases alike;

- To rescue fish species trapped in pools during construction of the dam and filling of the lake;

- To recommend mitigation measures capable of minimizing potential impacts on ichthyofauna caused by the project, proposing, to this end, conservation, monitoring, and management programs for local ichthyofauna;

- To train specialized human resources in Angola for the purpose of giving continuity to the academic and scientific research arising from collection and monitoring programs, in addition to the long-term ichthyofauna programs.
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- Complementary existing data and develop a diagnosis, as complete as possible, on the diversity of the fish fauna of the Middle Rio Kwanza and elucidate their conservation status in the current scenario, i.e., prior to implementation of the project;
- Identify reproductive aspects (breeding seasons and species migratory) and food (diet) of fish populations of the middle river Kwanza;
- Understand the fishing activity in the project area;
- Identify potential fish populations derived from the implementation of the projects impacts, both in steps of works or the operator;
- Rescue the fish eventually retained in pools during the construction of the dam and filling of the lake,
- Suggest mitigation measures that may mitigate the potential impacts on fish populations arising from the development, proposing conservation programs, monitoring and management of local fish fauna;
- To train specialized human resources in Angola, both to give
  - continue the academic and scientific studies in the field of collection and monitoring programs, and for continuing to own programs relating to fish populations in the long term.

6.6.5.3. METHODOLOGICAL PROCEDURES

The ichthyofauna Inventory and Monitoring Program should be constituted in different work stages, encompassing the following activities:

- Implementation of the data collection data for representative data of the fish communities in the direct area of influence of the units, with a view to understanding the population dynamics of the respective communities and the biological cycles of species potentially most affected by the dam;

- Monitoring of the principal tributaries of the Kwanza River drainage basin;

- Assessment and implementation of the measures necessary to save fish species during dam operations and filling of the reservoir, conducting follow-ups of changes in fish communities due to potential environmental impacts;

- Monitoring of the population dynamics of fish communities in the first three years following filling of the reservoir, with a view to contributing to the implementation of an ichthyofauna management program.

The field work in the Middle Kwanza River Basin region should be conducted through four campaigns/year in stages prior to, during, and following formation of the reservoir and under differing flow conditions in the dry and rainy season alike, with a view to analyzing potential temporal variations. The field work will include the sample points subject to earlier study, as well as other points, where different micro-environments are identified in Middle Kwanza River Basin areas subject to the direct influence of the project, both upstream and downstream from the dam site.

All the typical micro-environments found in the region will be subject to sampling, to the extent possible, including streams, rapids, pools, leaves, sands, large river beds, etc., for the purpose of
identifying the preferred habitats of different species and collecting the largest possible number of species. Further, other points may be added, the pertinent river access ways to which will be opened prior to the campaigns. The precise location of the points may change during the field campaigns according to the respective assessments of the technical team.

The different types of environments should be photographed and, subsequently, recorded and correlated with the type of sample ichthyofauna. In addition, a brief description of the collection locations should be prepared, setting out the respective vegetation cover, submerged vegetation, river bed structure, and characteristics of the margin, etc.

Collection will be executed, for the most part, during daylight hours. However, on some occasions collection may be performed at night for the specific purpose of capturing ichthyofauna known to be primarily nocturnal, such as members of the Siluriform order (catfish and bottom fish) and the Mormyridae family (electric fish), two highly diversified groups well represented in the Middle Kwanza River Basin region.

The specimens collected will be immediately fixed in loco in 10% formaldehyde and transferred to 70% ethanol, if possible, following a minimum period of 48 hours. Small muscle tissue samples may be removed from specific individuals for future molecular analyses. These will be placed directly in alcohol, without being set in formaldehyde, into Eppendorf containers. Prior to fixing of the material, the sample may be sorted in the field, in order to facilitate identification with the assistance of natural coloring (for example, fish species of the Cichlidae family). Relatively small materials with intense coloring or markings will be photographed in an aquarium at the collection site while still alive.

More precise identification of species should be performed in laboratory based on the pertinent literature and comparative analyses of materials and matter held in scientific collections of institutions in other countries.

### 6.6.6. FLORA CONSERVATION PROGRAM

#### 6.6.6.1. JUSTIFICATION

The diversity of plant species in the region, determined by the initial studies to be extensive, associated to the fact that formation of the reservoir will submerge species that may be necessary for future use, constitutes the primary justification for adopting effective flora conservation measures. It is important to note that genotypes of the flooded species may not be found in remaining populations, whether around the lake or in another location within their distribution areas. As such, the impacting agent (suppression of vegetation) will cause genetic erosion. These factors can be partially minimized and, in certain cases, reversed, by recovery measures and subsequent conservation efforts *ex situ*.

In addition to establishing effective measures, the program will allow for the generation of critical data, both for scientific knowledge in Angola and the sustainable development of the Middle Kwanza River Basin region. Expanded knowledge of the most relevant species identified for conservation, their reproductive capacities, distribution, and restructuring aimed at protection of marginal areas are significant factors of the program as well.

#### 6.6.6.2. OBJECTIVES
The general objective of the program is to mitigate the impacts arising from suppression of the vegetation at the construction site and project site; suppression of native vegetation, with the consequent loss of genetic variability of plant species; and disruption of communities in marginal areas of the reservoir.

The program is aimed at minimizing the impact of project implementation on local vegetation and flora through the identification of plant species and recovery and conservation of the germplasm of those species identified as priorities. Safeguarding of these species can serve to guarantee the genetic integrity of species in the environment subject to disruption.

An additional specific objective of the program is to train specialized human resources in Angola for the purposes of ensuring the continuity of academic and scientific research work.

### 6.6.6.3. METHODOLOGICAL PROCEDURES

Based the results obtained during the field studies conducted for the environmental studies, the program was divided into four stages:

**Stage 1: Complement and Enrich Floristic Composition Surveys in the Area of Influence**

The floristic composition survey is aimed at complementing and consolidating the knowledge and identification of plant species in the region to prioritize, through development of as comprehensive a check list as possible, those designated for recovery.

This study serves as the basis for the full impacted plant conservation plan, to the extent that very little is known about the local vegetation. The preliminary studies indicate that the region is home to a rich plant endowment, both in terms of species diversity and phytophysiognomies. The results of this stage will guide the entire recovery process and the final destination of the collected germplasm.

The following criteria should be adopted for the floristic survey:

- Collection of fertile botanical material (flower and/or fruit), performed through random walks in representative areas of each phytophysiognomy identified (at least 12 types of principal vegetation), in the largest possible number of each, along all sections of the reservoir;

- Along each section (to be determined), collect all vascular species observed with reproductive material, the dry season (*cacimbo*) and rainy season at least;

- Collect specimens of arboreal shrub, and herbaceous species, including epiphytes, palms, vines, and aquatic macrophytes;

- Subdivide field teams during the expedition by type of stratum, each responsible for collection activities in the arboreal stratum, the shrub stratum, or the herbaceous stratum. The division may also be defined by phytophysiognomies (one in forest environments and another in savanna and wilds cape environments).
The material collected in the field should be placed in plastic bags or submitted to preliminary preservation, that is placed directly in sealed field presses. These should be inserted in sheets of newspaper specifically numbered for each botanical specimen collected. The preservation process continues in the laboratory, where the collected samples are transferred to field ovens. After drying the specimens (following one or two days in the field oven), these should be prepared for final delivery (herbarium).

Detailed data on each collected specimen, including preliminary identification (botanical family, scientific name, and/or common name, the type of material collected (exicatas, germplasm), growth patterns (tree, bush, grass), morphological aspects of floral or reproductive samples (colors, size, etc.), the general environment and location of collection, type of substrate, location, relative frequency in the population, and other relevant information, should be entered in a field log (Walter and Cavalcanti, 2005b).

Preserved and dried materials should be deposited in the Luanda Herbarium, where permanent identification may be accomplished through consultations in the specialized literature or comparative analyses with specimens deposited in the facility. Duplicates of these specimens may be sent to experts in the different taxonomy groups (principally in Brazil), a step that should ensure accurate determination.

If possible, efforts should be made to perform phytosociological studies as a supplement to the floristic survey, with a view to generating quantitative data on the respective species. This information is highly useful for developing the priority species recovery list. In these cases, the surveys should compare the same phytophysiognomy within and outside the reservoir area, for the purposes of comparing data on the concentration, presence/absence of given populations of species in the reservoir area. For the different formations (forest, savanna, and field), differentiated survey methods are used, most for plant species in the arboreal stratum.

**Stage 2: Recovery of the Germplasm of Priority Species**

Recovery of germplasm, or the recovery of plants, means intensive and selective collection along the entire stretch of the future reservoir of plant matter identified as a priority of conservation efforts. The collection process focuses on seeds, seedlings, stems, tubers, fruits, etc. of the largest possible number of individuals in each population based on a previously determined strategy to ensure careful and proper preservation of the material obtained.

By virtue of the high expected number of plant species in the region, it is not possible or feasible to recover germplasm from all taxons in the area, principally due to difficulties in connection with the conservation of these. The related problems include the absence of techniques and scientific knowledge on the species in question, including their potential uses, in addition to the unavailability of adequate areas or locations for effect conservation *ex situ* of the recovered plant matter.

In contrast to the recovery of wildlife, which occurs basically from the time filling of the reservoir (lakes) begins, the recovery of plant species must commence far in advance.

A plant recovery program centers all the flora in a given area (in this case, the reservoir implementation area) and not simply on vegetation capable of serving as a potential source of timber and firewood. Rather, the flora of an impacted area is a potential source of useful genes,
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which would otherwise be lost in the absence of identification and collection efforts. While the recovery of plants may not provide any economic or financial return, at least in the short and medium terms, it unquestionably offers an ecological return, and one capable of generating economic or financial returns (through farming improvement programs, for example) in the long term.

In conjunction with this background overview, a number of practical questions warrant consideration as well:

- Which species should be recovered?
- How can the target species be adequately conserved?
- Where should it (they) be conserved?
- Are there established methods for adopting adequate conservation ex situ of the selected species?
- What is the status of the species in terms of conservation priority?
- What are the criteria for executing the recovery of a species to the detriment of another?
- What is the installed capacity for minimizing the loss of genes?

Taking into account these issues and given that species are not all equally important for humanity (see Bond, 1994; Lawton and Brown, 1994; Maxted et al., 1997), it is necessary to prioritize those that offer value to agriculture or forestry activities, defined as “genetic resources” (i.e. “genetic material with true value or potential”), provided these species can be properly preserved ex situ.

Germplasm recovery measures should be implemented in an integrated manner with the Angolan National Center for Phytogenetic Resources (Centro Nacional de Recursos Fitogenéticos de Angola – CNRF). The institute’s purpose is the conservation of genetic plant resources with potential use as nutritional, agricultural, industrial, health, and construction purposes or as ornamental plants. The entity initiated its activities in 1991 and currently operates a genetic bank with more than 3,000 germplasm samples of local plant varieties collected from almost every province in Angola.

Figure 6.3 sets out a flow chart of the measures and ends for recovered germplasm, as provided for in the pertinent flora recovery and conservation actions.
Parameters for entering species on the priority recovery list

As discussed above, it is important to prioritize species that should be targeted for recovery within the larger list of plants set out in the floristic survey.

To this end, parameters should be established to serve as species selection criteria.

The parameters on which plant recovery will be based are laid out below, including, subsequently, the priority levels in which each species (or taxon) should be classified. At the end of each parameter, some brief comments are offered.

- Species of economic and/or research value: this group includes forest, medicinal, fruit, ornamental, forage, and other species, as well as all those belonging to groups which are of interest to human beings. They encompass plants classified as “phytogenetic resources” (i.e. plants with current or potential socioeconomic value, which are or could be used as food or in agro-forestry activities;

- Species with an organized system of Germplasm Banks, that is, guaranteed conservation: these should be operated through a system headed by Angola’s CNRF. They include, preferentially, species with seeds presenting orthodox behavior and those with recalcitrant behavior preserved at the CNRF;

- Species with populations concentrated in the reservoir area: based on the floristic surveys, species of interest to local populations concentrated in the flooded area will be observed and recorded, for the purpose of prioritizing these in relation to others distributed outside the reservoir area or distributed in both areas (within and outside the reservoir area);

- River plant species (forests, savannas, etc.): these correspond to the phytophysiognomies most affected by the hydroelectric reservoir. Species recovered in these communities may be utilized for repopulating degraded areas and specific sections along the margins;
Species for the recovery of degraded areas: botanical matter should be recovered for this purpose and sent to the seedling greenhouse implemented in the region. The procedure includes the collection of grasses and forage legumes used as part of the respective conservation measures;

Endemic and/or endangered species: in the event endemic species are identified in reservoir area, these should be prioritized to ensure perpetuation of the species. The same applies to endangered species threatened by predatory exploitation (timber extraction for firewood, etc.) or imminent extinction; and

Species with more than one aptitude: innumerable species may be classified in more than one group of interest, with the potential for use as forest and medicinal, fruit, and ornamental plants, etc. These species will receive special attention within the framework of the pertinent recovery measures.

In addition to the parameters above, the species targeted for recovery are classified by priority level, a procedure aimed at contributing to the measures and decisions adopted in the field. When two or more species on the priority recovery list are located and there is not sufficient time to execute widespread collection, the recovery efforts taken in relation to one species or another will be based on the following priority levels:

- Level 1: Species classified in this level must meet one or more of two of the three first parameters;
- Level 2: The species must meet at least two parameters; and
- Level 3: The species fall under only one parameter.

After determining the species identified for recovery and establishing the selection sites to be explored (where collection is to be performed), the collection sampling strategies should be specified (the quantity to be collected). The key challenge here is to determine the strategies professionals responsible for collection activities should adopt to obtain the largest quantity possible of genetic variation with the smallest number of samples (Walter and Cavalcanti, 2005a).

As there will be very little or no information on the genetic populations of the species identified for recovery, the following guideline criteria should be adopted:

- Collect individuals randomly at each site with separate samples from the various micro-environments (phytophysiognomical changes, different soils, etc.), provide the site is heterogeneous;
- Sufficient seed or vegetation samples for planting, with a view to representing each original plant through potential duplicates;
- Conserve genetic variability of cross-pollinated species, perform extensive and casual seed collection in each population, with small samples of each plant, yet an equal number, or approximately equal number, per plant, of the largest number of populations possible;
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- Conserve the genetic variability of autogamous species, perform extensive and casual collection of each population, with large samples of each plant, of the largest number of populations possible; and

- Accelerate conservation/improvement programs; perform abundant material from plants considered elite specimens, with a view, to the extent possible, to representing these in the sample through collection of vegetation matter.

Given the difficulties of putting the criteria above into practice, Walter and Cavalcanti (2005a) suggest that it is more important to perform samples on the largest number of locations (sites/populations) possible than to sample the theoretically ideal number of plants per location, with the largest samples possible.

Seeds and other propagules (stems, seedlings, etc.) should be collected prior to filling of the reservoir and referred to conservation programs *ex situ*, including re-composition efforts in marginal areas of the future reservoir.

To ensure recovery truly meets the prescribed protection objectives, Angola’s CNRF should be directly involved, undertaking to ensure conservation of the collected matters.

For species that reproduce through seeds, the major part of the priority list prepared on the basis of the floristic analysis, during execution of the corresponding services, species should be immediately collected if the plant is in the fruit maturation stage. Fruiting periods are variable from one species to another and, within the same species, between populations and in different years, a factor that should be considered in the respective strategies as well.

During execution of field activities, a form should be completed with individual data on each access collected form (passport information), where access is understood as a sample population or live matter sample representative of an individual or various individuals of a population. More generally, according to Valois et al. (1996), it is any individual record of a germplasm collection (e.g. seedling, manioc, etc.). In other words, the idea centers on collecting an additional access per species. Preferably, the larger the number of accesses, the more effective the recovery efforts. Collected seeds, therefore, should be forwarded to the receiving unit, specifically the seedling greenhouse located at the project site or to CNRF, ensuring these are duly identified.

For purposes of handling of the material following the respective post-harvest measures, seeds should be placed in appropriate packaging, duly labeled and delivered to their final destination.

Species that reproduce through underground structures or cuttings should be recovered and immediately replanted in pre-established areas (outside the reservoir area or in the seedling greenhouse), with a view to ensuring successful replanting. Recovered species should not be transported to other locations where transplanting may occur in conditions other than those in the original location. The recovery of cuttings should be performed for woody species with the ability to take hold. In addition, the biological characteristics of individuals/populations at the time of recovery, such as phenological state and age, are factors which may interfere in the ability of the respective propagules to take hold.
Stage 3: Implementation of Seedling Greenhouse

A seedling greenhouse is the convergence point for a variety of measures encompassing the Flora Conservation Program, in particular for landscape reconstitution projects. The production of a large quantity of high quality and robust seedlings will be necessary through use of the best technical standards possible, as ensured through a careful seed collection, processing, conservation, and reproduction strategy.

In this stage, seedlings may be produce initially in the Capanda Hydroelectric Unit greenhouse, which has capacity for meeting a minimum demand. However, depending on the recovery program’s progress and results, expansion of the greenhouse should be planned to ensure it is equipped to meet the larger volume of collected germplasm provided for under the program.

6.6.7. TERRESTRIAL FAUNA CONSERVATION PROGRAM

6.6.7.1. JUSTIFICATION

Human activity in natural environments, including the construction and operation of hydroelectric unit results, inevitably, in disruptions in the physical continuity of green areas. This fragmentation can reduce biodiversity at the local and regional level, to the extent habitats are eliminated and the genic flow of populations disrupted and increase the deleterious effects of competition and other types of adverse interactions within environmental fragments.

In addition, the construction of hydroelectric units is invariably criticized in regard to the effectiveness of fauna rescue operations, especially due to the fact that the respective activities are costly and do not offset the cost of losses arising from the filling of reservoirs. Moreover, those saved from flooding arrive to release sites with significant stress levels and are often unable to survive in the face of predators, competitors, and parasites in their new habitats.

Despite questionable results, it is possible to establish an appropriate rescue methodology, apply that methodology, and track the results in detail. In this light, it is important to maintain a basic team composed of researchers during all program stages. In addition to ensuring optimization of the works and use of the corresponding data in scientific publications, this fosters greater participation by educational/research institutions in the long term.

To adopt an intervention strategy in the communities, including the rescue and release of wildlife, it is important to bear in mind that there is no single ideal methodology to resolve problems stemming from the filling of reservoirs. It is first necessary to have primary data in hand and test the respective methodologies, verifying their consequences on a small scale, prior to selecting the intervention strategy.

Precise knowledge of regional fauna is the starting gate for execution of any conservation project. This knowledge is essential to ascertain the structure and dynamics of populations and to estimate the potential risks of the filling reservoirs on fauna. These studies represent the basis for enabling rescue operations or any other type of management activity.

Therefore, execution of a fauna conservation program, if well structured, will not only mitigate the impact on populations, but can contribute to enhancing the knowledge of Angolan fauna.
6.6.7.2. OBJECTIVES

The objective of the program is to mitigate the impacts arising from a reduction in diversity and the size of habitats, affecting the stability of ecosystems; the displacement of terrestrial fauna to adjacent areas; the increase in accident risks involving poisonous animals; and changes in hunting activities.

The program was divided into three distinct stages for purposes of meeting the specific general objectives below. In the fauna inventory compensation stage:

- To undertake an intense sampling effort, with a view to supplementing the inventory so as to contribute to rescue and monitoring activities.

In the fauna rescue operation stage:

- To execute an operation based on the scientific use of collected matter, contributing data capable of bolstering the knowledge of local fauna;

- To manage additional data for basic research in regard to the systematic, biogeography, and ecology of communities through the assembly of specialized collections associated to museums, including collections of frozen tissues, chromosome slides, stomach content of specific groups, and visual databases;

- To manage quantitative fauna data on lost habitats that could be used for the adoption of relevant decisions on areas affected by the filling of reservoirs and applied to other regions;

- To assemble zoo collections with all identified entities, with high resolution of ecological location data for all selected groups.

In the fauna monitoring stage:

- To perform field surveys to monitor species or groups of biological indicators studied in the previous phase of the diagnostic analysis, in particular herpetofauna, avifauna, and mastofauna;

- To conduct field surveys to monitor densely populated wildlife areas, subject to natural displacement and/or targeted for induced displacement through release;

- To incentivize and stimulate studies to monitor biodiversity based on two key focal points: potential areas of dense fauna concentration and relevant questions involving more detailed analysis of one of the respective study indicators, specifically herpetofauna, avifauna, and mastofauna; and

- To assign priority to endangered species and those of special interest for purposes of rescue, marking, and release, as set out in the diagnostic analysis, with a view to continuous monitoring;
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- To train specialized human resources in Angola, in order to ensure continuation of the academic and scientific studies undertaken in connection with the collection and monitoring programs.

6.6.7.3. METHODOLOGICAL PROCEDURES

The program was divided into three separate stages based on the field surveys conducted for the environmental studies and similar previous experiences:

Stage 1: Supplementing Wildlife Inventory

This activity will involve intense sampling efforts, with a view to supplementing the inventory and contributing to rescue and monitoring of wildlife populations using qualitative and quantitative data. The studies will be performed through specifically positioned sampling sites, in an effort to cover the various plant formations in the region.

The survey will employ capture techniques (based on the specific methodology indicated for each species), in addition to common methods for the detection of species in the field, and wildlife observation techniques based on the use of binoculars, identification of vocalizations, and other indirect evidence (feces and prints/tracks). For all specimens collected removed from the transect/collection areas, basic data on habitat use, biometry, location, and feeding habits will be recorded (for the purpose of facilitating comparative studies) and maintained as museum specimens. The collection will serve to constitute a new primary data bank for the entire inventory study (and, by extension, of the corresponding wildlife rescue activities). For purposes of this stage, collection of specimens of the following taxonomical groups will be executed:

**Arthropods**

Special attention will be given to the following groups:

- **Diptera** (flies and mosquitoes): the creation of artificial reservoirs provides ideal environments for the proliferation of insects, including potential disease transmitters, among them malaria and sleeping sickness. In addition, workers hired or who may be hired for the project may be disease carriers. As such, identifying the presence of vectors in the region, composition studies, and measures to combat these diseases is critical;

- **Hymenoptera** (ants): a dominant social insect group in the region. Its widespread distribution, relatively high abundance at the local level, the richness of species, and the relative ease with which specimens can be baited or trapped render the group a good ecological indicator for biological diversity studies in areas on which there is little information; and

- **Arachnid**: special attention will be given to the Araneae and Scorpionid Order (animals with potential medical value).

Capture of Arthropods in general will be accomplished using illuminated “Malaise” and “Moerike” pitfall traps, with containers and hunting bags, in addition to searches in rocky areas and random collections. Captured animals will be preserved in 70% alcohol solution.
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In the case of glossina, traps will be distributed at 200 m intervals in areas of heavy vegetation, military outposts, and locations inhabited by civilian population, hung on bushes and trees at a height of 50 cm above ground level. Capture of glossina will be preserved through desiccation in 70% alcohol solution and sent to the Institute for the Prevention and Control of Typanosomiasis (Instituto de Combate e Controlo das Tripanossomiasis).

**Aquatic Macroinvertebrates**

The community at the water-sediment interface is constituted by a vast range of taxonomical groups. This community most accurately reflects environmental conditions due to its limited capacity for movement and the fact that individuals live in direct contact with the substrate. In addition, the community exercises an important role in the food chain, contributing to the processing of allochthonous and autochthonous organic carbon, influencing, in this way, the food supply for fish and bird species.

For purposes of the inventory, collections will be performed in the Kwanza River and its principal tributaries, with the assistance of a vessel and an Eckman bottom sampler or nets and traps.

**Herptofauna**

Little is known about amphibians and reptiles. The gaps in existing knowledge on the diversity and distribution of species can be explained by their nocturnal and fossorial habits, rendering collection difficult. Adequate samples of herptofauna is only possible through intensive collection in different habitats and in different periods of the year and the use of specific collection methods. The herptofauna inventory will be based on pitfall trapping and drift fence methods (50 collection stations, each with four buckets arranged in a Y shape) and active searches in the soil, under leaves, and in and under fallen tree trunks.

**Avifauna**

The diversity of phytophysiognomies in the region is the result of a rich species of avifauna. Samples will be performed with mist nets, identification through direct observation, vocalization, and photographs.

**Mammals**

The justification for performing an inventory of this group rests on the same grounds as those invoked for recording the region’s herptofauna and avifauna, namely that large species collections in series associated to ecological data, tissue, ectoparasites and endo-parasites, etc. will provide for significant advances in the existing knowledge and understanding of Angola’s biodiversity. The use of different methods for mammalian fauna derives from the wide morphological, behavioral, and ecological diversity of species in this group:

- Small non-flying mammals: capture will be accomplished using two distinct methods: pitfall traps and live traps;


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- Flying mammals: bat fauna will also be evaluated using direct methods. Specifically, mist nets and traps will be used along potential corridors of bat movement (trails located in the forest and along rivers); and

- Medium and large mammals: the inventory for this group will not require trapping. These animals will be recorded primarily through indirect methods, including: census surveys based on prints/tracks, feces, shelters, and marks, in addition to interviews with local inhabitants. Direct methods will be employed, such as census surveys and stakeouts, in addition to photography traps in pre-established locations where indirect evidence of wildlife is found.

Stage 2: Fauna Rescue Operation

- Databank

With a view to optimizing use of biological matter and rescue data, development of the following databanks will be incentivized:

  o Visual: photographic documentation of rescue activities;

  o Tissue: tissue (blood, heart, liver, stomach, intestines, kidneys, and skeletal muscle) will be extracted from various specimens of each species for the purpose of ensuring material for cytogenetic, genetic, biochemistry, and immunogenetic, and other research projects conducted by universities; and

  o General databanks: on all aspects of collection, identification, management, and referral activities in connection with collected specimens.

- Principles of rescue activities

  o Coordination by a trained team to direct and optimize the related work;

  o Collection of wildlife restricted to reservoir area during filling;

  o Sorting, taxonomical identification, sex determination, recording, biometry, and appropriate referral of rescued wildlife;

  o Tagging, release, and monitoring during rescue of endangered species or species deemed of particular value to predetermined fields;

  o Collection of biological material for reviewed and approved research projects and/or tissue, parasite, venom, etc. databanks; and

  o Packing and delivery to requesting institutions qualified and eligible for the receipt and curatorship of biological material.
Rescue should be qualitatively and quantitatively selective, with a view to conserving rare and endangered species (subject to capture), preserving of genetic variability, and ensuring use of fauna for scientific ends.

**Implementation Stages**

- **Pre-Rescue**

  This refers to the period prior to filling of the reservoir. General activities include monitoring and follow-up by deforestation teams and organization and formation of collection teams responsible for rescue efforts. In this phase, collection methods will follow the inventory, with a view to assisting the assembly of the infrastructure required for rescue procedures and ensuring proper functioning before filling of the reservoir.

- **Rescue**

  Rational rescue is based on examples from previous projects, with a view to avoiding errors and improving upon positive aspects. Special precautions should be taken with social groups (primates) and when holding and caging animals subject to significant stress (rodents and deer). The regional fauna indicates a large number of medium- and small-sized mammals. These groups should receive differentiated treatment to prevent unnecessary losses. A total of 6 vessels will be used, divided into 4 teams (two vessels will serve as emergency support, meal transport, and ferry units). Crews will be made up of 1 biologist, 1 pilot, and 2 rescuers.

- **Downstream Monitoring**

  During the fauna rescue period, monitoring of downstream conditions on the Kwanza River will be performed along sections with reduced flow, with a view to locating and rescuing animals that have been weakened or are confined to locations in which their survival is jeopardized. Fauna groups directly affected by adverse impacts on this section of the river, in addition to ichthyofauna, should be given proper attention: benthic invertebrates, amphibians, reptiles (in particular turtles and crocodiles), and aquatic and semi-aquatic mammals.

  For downstream monitoring of fauna, the following coverage areas are included:

  - Fluvial (along sections in which conditions enable access or navigation);
  - Terrestrial, in 4x4 vehicles or on foot.

  Monitoring actions will be conducted every 2 days and may be adjusted according to downstream conditions and to enhance estimates regarding the presence of threatened wildlife. A team composed of one biologist and three assistants will be deployed for this activity.

- **Rescue Support Camp**

  For purposes of fauna rescue operations, a well equipped support camp is a key component to ensure the success of the related activities and the delivery of biological material to its final destination (release and referral for scientific research).
Internal areas (internal quarantine): these will accommodate reptiles, amphibians, arthropods, birds, small mammals, and newborn wildlife in general. Wood and steel shelves will be installed for purposes of storing wildlife holding containers. Industrial containers of three sizes are used (small for vivarium animals such as mice, medium for rat-size specimens, and large for wildlife such as guinea pigs or rabbits). Some cages will include lighting to provide heat to poikilothermic animals and young individuals.

The strategy of the support camp is to retain wildlife the minimum time necessary, ensuring transfer to the final destination as quickly as possible.

- **Sorting and Management of Wildlife**

Following rescue, the cages containing wildlife will be taken to the quarantine sorting room. Each rescued animal will receive a numbered tag on which the scientific name, common name, date of entry, and origin of the species is entered. In addition, the dated should be recorded in the sequential log. The identification tag will accompany the animal to its final destination: release, delivery to an institution, or taxidermy. The procedure will avoid the duplication of registries as each previously numbered tag will correspond to a single animal. Following the sort process, wildlife will be submitted to different treatment based on their taxonomical group. Reptiles, amphibians, arthropods, and birds will be placed in quarantine until delivery to the interested institutions. Birds not included on request lists will be tagged and released.

In the case of mammals, the following procedure will be employed: wildlife will be anesthetized with Ketalar (ketamine hydrochloride) or Ketalar + Rompum (ketamine hydrochloride + xylazine) and taken to the processing room for weighing, temperature verification, and biometric measurements: length of head-body, length of tail, length of front and rear extremities, length of internal and external portions of ears. Following measurement, animals will be marked for individual identification to ensure monitoring following release. In some cases, in addition to biometrics wildlife will be submitted to detailed examinations for research purposes, according to demand and the protocols established on the basis of the specific interests of research institutions accredited to participate in the related investigations. Following processing, mammals will be referred for release or placed in quarantine through delivery to the respective institutions.

Mammals will undergo physical examinations and maintained in quarantine for a period of 1 to 7 days, in a majority of cases, or weeks, in the case of young individuals or wildlife with small abrasions and cuts. Wildlife presenting difficulties in accepting food will be held in quarantine for a longer period. In the case of reptiles, amphibians, and arthropods, the average stay in quarantine will be two weeks.

- **Release**

For wildlife groups selected for release, the following marking systems will be used:

- Hair dye: mammals may be marked on the back with hair dye that contrasts with their natural color;
- Numbered rings or ringlets; and
Radio-telemetry receivers and transmitters, with transmitters of various sizes and specifications provided to accommodate different species of wildlife.

**Feeding Wildlife**

In general feeding of wildlife held in quarantine follows the specific recommendations for animals maintained in confinement, specifically:

- **Primates:** fruits, such as, bananas, pineapples, oranges, mangos, and guava. In some cases, dog food, milk, honey, infant formula, and bananas may included. This mixture is well accepted by both adults and young individuals;

- **Small mammals:** pineapple, carrots, beets, and dog food. In the case of wild rodents, species should be fed pelletized rat food;

- **Carnivores:** raw meat. In the case of canids, diets should be supplemented with fruit and other items;

- **Artiodactyla:** species should be held in quarantine for only brief periods due to susceptibility to high "stress" levels, principally deer. As such, these animals should be referred for release or another purpose as quickly as possible;

- **Birds:** rarely rescued during filling of reservoirs. In the case of sporadic capture, specimens will be addressed on a case-by-case basis.

**Management of Offspring and Young Individuals**

Offspring or young individuals rejected by their mothers or rescued alone will be placed in cages equipped with heat lamps to ensure an average temperature of 36-38° C. Offspring or young individuals should be fed diluted condensed milk, soy milk, infant formula, and/or mashed banana in intervals of 4 to 6 hours. Various institutions will be contacted for purposes of receiving young wildlife, as these individuals cannot be released.

**Veterinary Care**

In general, the incidence of animals requiring special care in quarantine is relatively low. The principal occurrences include abrasions/cuts and some fractures arising from rescue procedures or struggles or confrontations with other wildlife. Small sutures and bandages will be used to treat wounds caused during rescue operations. In these cases, animals will be maintained for care and observation, followed by release or transfer to interested institutions.

**Taxidermy**

Wildlife found dead or those in good condition that die during rescue or quarantine will be entered and forwarded for taxidermy. In the case of animals transferred to scientific collections, the skin (filling or stretching), cranium, and, in some cases, skeleton will be prepared.
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- Health issues during care and handling

Handling of wild animals should include attention to the potential dissemination of diseases and parasites. Wild animals are potentially dangerous to personnel engaged in their handling and care due to the risk of bites or scratches capable of transmitting viruses or infections. The attendant risks should be carefully considered. In addition to avoiding bites or scratches, professionals tasked with handling animals should protect themselves from fluids such as saliva, urine, and feces and, in particular, direct contact with blood. Parasites and pathogens may be present in these transmission channels.

A recognized protocol of good practices and techniques adopted by distinguished institutions should be employed to ensure safe and competent performance of routine tasks.

- Transfer of biological material

Learning/research institutions will be contacted for purposes of receiving biological material deriving from the respective activities. Each institution will be asked to complete a form listing the degree of interest, the quantity of material sought, special observations, and the end uses of the corresponding material.

Each request will be signed by a responsible lead professional with whom all subsequent contacts will be made. Requests will be evaluated and met to the extent possible, depending on the quantities of biological specimens rescued and the pre-established criteria for transfer of biological materials.

Each institution will be asked to provide the respective manner of participation, whether through receipt of materials and/or direct participation in rescue activities.

Stage 3: Fauna Monitoring

The fauna monitoring project will run for a period of 30 months. This will provide sufficient time for monitoring dense populations, test hypotheses regarding the likelihood of populations returning to normal levels, and, further, contributing technical and scientific means for the conservation of habitats and fauna in areas surrounding the reservoir.

Monitoring activities will begin six months prior to filling of the reservoir (designation of release and biological indicator areas) and intensified during rescue activities. As such, every rescued animal released into the wild will be tagged and monitored within the project scope.

To this end, the respective activities are subdivided into three stages:

- pre-filling phase: 3 campaigns will be conducted over a period of 15 days to identify critical points in habitats similar to those targeted for flooding, where natural wildlife populations will concentrate due to displacement caused by filling of the reservoir or wild animal releases;

- filling phase: monthly campaigns running 10 days for the purposes of tracking the effects of filling of the reservoir on animal populations and release activities in connection with rescued individuals; and
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- Biological Indicator Concept

The use of biological indicator species to assess and monitor biological processes in ecosystems is a practice that dates to the early part of this century. The concept has been widely developed in the intervening years as a pollution control measure in rivers and lakes. The indicator species concept is based on the use of species present in the community and subject to man-made impacts currently or in the past. The value of indicator species may be due to their intolerance to degraded conditions, rendering them the first to disappear following a man-made impact, or to their tolerance for the modified conditions generated by the respective impact.

Knowledge of the nature of the interaction between the presence and/or abundance of a given species in relation to the type of impact generated may serve as an indicator. Impacts caused by human action trigger changes in the nature of the relationship between species in a community. Based on this, groups or sets of indicator species can be expected to define the status of the system in respect of the current impact. In this light, it is extremely important to understand the effects of impact factors at the species, population, and community level previously. As such, the following criteria will be used for objective selection of biological indicator species:

- Biological indicators should be stenotypes or sensitive, with limited variability response to the impact factor or factors, such that a change in abundance relative to the species serves as an indicator of the habitat’s condition;
- Biological indicators must be year round residents of the habitat;
- Biological indicators should be easy to monitor;
- Biological indicators should present short generation times, thereby ensuring the population varies quickly when exposed to environmental factors; and
- Biological indicators must be abundant to ensure variability in population size is of a sufficient magnitude to respond to the respective environmental impacts.

The first criteria relates to the concept of key species and guilds, referring to species whose presence a series of other species depends on directly or indirectly. The key species may not be the most abundant, but its effect is greater than expected based on its abundance.

The concept of guilds is similar to the idea of biological indicators, with the exception that the respective indicators are transformed into indicator guilds. Indicator guilds respond in similar fashion to impact factors. For purposes of monitoring and assessing man-made impacts, biological indicators, key species, and indicator guilds should be employed separately.

- Proposed Measures

1. Monitoring of Herpetofauna (Community Structure)
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The purpose of this study is to examine the hypothesis that local anuran and lizard communities will be subject to modifications in their composition and structure by virtue of filling of the reservoir, due specifically to the loss of forest habitats and little or no representation outside the reservoir areas.

Modifications in species structure are also expected due to population concentrations (both in open and forest areas around the reservoir), selective effects on reproduction, and greater or lesser capacity of species to colonize and adapt to the new environmental setting created by filling of the reservoir.

Monitoring of herpetofauna will contribute to the collection of information on the effects of reservoir formations on the composition, abundance, and structure of local communities. Field research will further allow for a more substantiated assessment of the routine methods and activities adopted for purposes of monitoring the corresponding organisms, as well as recommended adjustments.

• Objectives:

  o To determine the composition of anuran and lizard communities in areas around the reservoir, comparing these with the data obtained during the diagnostic analysis phase;

  o To determine the relative abundance of the species detected in surrounding areas, comparing the results with the data obtained during the diagnostic analysis;

  o To identify potential changes in population density levels in terms of reproduction and movement standards for selected anuran and reptile species in areas adjacent to the reservoir;

  o To assess the degree of re-adaptation of selected reptile species to the habitats into which they are reintroduced following the fauna rescue stage.

• Methodology

The traditional method employed in herpetofauna inventories is based on recording “all occurrences.” The use of pitfall traps, in conjunction with marking-recapture techniques, will provide estimates on population densities, in addition to demographic parameters and standards for using the space.

For the marking-recapture studies on both lizards and anurans, a digit cutting technique will be used, based on the schematics and recommendations in Donnelly et. al (1994). Larger individuals (see Varanus spp.) obtained during rescue should be released after registering the respective biometric and individual marking data, with a view to tracking their movements, attachment to release sites, and condition factors, when relocated.

2. Monitoring of Transferred Mammals

The impacts of flooding on fauna range from the loss of habitats to death by drowning and population densification resulting from the expulsion of individuals previously residing in the flooded area. There is little scientific data quantifying these impacts on terrestrial fauna.
Various translocation projects have been conducted, many successfully, others less so. A large portion of the work was aimed at reintroducing endangered species, such as the white rhinoceros (Player, 1967) and the gray wolf (Fritts et al., 1984). This project strives in a similar manner to monitor the re-adaptation of adult wildlife living in the wild to new habitats, by virtue of the filling of the reservoir. Given that the fauna targeted for relocation will derive from the same region into which individuals will be released, re-adaptation will merely involve the process for establishing a new habitat in release sites or contiguous areas.

The monitoring actions for relocated fauna will be divided into two stages:

2.1. Primate Monitoring

- Objectives
  - To verify the degree of re-adaptation of primates subject to rescue and relocation to new areas, in addition to the obtainment of other ecological data. Evaluation of the re-adaptation process will be accomplished principally through observations during search operations and the obtainment of food resources, shelters, and territorial expansion;
  - To evaluate the survival of transported wildlife, the maintenance or failure of study groups to maintain their social structures and their re-adaptation to release sites and the distribution of their food resources; and
  - To generate data for the conservation area survey on the biology of local species and the inherent difficulties and challenges of studying these in the wild.

- Methodology

During rescue and following filling of the reservoir, groups of each primate species found in the area should be monitored through radio-telemetry techniques for a period of 24 months. Tracking of groups should be conducted for 10 days/month. Upon each encounter with released groups the following should be registered:

  - Location and time of encounter;
  - Head count of animals and confirmation as to whether they all belong to the original group. In the event of death, determine probable causes;
  - Verify natural state of each individual. To draw conclusions on this component without the recapture of animals, the following must be observed: condition of fur; confidence in displacement; and signs of weight loss; and
  - Enter ecological data such as: height (vegetation stratum) in which the troop is found; for use of food sources, record the specific plant species and food item.

- Measures prior to release:
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- Groups designated for release should maintain the same social structure and composition identified prior to rescue, with preference given to groups with young individuals. In previous studies on reintroduction, groups with more cohesive structures demonstrated greater success in adapting to release (Passamani et al., 1997);

- At least one individual from each group should be equipped with a radio telemetry device. Preference should be given to the adult male;

- In placing the collar on individuals, each animal should be sedated via an intramuscular injection, weighed, and fitted with an appropriate Telonic transmitter. Weighing and other biometric measures should be executed on all individuals of the groups targeted for translocation;

- The tails of both the animal on which the transmitting device is fitted and the remaining members of the group should be dyed with Nyenzol. The purpose of the markings will be to distinguish males from females (proximal and distal portion of the tail respectively) and between members of different groups of the same species (thigh and rib areas). This procedure will enable verification of the dispersal of translocated group members to resident groups or vice versa; and

- Following the respective procedures, animals should be observed for a period of four to ten days or as necessary for confirmation of their adaptation to the transmitters. This stage is necessary to ensure recapture of animals is not required later in the event due to discomfort with the devices.

- Measures following release:

  - Following release, food should be provided in feeders, principally for frugivores. As adaptation to the release site is observed, food will be removed gradually. This procedure is necessary to the extent previous studies revealed that more than 20% of animal deaths following release is due to starvation (Passamani et al., 1997);

  - Animals must be observed systematically over time to verify if wounds form or emerge and the radio-transmitters are in good working order.

2.2. Monitoring of Medium- and Large-Sized Wildlife

- Objectives:

  - To estimate the population density of medium- and large-sized mammal species, with an emphasis on carnivores and track changes in density arising from translocation and movement of animals displaced by the reservoir;

  - To track the daily movements of core carnivore species and describe variations in the patterns identified by virtue of filling of the reservoir;

  - To track medium- and large-sized core mammal species transferred as part of the rescue operation and to assess the success of the respective translocations through survival criteria and settling of the target individuals in transfer areas.
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- Methodology

Tomahawk traps will be distributed throughout the study area and baited with pieces of cooked chicken (to enhancing the odor), for the purposes of capturing carnivores. Daily inspections of the traps will be performed on a daily basis. Captured animals will be sedated, measured, tagged with ear tabs and fitted with a radio-transmitter collar, and released after recovery from the effects of the sedation. Tracking by radio-telemetry will be performed daily and the locations determined by triangulation of the respective lines of sight. Individuals will be selected, among the rescued animals designated for transfer, for purposes of radio-telemetry tracking, in accordance with the procedures above.

Visual census surveys will be performed four to six times per week (half the total at night, half the total during daylight hours). Pre-established transects will be covered by motor vehicle with two observers (each verifying one side of the transect. With each visualization, the species, group size (where applicable), and the perpendicular distance of the animal(s) from the transect will be recorded. The population density estimated will be performed using the DISTANCE program (Buckland et al., 1993). In addition, areas will be selected for tracking census surveys. Tracks will be identified and counted and evaluated for possible changes in mammal population density.

3. Monitoring of Birds

Formation of reservoirs with water diverted by damming of rivers modifies the natural environment and can create “archipelagos” with dynamics very similar to the theory of Islands of Biogeography postulated by MacArthur and Wilson (1967). However, a majority of the studies performed using biogeography involve the composition of species (richness) and not the processes underpinning the respective specific compositions, such that the results are applied to the conservation of island environments in fragmented landscapes and the design of natural reserves (Diamond, 1975; Wilson and Willis, 1975).

The response of bird species may vary according to fragmentation of the environment; populations may increase, remain unchanged, decline, or disappear (Hass and Cavalcanti, 1998). The different responses of bird communities to fragmentation processes may be associated to the ecological requirements of the respective species, such as, for example, natural rarity (Karr, 1990), body size (Karr, 1990), fertility rates (Sieving e Karr, 1997), and survival (Karr, 1982a, b).

- Objective

To describe the responses of bird communities to the loss and reduction of habitats arising from formation of the reservoir, addressing, to this end, the following questions:

- How does the displacement of populations dependent on forest formations operate?
- How are resident populations affected by reductions in their living areas?
- How do guilds reorganize in the face of isolation, fragmentation, and habitat reduction processes?
Methodology

Planning of experiments will be described by four specific methodologies.

- Ornithological nets: capture of birds (Karr, 1981a) at different water elevations. Three points will be selected for the placement of nets, the first at water level and the other two at higher elevations. At each sample point, 20 mist nets arranged in sequential order will be placed for a period of five days. For each captured bird, the respective biometric information will be entered and a metallic or colored tab fitted on captured individuals;

- Census points: (Karr 1981b; Bibby et al. 1993) at three different contour lines. Each census survey will consist of visual or vocal recording of birds, entry of the species, the number of individuals, the distance from the respective researcher, and the stratum utilized by the bird. Each point should be sampled for a period of 20 minutes in the early hours of the day. Bird vocalizations will be recorded by a professional audio recorder (Sony TCE 500);

- Sampling: opportunistics of avifauna, with a view to describing bird communities in the region;

- Tracking of tagged birds: through binoculars for the determination of bird habitats in the study area. For each entry, the species, stratum utilized, and behavior (feeding, vocalization, etc.) will be recorded. The living areas of species are determined through the Minimum Polygon Convex Method.

6.6.8. VECTOR CONTROL PROGRAM

6.6.8.1. JUSTIFICATION

Angola is a tropical country with a high incidence of endemic diseases. The principal endemic diseases identified at the National Conference on Major Endemic Diseases in Angola (February/2000) were malaria, tuberculosis, HIV/ADIS, sleeping sickness, leprosy, and schistosomiasis.

Of the six endemic diseases above, three are parasitosis transmitted by invertebrate vectors with life cycles closely tied to lentic aquatic environments, including backwater areas and lakes. In this light, damming of the river’s water by coffer-dams, in conjunction with the temporary increase in human populations due to the construction project, could have significant adverse impacts on local public health.

Among the potential endemic diseases which could be exacerbated by the project, malaria warrants special attention, to the extent it already represents a serious public health challenge in Angola. According to WHO’s 2006 annual report, approximately 3.5 million cases were registered in that year, while an additional 3 million were reported in 2010. The number of malaria cases resulting in death reveal a gradual decline as of 2001. The peak year was 2003, when 38,598 malaria-related deaths were reported. This total fell to 9,812 in 2007 and to approximately 6,000 is 2010.
Given the lack of specific studies in this area, additional vectors to those identified above may exist in the region. As such, a vector proliferation monitoring and control program is necessary to ensure the health of project personnel as well as the local population.

6.6.8.2. OBJECTIVES

General Objective

The program is intended to mitigate the following impacts: the formation of humid and flooded areas; changes in the population dynamics of benthic macroinvertebrate species; overloading of existing health, sanitation, education, and safety infrastructure; health effects arising from the establishment of propitious conditions for the proliferation of water-borne disease vectors.

Specific Objectives

- To identify and monitor vector populations in the project area of influence;
- To prevent the installation and exacerbation of water-borne vectors in habitats at support infrastructure sites and main project construction sites;
- To control vector populations with a view to preventing potential epidemiological outbreaks;
- To contribute to and supplement public health and environmental, socio-cultural, and health education measures by providing support to disease prevention and control efforts.

6.6.8.3. METHODOLOGICAL PROCEDURES

To fulfill its objectives and implement mitigating or offset measures in response to forecast impacts, the following measures should be executed through the program:

- To train and build capacity of teams with primary responsibility for implementing the program;
- To conduct a survey of the vectors present in the area of influence, with a view to providing the necessary contributions to the program’s action plans. The survey should be performed periodically as a means for monitoring the vector populations and the detecting possible vectors that may have not been identified in previous studies;
- To perform periodic inspections of support infrastructure points, the project’s key works, and residential clusters in the vicinity, in an effort to identify possible vector hot spots and breeding sites and eradicate them. Special importance should be given to areas modified by human occupation through the accumulation of standing water and waste;
- To perform surveys in the Directly Affected Area at natural aquatic, shallow, and lentic points; in degraded forest environments, areas of well formation, and aquatic plant deposits; and in abandoned areas modified by humans, for the purpose of assessing the formation...
vector breeding sites. For the examination of environments, the pertinent measures should be adopted to ensure these area do not become vector proliferation hotspots;

- To engage with the fauna conservation program for the purpose of providing the entities with primary responsibility for the epidemiological surveys in the region systematic biological data on captured wild animals with endemic diseases;

- To prepare presentations and informational material consistent with the relevant public health and environmental education, socio-cultural, and health programs so as to raise awareness among workers and local populations on diseases and the respective preventive measures;

- Where necessary, to conduct vector population controls using the most appropriate methodology on a case-by-case basis (insecticides, molluscicides, biological controls, etc.).
CHAPTER 7
CONCLUSION
7. CONCLUSION

Angola continues to require electric power sources to foster national development, both to supply the industrial sector and individual alike, given the inability of the current production system to meet demand. The maximum initial forecast demand for 2009 in the North System was approximately 520 MW, while peak consumption in Luanda in April 2009, between the hours of 5:00 p.m. and 11:00 p.m., was 678 MW. Supply, however, was limited to 520 MW of full load delivery with the remaining 158 MW met only partially through a rotating system powered by thermoelectric sources.

The Kwanza River Basin has the largest energy generating capacity of Angola’s 48 basins; currently, the two hydroelectric plants that supply the North System generate 700 MW, specifically the Cambambe Dam, with an installed capacity of 180 MW, and the Capanda Dam, at 520 MW. To boost energy production in the Basin, dam-raising work on the Cambambe facility is underway and additional hydroelectric projects are planned between Capanda and Cambambe. Of these, the furthest along to date is the Laúca Dam project.

Data from the Ministry of Energy and Water indicate that the estimated capacity of the entire Kwanza River Basin is 6,780 MW, with guaranteed energy supplies of 26,200 GWh. Based on this scenario, studies were prepared providing for the construction of an additional seven (7) hydroelectric units downstream from the Capanda Dam and upstream from the Cambambe Dam.

The Laúca Dam, one of the projects encompassed in the studies, will be located at kilometer 307.5 of the Kwanza River in a narrow S-shaped valley surrounded by vertical walls rising more than 100 meters, characterized by rapids and a natural fall of approximately 100 meters running 2 kilometers. The facility will have an installed capacity of 2,070 MW to will supply the North System. In the coming ten years, the Angolan Government plans to interconnect the energy production system, specifically the North, Central, and South Systems.
In compliance with the applicable Angolan environmental laws, the project proponent, the Kwanza Environmental Development Office (Gabinete de Aproveitamento do Médio Kwanza – GAMEK), through Odebrecht (the company charged with the respective river diversion work and construction of the dam), contracted Holísticos and Intertechne to prepare an Environmental Impact Assessment.

A vast body of bibliographic research and technical field surveys was performed, with a view to producing an Environmental Impact Assessment (EIA) consistent with the Laúca Dam implementation project located on the boundary line between Malanje, Kwanza Norte, and Kwanza Sul provinces. The results of the EIA reveal highly complex socio-environmental characteristics deriving from the project’s location, nature, and scope.

From a strictly environmental standpoint (physical and biotic environments), the project affected areas (subject to direct physical impacts from the project) are situated in locations on which scarce scientific information and studies is available, with limited reference data, rendering, as such, the technical work performed for this study of great value. Therefore, this report will serve as a reference for new projects planned and implemented in the region, in particular those developed along the Middle Kwanza River.

The surveys of the physical and biotic environments revealed the existence of significant environmental diversity in the region (in particular ichthyofauna, herptofauna, and avifauna) and that despite the absence of any endangered species or of any requiring a high degree of environmental protection, the species identified in the project area are important for maintaining the region’s environmental balance. The proposed environmental plans offer research and monitoring strategies capable of supporting the consolidation of a body of technical information on the project’s implementation area that could be used subsequently to record the ecological systems arrayed along the Kwanza River.

The Environmental Impact Assessment includes, in addition, an exhaustive program of consultations and interviews with communities in the Project Affected Areas (Áreas Directamente Afectadas – ADA) and Areas of Direct Influence (Áreas de Influência Directa – AID), enabling deeper understanding of the local populations and their habits and customs, in addition to the opportunity to foster a closer relationship between the project and surrounding communities.
Further, this process enables the collection of information on the expectations and concerns of local populations in regard to the project, in particular connection to job opportunities and improved living standards.

The field studies did not identify any man-made pressures on the region’s natural resources, including local water resources, as no significant population centers are located in the Project Affected Area (Área Directamente Afectada – ADA) or the Area of Direct Influence (Área de Influência Directa – AID). The areas potentially affected by flooding of the reservoir in the ADA include the Village of Kissaquina, a fishing settlement, and two cemeteries (one on the left bank and one on the right bank of the river). Natural resource consumption in the area is limited to subsistence communities engaged in hunting and fishing activities and small-scale farming.

From a social standpoint, the bibliographic studies and surveys revealed, in addition to analyses of the current condition of local populations conducted in the project's area of influence (in particular, the ADA and AID), the development strong, rich, and enduring cultural ties and habits and customs over the past 20 years. Additionally, a fragile social setting was observed with respect to living conditions, associated primarily to precarious housing and the direct dependence on natural resources as virtually the sole source of income and subsistence.

Based on the environmental analysis presented in the study, it was possible to outline the current socio-environmental realities of the project area and, above all, delimit effective control and monitoring plans and, in addition, offsets for the negative impacts identified. Of particular importance in this context is the development of an appropriate Resettlement Plan for project affected communities by virtue of flooding of the reservoir. The Resettlement Plan must include procedures for the physical resettlement of individuals and for addressing issues in connection with dwellings and means of subsistence affected or lost due to the project. As such, detailed studies should be conducted of the potential scenarios, as well as consultations with project affected populations, with a view to forging agreement between the parties on resettlement.

It is essential that the related projects generate the expected benefits with the minimum possible adverse impacts from an environmental and social standpoint alike. To this end, strict fulfillment of the proposed mitigation measures will be required to ensure the safety of workers and local
communities, in addition to the protection of the environment and the surrounding areas. With this in mind, an Environmental Management Program is presented for the dam construction and operation phases. The Program sets out a series of subprograms for various aspects of the project, the most important of which are the support to project work, support to local communities, wildlife and plant conservation, and degraded area recovery programs. The project support program is accompanied by a Waste Management Plan, prepared pursuant to the requirements of the Waste Management Regulation (Presidential Decree No. 190/12).

As described in the previous sections, in general the adverse impacts underscored in this document can be mitigated and/or prevented, provided the proposed mitigation measures set forth in this document are fulfilled and the good practices of environmental management and the environmental management programs specified in this Environmental Impact Assessment are applied.

From an economic and social standpoint, and taking into account the country’s energy needs, it is important to underline that the project has an important role in diversifying Angola’s energy grid and strengthening the national economy, while falling within the scope of the country’s Executive Program for the Energy Sector (Programa Executivo do Sector de Energia).

The project’s construction and operational phases will employ cutting-edge technology and equipment. In this light, the selected technological option is the most appropriate, as the project will also apply good practices of construction for hydroelectric projects.

Based on the results set out in the pressures and impacts matrixes, the projected adverse impacts of the project, and the concrete measures adopted to minimize or mitigate these, the plans should be followed by the project proponent and executor, as recommended in this document. The applicable domestic legislation, compliance with which is mandatory, should be implemented during the construction and operational phases of the Laúca Dam.

In the light of the environmental and social impacts identified in the Environmental Impact Assessment and based on proper application of the respective mitigation measures and monitoring plan, construction of the dam is deemed feasible from an environmental and social standpoint and highly relevant from an economic perspective.

Confidential
8. Bibliography
8. BIBLIOGRAFIA


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ATTACHMENT 1

REGISTER CERTIFICATE
Republic of Angola
Ministry of the Environment

CERTIFICATE

Register No. 1
Page 01
Book No. A-1

a) Holisticos – Serviços e Consultoria, Ltda.

Pursuant the terms of Decree no. 59/07 of July 13th, having being accomplished all the formalities provided in Articles 29th, 30th and 31st of the mentioned Decree, provided there is no legal impediment, the present Register Certificate is issued in behalf of:

b) **Issued on 05/22/2012**  **Valid until 05/22/2013**

**Signature**

(signed)

**Director of the Legal Office**

a) Board, Office, Department or Institute
b) Consultant, Consulting Society or Consortium

Register Certificate of Environmental Consultant
ATTACHMENT II
ATTENDANCE LIST OF THE VILLAGES IN HEARINGS
# Project of the Laúca Hydroelectric Power Plant in the Medium Kwanza

## Attendance List of the Public Hearing Process

<table>
<thead>
<tr>
<th>Name</th>
<th>Village</th>
<th>Function/Title</th>
<th>Contact</th>
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Legend:
- Moradores - Inhabitants
- Coordenador - Coordinator

Date: 04/10/13
### Project of the Laúca Hydroelectric Power Plant in the Medium Kwanza

**Attendance List of the Public Hearing Process**

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Legend:
- Conselheiro - Counselor
- Moradores - Inhabitants

Date: 04/08/13
### Project of the Laúca Hydroelectric Power Plant in the Medium Kwanza

#### Attendance List of the Public Hearing Process

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Legend:
- Moradores - Inhabitants
- Esposa - Wife

Date: 04/08/13
## Project of the Laúca Hydroelectric Power Plant in the Medium Kwanza

### Attendance List of the Public Hearing Process

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**Legend:**
- Adjunto - Adjunct
- Moradores - Inhabitants

**Date:** 04/10/13
### Project of the Laúca Hydroelectric Power Plant in the Medium Kwanza

Attendance List of the Public Hearing Process

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Legend:
Moradores - Inhabitants
### Project of the Laúca Hydroelectric Power Plant in the Medium Kwanza

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**Legend:**
- Moradores - Inhabitants
- Regador - Watering
- Esposa do Regador - Wife Watering
## Project of the Laúca Hydroelectric Power Plant in the Medium Kwanza

### Attendance List of the Public Hearing Process

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**Legend:**
- Coordenador - Coordinator
- Moradores - Inhabitants

Date: 04/09/13
## Project of the Lúica Hydroelectric Power Plant in the Medium Kwanza

Attendance List of the Public Hearing Process

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Legend:
Moradores - Inhabitants

Date: 04/09/13
### Attendance List of the Public Hearing Process

**Legend:**
- **Moradores** - Inhabitants

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**Legend:**
- **Moradores** - Inhabitants
**Project of the Laúca Hydroelectric Power Plant in the Medium Kwanza**

Attendance List of the Public Hearing Process

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<th>Name</th>
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Legend:
Moradores - Inhabitants
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**Date:** 04/09/13

**Legend:**
- Coordenador - Coordinator
- Enfermeiro – Nurse
- Catequista - Catechist
- Pedreiro - Mason
- Moradora - Inhabitant
- Adjunto - Adjunct
- Morador - Inhabitant
- Pedreiro - Mason
- Morador – Inhabitant
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GAMEK – Office of the Medium Kwanza Power Plant
Rua do Massangano, s/n no., Bairro Operário
Sambizanga – Luanda
Telephone: +244 222-445 072/222-675 801
Fax: +244 222-447 973
http://www.gamek.com

Holísticos – Consultoria Ambiental
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Telephone: +244 222 006 938
Fax: +244 222 006 435
Email: holísticos@holísticos.co.ao

Odebrecht Angola – Construção e Projectos de Energia SA
Avenida Talatona, s/n, Belas Business Park II
Torre Cabinda – 8º andar
Luanda Sul – Luanda
Telephone: +244 222 675 811
www.odebrecht.com

Project of the Laúca Hydroelectric Power Plant in the Medium Kwanza
Preliminary Information for the Environmental Impact Study’s Public Hearing Process

March 2013
Project’s History

Among the 48 hydrographic basins of Angola, the Kwanza River basin has the highest power generation capacity. Presently, 700 MW are generated in the two power plants that supply the North System, specifically Capanda and Cambambe. Considering the high power generation capacity of the Kwanza River and the need to increase the country’s energy offer, the Laúca dam will be built for future power generation use.

Environmental Impact Study

The project for the Laúca dam construction requires environmental licenses pursuant the national legislation. Therefore, an Environmental Impact Study (EIA) must be carried out according to the social-environmental legislation (Decree no. 51/04) that recommends the execution of the EIA for projects that may affect the environmental balance and harmony.

The purpose of the EIA is the identification and previous analysis of how the project activities will result in potential impacts on the environmental components (air, water, soil, flora, fauna, ecosystems, etc.) and the quality of life of the people, workers and local communities. The EIA also intends to suggest measures to avoid, minimize or compensate the environment and the communities for identified environmental impacts.

A preliminary study was carried out in 2009 covering the region of Caculo-Cabaça and Capanda, in the Laúca region. An EIA for the construction of the Kwanza River deviation was carried out in 2012, in Odebrecht’s behalf, by the Holísticos company in partnership with InterTechne, and was submitted to the appropriate authorities for environmental licensing purposes. The social and environmental characterization of the project’s influence area was carried out through documentation analysis, field surveys and specialized basic studies for the following components:

- Hydraulic resources;
- Climate;
- Geology and soils;
- Fauna and flora;
- Landscape;
- Social-economic aspects.

The preparation of the EIA for the dam has the purpose of:

- Inform and hear the stakeholders;
- Elaborate the social and environmental diagnoses;
- Improve the assessment of the social and environmental impacts;
- Prepare adequate mitigation measures.

Stakeholders’ Hearings

As a complement to the Environmental Impact Study process, public hearings of the interested population are being held. For the execution of the river deviation EIA, hearing meetings were held in the villages of Dumbo Ya Pepe, Kibenda, Nhangue Ya Pepe, and Ngola Ndala, when the respective population conveyed their concerns and expectations with respect to the works.
The public hearing phase is of extreme importance for the EIA process, since the meeting of the stakeholders allows the joint and participative performance of a fair and complete assessment of the potential project’s impacts, as well as the definition of the adequate mitigation measures. In this stage, such meetings are foreseen in the villages of Dumbo Ya Pepe, Kibenda, Nhangu Ya Pepe, Ngola Ndala, Muta, Quirinji and Kassule.

Additional information, comments and suggestions can be sent to the available contacts by using the comment’s form handed out together with this booklet.

Next Steps

Additional environmental and social-economic surveys are being carried out in areas and infrastructures close to the Laúca works, which shall be concluded until April 2013. These additional surveys will allow a better knowledge of the project insertion area.

The Environmental Impact Study will be submitted to the government authorities responsible for the project activities (Ministry of Energy and Water) and for the environmental activities (Ministry of the Environment) for environmental licensing purposes.
The construction will be carried out in the Province of Malanje in the Kwanza River’s medium section (Km 307.5) and around 47 km downstream of the Capanda dam and close to the locality of Nhangue Ya Pepe.

Environmental Characterization

The Medium Kwanza climate is tropical with the dry season in winter with temperatures of 30 to 37°C, registered in September, and the coldest months are between June and August. The relative humidity is around 55 and 80%.

The enterprise is inserted in an area where savannas prevail, but forests and fields are also present. The tree and bush vegetation with thick trunks are characteristic of the region. The herbaceous and sub-bush vegetation is formed mainly by permanent species with resistant underground organs that allow it to survive droughts and fire.

The first studies carried out in the region led to the conclusion that there is a large variety of mammals, although in small numbers. Large animals were not seen in the visited places. Birds are frequently seen in this region, and 91 species were identified in preliminary studies.

In field surveys, few of the species included in the UICN’s red list of endangered species were identified. Those identified were classified as of “Low Extinction Risk”, with wide geographically distributed habitats. However, it is worth pointing out the leopard that is classified as “Vulnerable” to extinction and the “Vulnerable” hippopotamus. Additional surveys are being carried out.
Social Characterization

The social survey has placed greater focus on the villages that can suffer the greater impact with respect to employment and income. The number of inhabitants per village is far lower than average that can be found in other regions of the country. Only two (2) villages have more than 100 inhabitants. According to the population reports the younger people is returning to the villages due to the employment offer in the Laúca works.

The river deviation EIA has ascertained that the population’s living conditions is very precarious as a result of the absence of basic infrastructure, as water supply, basic sanitation, and electric power, as well as the rarity and precariousness of the health care and education equipment, the absence of transport systems and the absolute lack of employment and production activities.

The production system in the studied villages consists exclusively of the subsistence farming, with the eventual sale of the surplus, and fruit collection. In addition of the raising of goat and swine cattle by some families and some poultry as chicken and duck, hunting and fishing provides a food supplement to the families.

The Project

Several project phases will be necessary for the Laúca dam construction until the work is fully completed. These phases include:

- Kwanza River deviation and the building of two tunnels;
- Residual water treatment station (ETAR);
- Sanitary landfill;
- Building of the dam and the associated infrastructure;
- Reservoir filling.
Open air and underground interventions will be necessary for the execution of the works. The valley will be closed by a concrete dam approximately 132 m-high and with a crest extension of approximately 1,100 m. The future power generation will be carried out in the power house with 6 turbine sets with 2,070 MW of installed power. The Laúca dam reservoir will operate with flow reduction in order to regularize the flows and will have the following main characteristics:

- Total area: 188 km$^2$;
- Total volume: 5,729 Hm$^3$;
- Maximum WL: El. 850 m;
- Minimum WL: El. 800 m;

**Work Force**

The Laúca dam construction is foreseen to be carried out in 5 years and will employ around 3,700 workers during the so-called “work peak.”
ATTACHMENT IV
REGISTER FORM AND
COMMENTS
Project Dam Construction Lauca
Registration Form and Comments

Name (optional):  

Contact (optional):  

Community / Organization:

Comments on the proposed construction of the dam (expectations and concerns):

Please send this form to:

Alice Ponciano (Environmental Engineer)
Odebrecht Angola
Av. Talatona s/n; Belas Business Park II, Torre Cabinda - 8º Andar
Luanda Sul – Luanda
Phone: 222675811
Fax: 244 26 75000
Email: alicesp@odebrecht.com
www.odebrecht.com

Joana Huongo
Holisticos - Serviços, Estudos e Consultoria
Rua 60, Casa 559, Urbanização Harmonia, Benfica, Luanda.
Mobile: 927442844
Phone: 222 006938;
Fax: 222 006435
Email: holisticos@holisticos.com
www.holisticos.co.ao
ATTACHMENT V

SOLID RESIDUE MANAGEMENT PLAN
1. PURPOSE

The Residue Management Plan (PGR) consists of the detailed planning of the direct and indirect actions that involve the phases of collection, transport, treatment and the environmentally correct final destination of the solid residues and waste. It seeks the minimization of residue generation at the source, adequate the segregation at the origin, control and reduce risks to the environment and ensure correct handling in compliance with the legislation in force.

The Residue Management Plan shall fulfill the following requirements:
- Type and quantity of the generated residues;
- Definition of the operation flow and the handling standards for each type of residue;
- Residue treatment forms;
- Residue’s final destination;
- Residue transport waybill;
- Monthly report model.

1.1 SPECIFIC OBJECTIVES

- Ensure the prevention of the pollution associated to the significant environmental aspect of solid residue generation;
- Ensure the fulfillment of legal requirements and the local good environmental practices;
- Prevent corporate and civil liability risks arising from the treatment and final disposal of solid residues;
- Implement the “Selective Residue Collection” and the “Solid Residue Handling” concepts in the Work Quarters of the Laúca AH project works – River deviation.

2. REFERENCE DOCUMENTS

- Residue Management Regulation – Presidential Decree no. 190 of 07/18/2012;
- Environment Basis Act of 05/98;
- Decree no. 59/07 of 2006 on Environmental Licensing;

3. COVERAGE

This procedure applies to contracts that perform their activities within the facilities of the Laúca AH Project – River Deviation work quarters, or that are directly associated to the same.
4. DEFINITIONS

ABNT: Brazilian Technical Standards Association

Temporary Storage: The temporary storage of solid residues for further destination to management alternatives as: recycling, recovery, reuse, treatment or adequate final disposal in compliance with the legal SUSTAINABILITY requirements.

Residue classification: The classification of solid residues involves the identification of the original Process/Activity, their composition, their main characteristics, as well as the comparison of the components with the residue lists of Technical Standards and/or Good Environmental Practices. The environment quality degradation resulting from activities that, either directly or in directly:

✓ Harm the population’s health, safety and well-being;
✓ Create adverse conditions for the social and economic activities;
✓ Affect the biota unfavorably;
✓ Affect the environment’s esthetic or sanitary conditions;
✓ Dispose matter or energy in disagreement with the established environmental standards;

Solid residues can be classified according to the Standard ABNT No. 10.004/04, following the requirements below:

CLASS I – Hazardous Solid Residues: Are those presenting hazards or at least one of the following characteristics: flammability, corrosiveness, reactivity, pathogenesis or toxicity.

CLASS II – Non-Hazardous Solid Residues:
CLASS IIA - Non-Hazardous – Non-Inert: Are those not classified either in Class I – Hazardous or in Class II B – Inert. Class II A residues may have properties such as: being subject to combustion, to biodegradation or solubility in water.
CLASS IIB - Non-Hazardous –Inert: Any residue that, when sampled according to the Standard ABNT NBR 10007 and submitted to a Solubility Test (dynamic and static contact with distilled or deionized water at ambient temperature) according to the Standard ABNT NBR 10006, presents none of its components solved at concentrations higher than the water drinkability standards, except for appearance, color, turbidity, hardness and flavor.

CGR – Residue Management Center

Selective Collection – A planned process for separation, packing, collection, temporary storage, transport and reuse or recycling of the solid residues generated at the Laúca AH – River Deviation work quarters (DRL).

Final Residue Disposal – Disposal or definitive destination of the solid residues in an environmentally adequate manner in compliance with the local legislation and specific standards.

Generator – Contract’s process/activity that generates solid residues.

Incineration: Incineration is a thermal destruction process carried out in high temperatures and under controlled residence time and that is used for the treatment of highly hazardous residues, or those needing complete and safe destruction.
**NBR:** Brazilian Regulating Standard

**Recycling:** A prevention process where the solid residues are treated with the generation of new products or raw materials, through separation, segregation, collection, transport, reprocessing or remanufacturing.

### 5. RESPONSIBILITIES

#### 5.1 Contract Director

- Ensure the human, financial and material resources necessary for the implementation of these processes.

#### 5.2 Management Team

- Provide support and act as facilitators in these processes within its competence area;
- Learn, comply with and ensure compliance with the applicable local legislation with respect to transport, temporary storage, treatment and final disposal of solid residues, with the help of the SUSTAINABILITY area.

#### 5.3 SUSTAINABILITY Team

- Be responsible for the temporary storage and final disposal of solid residues and help the work fronts with cleaning orientation and organization, together with the adequate segregation of the residues;
- Identify, make available and enforce compliance with the local legislation applicable to the management of the solid residues generated by the Laúca AH – River Deviation work quarters;
- Provide when necessary the execution of the necessary trials and tests of the characterization of solid residues to verify their pollution potential defines control actions;
- Define, together with the Supervisors and Leaders of each Process / Activity, the internal and temporary storage places for the solid residues to be collected;
- Develop and select solid residue management alternatives covering all the sustainable handling phases;
- Make available in the work fronts the adequate Selective Collection service kits for each type of residue generated on the site;
- Provide the final destination according to the class of each residue;
- Supervise the solid residue temporary storage places, called “Solid Residue Management Centers - CGR”; 
- Provide specific authorizations and prepare Bills of Lading for the external transport of hazardous solid residues;
SUStAINABILITY
INTEGRATED PROGRAM

LAÚCA AH – RIVER DEVIAITON

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<tr>
<td>TITLE: RESIDUE MANAGEMENT PLAN</td>
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- Develop and support the process managers in the definition of options for no generation,
- reduction, reutilization, recovery and recycling of solid residues;
- Carry out training with the purpose of making aware and recycling the participants;
- Inspect and apply Checklists periodically in the solid residue temporary storage places and in the residue generation points in the work fronts;
- Monitor the Residue Management and Selective Collection processes keeping the registers of the solid residue shipping for recycling, recovery, reutilization and final disposal;
- Approve, keep and review this procedure whenever necessary.

5.4. Contractual / Commercial Administration Area:

- Provide support and act as facilitators in this process within its area of competence, by enforcing compliance with the local legal requirements applicable in the hiring of the services of transport, treatment and final disposal of solid residues.
- Provide support, giving preference for the hiring of manufacturers and/or suppliers that collect and recycle their own products used in the contract.

5.5. Administrative Area:

- Be responsible for the collection and transport of the residues generated in the work fronts and carry them to the solid residue temporary storage place, called “Solid Residue Management Centers - CGR”.
- Act in the systematic cleaning of the administrative areas and other work fronts, in the adequate segregation and packing the generated solid residues;
- Guarantee that people involved will be skilled in the application of this procedure.

5.6. Supervisors and Leaders:

- Guarantee the primary selection and disposal in the places defined and identified (selective collection recipients) of all the residues generated by the Processes / Activities under his responsibility, including in the work fronts;
- Guarantee the cleaning, disposal, collection and transport of the specific solid residues from his work front to the solid residue temporary storage places, called “Solid Residue Management Centers - CGR”.
- Appoint the responsible person in each work front for cleaning, collecting, identifying, transporting and disposing the solid residues in the temporary storage areas as defined and identified;
- Keep his work areas clean and organized;
- Guarantee that people involved will be skilled in the application of this procedure;
5.7. Occupational Doctor:

Act as facilitator and provide support on the implantation of this procedure, especially in the interface with the Solid Residue Management Programs of the Health Service.

5.8. Participants, Subcontractors and Service Providers:

✓ Carry out the primary selection of the solid residues for collection and temporary storage in the places defined and identified.
✓ Keep the work environment (Works) always clean and unobstructed, separate and discard adequately and daily all the residues generated in the construction as consequence of the works.
✓ Act as disseminators of the residue Selective Collection process.

5.9. Supply, Procurement and Warehouse:
✓ Keep, store and send the products out of validity to be returned to the respective manufacturers and/or suppliers.

6. PLANNING

The Residue Management Plan of the Laúca AH – River Deviation was planned according to the mapping of the activities and processes developed in the works. The management comprises the following phases:

1. Identification of the generating units;
2. Inventory of the generated residues;
3. Residue segregation in loco;
4. Residue collection;
5. Temporary storage of the residues in the Residue Management Centers – CGR;
6. Final destination by the recycling companies capable of receiving and recycling the residues, registered in the Ministry of the Environment of Angola.

7. TYPES OF RESIDUES GENERATED

The residues to be generated will be identified and registered in the spreadsheet called “Solid Residue Inventory”, included in the ATTACHMENT OF THE INTEGRATED PROCEDURE FOR SOLID RESIDUE MANAGEMENT (PI DRL 25 – Execution Plan).

The solid residue inventory comprises the following fields:
✓ Generating process / activity;
All the paths / types of solid residues generated in the Work Quarters, regardless of their reuse, reprocessing, recovery, or recycling, will be included in the Solid Residue Inventory; The Management Inventory will be updated once a year, under the responsibility of the SUSTAINABILITY area, with the support of the Process Managers; Such updating will take into account changes in the quantity and types of the generated solid residues, requirements and changes in the applicable legislation, as well as corporate risks and the costs involved.

Residue Classification

The residue characterization will follow the classification into one of the Classes:
I – Hazardous or II – Not hazardous, IIA – Not inert or IIB – Inert, in the terms of the ABNT Brazilian Technical Standards NBR 10004 / 10005 / 10006 and 10007:04.

A characterization / classification is decisive for a definition of the methods for temporary storage, transport and of treatment / final disposal of the solid residues as described in ATTACHMENT OF THE PI DRL 25/2 Flowchart of the Solid Residue Management Process.

The Laúca AH Project – River deviation will use the Brazilian Technical Standards and the Presidential Decree of Angola no.190/12 – Regulation on Residue Management as good environmental practices.

As an orientation guide for the accomplishment of this process phase – Identification and Classification, Table 01 presented below, provides a list of the main solid residues generated in the work quarters and their respective classification, in a generic and illustrative way, in the Classes of Hazardous and Not Hazardous.
<table>
<thead>
<tr>
<th>Type of Solid Residue</th>
<th>Class</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Domestic residues from offices</td>
<td>Hazardous</td>
<td>X</td>
</tr>
<tr>
<td>2. Civil construction waste</td>
<td>Hazardous</td>
<td>X</td>
</tr>
<tr>
<td>3. Used PPEs – Personal Protection Equipment</td>
<td>Hazardous</td>
<td>X</td>
</tr>
<tr>
<td>4. Used lubricating oil and contaminated oil</td>
<td>Hazardous</td>
<td>X</td>
</tr>
<tr>
<td>5. Empty paint cans</td>
<td>Hazardous</td>
<td>X</td>
</tr>
<tr>
<td>6. Empty solvent cans</td>
<td>Hazardous</td>
<td>X</td>
</tr>
<tr>
<td>7. Mercury vapor lamps</td>
<td>Hazardous</td>
<td>X</td>
</tr>
<tr>
<td>8. Incandescent lamps</td>
<td>Hazardous</td>
<td>X</td>
</tr>
<tr>
<td>9. Sodium vapor lamps</td>
<td>Hazardous</td>
<td>X</td>
</tr>
<tr>
<td>10. Slurry from Water Treatment Stations – organic ETA</td>
<td>Hazardous</td>
<td>X</td>
</tr>
<tr>
<td>11. Sweeping residues</td>
<td>Hazardous</td>
<td>X</td>
</tr>
<tr>
<td>12. Slurry from Sanitary Effluent Treatment Stations</td>
<td>Hazardous</td>
<td>X</td>
</tr>
<tr>
<td>13. Slurry from water reservoir cleaning – organic ETA</td>
<td>Hazardous</td>
<td>X</td>
</tr>
<tr>
<td>14. Lead electric batteries and their residues</td>
<td>Hazardous</td>
<td>X</td>
</tr>
<tr>
<td>15. Other batteries – depending on the composition</td>
<td>Hazardous</td>
<td>X</td>
</tr>
<tr>
<td>16. Thermal insulation oil</td>
<td>Hazardous</td>
<td>X</td>
</tr>
<tr>
<td>17. Used cutting and machining oil</td>
<td>Hazardous</td>
<td>X</td>
</tr>
<tr>
<td>18. Residues from food waste</td>
<td>Hazardous</td>
<td>X</td>
</tr>
<tr>
<td>19. Not contaminated metallic scrap</td>
<td>Hazardous</td>
<td>X</td>
</tr>
<tr>
<td>20. Paper, cardboard and plastic</td>
<td>Hazardous</td>
<td>X</td>
</tr>
<tr>
<td>21. Not contaminated rubber</td>
<td>Hazardous</td>
<td>X</td>
</tr>
<tr>
<td>22. Healthcare service residues</td>
<td>Hazardous</td>
<td>X</td>
</tr>
<tr>
<td>23. Stubs of welding electrodes</td>
<td>Hazardous</td>
<td>X</td>
</tr>
<tr>
<td>24. Wood waste</td>
<td>Hazardous</td>
<td>X</td>
</tr>
<tr>
<td>25. Soil waste / surplus rock / aggregate production</td>
<td>Hazardous</td>
<td>X</td>
</tr>
<tr>
<td>26. Residues of asphalt production</td>
<td>Hazardous</td>
<td>X</td>
</tr>
<tr>
<td>27. Empty packing of chemical products</td>
<td>Hazardous</td>
<td>X</td>
</tr>
<tr>
<td>28. Vegetation waste (branches and leaves)</td>
<td>Hazardous</td>
<td>X</td>
</tr>
<tr>
<td>29. Printing and tonner cartridges</td>
<td>Hazardous</td>
<td>X</td>
</tr>
<tr>
<td>30. Scrapped straps, belts, steel ropes</td>
<td>Hazardous</td>
<td>X</td>
</tr>
<tr>
<td>31. Thermal insulation – silicate</td>
<td>Hazardous</td>
<td>X</td>
</tr>
<tr>
<td>32. Glass wool</td>
<td>Hazardous</td>
<td>X</td>
</tr>
<tr>
<td>33. Asbestos tiles</td>
<td>Hazardous</td>
<td>X</td>
</tr>
<tr>
<td>34. Fat from ETE</td>
<td>Hazardous</td>
<td>X</td>
</tr>
</tbody>
</table>
8. PACKING / SEGREGATION OF SOLID RESIDUES

The solid residues produced in the work quarters will be packed in a safe way and protected against contra risks during handling and transport, in alternatives such as: drum, buckets, dumpsters, in bulk and large bottles, among other types according to the specific need and as a prevention mechanism against leaks, spills or water infiltration.

The recipients used in this residue packing shall be made of material compatible with the residues to be received and be in perfect conservation state. The reutilization of recipients from raw materials or chemical products will be conditioned to their decontamination and identification.

Sharp-edged and pointed residues shall be packed in water-tight recipients, sealed and identified by the symbol “Infecting Residues” according to the procedure PI DRL 18 - Management Program for Healthcare Service Residues – PGRSS;

Other infecting residues will be packed in white and translucent plastic bags and transported with the symbol infecting residues, in compliance with the legal requirements;

The hazardous oily residues and other hazardous residues will be packed in drums or buckets identified by the symbol “Hazardous Residues” and the non-recyclable symbol in an orange-colored recipient;

Hazardous residues as lamps shall be stored in boxes with protection against breaking, and broken lamps shall be stored with the corresponding label (for example: “Broken fluorescent lamps - contain mercury”);

The storage of batteries shall be made in duly sealed containers, to prevent the release of any of their components.

Residues classified in the Selective Collection system will be packed in recipients with the defined colors, as described in item 7.1;

Solid residues packed in open containers will be disposed in a way that prevents water build-up and the consequent proliferation of potential disease vectors such as: dengue, yellow fever and malaria;

Participants involved in the handling and internal transport of solid residues, particularly the hazardous ones, shall wear the following PPEs – Personal Protection Equipment: rubber gloves, safety boots, protective glasses against spills and, when applicable, breathing protection.
The solid residue packing recipients, as a means of awareness and communication, will be identified by the use of Labels / Tags containing information as the name of the Solid Residue and its Class.

With the same awareness purpose and also to control costs, the solid residues will be packed in a segregated way, being the mixture of residues of different classes not allowed, as for example, mixing hazardous residues with other types. In case such mixture takes place accidentally, the mixed residues shall be treated as hazardous.

8.1. Residue Collection

Residue collection in the Laúca AH – River deviation work quarters will be divided in three types, as described below:
- Selective;
- Differentiated;
- Especial

a- Selective collection:
The Selective Collection process handles solid residues classified in the Not-Hazardous category, which is usually composed by:
Canteen residues (food waste), not contaminated scrap of ferrous and non-ferrous metals, plastic, paper, wood and rubber;

The Selective Collection process will be conducted by the Laúca AH Project – River deviation, based on the following phases:
- Packing of the residues by making the recipients available in the work fronts in order to fulfill the generation point needs;
- Awareness of the participants of the Selective Collection process;
- Definition of places for recycling, reutilization or recovery;

Packing of solid residues for the Selective Collection
The identification and sizing of the recipients destined to suit the Selective Collection of Residues in the work fronts shall be carried out based on information from the “Solid Residue Inventory”, found in Attachment I – Execution Plan.
The Selective Collection process will use recipients, drums and buckets identified by specific colors for the packing of each type of residue, as shown in the table below:
The definition of the recipient colors shall follow the legal requirements and / or the good practices applied in Angola.

**Awareness of the Participants for the Selective Collection**

Practice has shown that the success of Selective Collection initiatives is directly associated to the awareness level / motivation of participants, subcontractors and the involved service providers. Therefore, the Laúca AH Project – River deviation will support the implementation of the Selective Collection in awareness / motivation actions about:

- The significant environmental aspects associated to solid residue generation, as a result of the waste of Processes / Activities;
- The colors of the adequate recipients for each type of residue;
- Labels on the recipients containing information about the separation of residues;
- The benefits of the Selective Collection as environmental, economic and social advantages.

These actions can be conducted through mechanisms such as: lectures, campaigns, daily task training – TDT, etc.

**Definition of the places for recycling, reutilization and recovery**

This phase of the Selective Collection process will be developed under the responsibility of the SUSTAINABILITY area, through the selection of alternatives for the sending of solid residues for recycling, reutilization or reduction.

The selection of these alternatives may consider, among others, the following requirements:

- Give privilege to local options;
- Partnership with the customer, when applicable;
- Partnership with suppliers of materials, raw materials or services that generate solid residues;
- Partnership with institutions / companies dedicated to selective collection.
Reutilization

The Laúca AH Project – River deviation shall give priority to reuse, seeking a lower production of residues:
- Reuse as notepads, the paper sheets printed on only one side;
- Use of recyclable cartridges in printers and photocopiers;
- Repair and reuse office furniture, as well as electric and electronic equipment;
- Replace residue collection companies for suppliers that accept retaking;
- Selective collection of residues to send for recycling or landfills.

b- Differentiated Collection:

Differentiated collection is the one in which other means than the selective collection shall be used, due to the physical characteristics of the residue, as volume and weight.
It comprises for example: the collection service of tires, concrete waste and metallic scrap, which are in general materials that require buckets instead of drums for packing.

c- Special Collection:

Special collection applies to the residues of healthcare services and other hazardous residues (Class I).
The collection of these residues cannot be carried out together with others and require special transport conditions.

8.2. Temporary Storage

All residues collected in the Work Quarters, Work Fronts and administrative areas will be sent to the previously defined temporary residue storage areas for further treatment or final destination.
In this phase of the solid residue temporary storage, the following requirements are considered:
Selection criteria of the area(s) associated to layout, accessibility, quantity to be stored, distances from the Work Fronts, etc;
- Segregation and compatibility among the residues to be stored, etc.
Since the temporary storage areas and the final destination of the solid residues is a process belonging to Environment - Sustainability, the Laúca AH Project – River deviation will deal with them under the denomination of “Residue Management Center” that has its plan view attached.
In the special case of the temporary storage of out of validity products, the storage place is the “Bay for Out of Validity Products” located in the warehouse, from where they will be returned to the respective manufacturers.
8.3. Good Environmental Practices

The good practices are associated to the ABNT Technical Standards – NBR 11174:90 for solid residues classified as non-hazardous, NBR 12235:92 applicable to hazardous residues and the Presidential Decree of Angola no. 190/12 regarding the Regulation on Residue Management.

The above practices define that the **non-hazardous** residues shall not be stored together with hazardous residues, because the resulting mixture will characterize all the residues as hazardous.

When **non-hazardous** residues are stored, they shall be labeled according to the type of residue. The access to the disposal place and the collection must allow their utilization under any climate conditions. Non-hazardous residues cannot be disposed directly on the soil, being necessary either some type of impermeable protection or that they be deposited in recipients (buckets, containers, tanks and/or drums) with measures for the containment of accidental leaks.

Provided it is feasible, places or recipients will be defined in the storage areas, as defined in each Process /Activity for the local and temporary storage of the generated residues, where they will remain until the shipment to the Residue Management Center or to treatment / final destination.

According to the standard, the area must be inspected for the identification and correction of eventual problems that may favor the occurrence of accidents capable of harming the environment. For this purpose there are CHECKLISTS to be used in the storage place.

9. COLLECTION AND TRANSPORT

The collection of residues in the work quarters area will be carried out by trucks and the own support team of the Laúca AH Project – River deviation.

The SUSTAINABILITY team is responsible for providing the final destination or the temporary storage.

The phase of the solid residue External Transport, when necessary, will be carried out in compliance with the local environmental legislation requirements for hazardous and non-hazardous residues.

The transport of solid residues shall only be conducted after adequate packing conditions are guaranteed.

The external transport of hazardous residues will only be conducted after filling out the document included in the **PI DRL 25/4 ATTACHMENT – Bill of Lading or through Collection Certificates**, based on the ABNT Technical Standard no. NBR 13221. The hiring of companies for solid residue collection and transport comply with the local legislation in force, and such companies...
shall be duly licensed by the Ministry of the Environment of Angola. The collection companies shall be requested to ensure the packing conditions, the shipment and the final destination of the residues.

10. TREATMENT AND FINAL DISPOSAL

The definition phase of methods / alternatives for solid residue treatment / final disposal shall be conducted to prevent potential corporate risks.

As part of the implementation of the pollution prevention and continuous improvement processes, a hierarchical classification is defined for the techniques associated to recovery, reutilization, reuse or recycling, provided they are technically / economically feasible with respect to the alternatives of treatment and final destination on the soil (sanitary landfill).

The “Residue Management Center” installed on the right bank, will include the following structures:
- Sanitary landfill for non-recyclable residues with impermeable bays;
- Composing of organic residues;
- Incinerator;
- Treatment of contaminated soil through the bio-remediation process.
- Sorting yard for recyclable, hazardous and healthcare residues with selective bays.
- 

Within the set of the technical alternatives available for solid residue treatment / final disposal, the SUSTAINABILITY team will analyze and select the recommendations considered more appropriate for the several phases of the works, taking in consideration the following parameters:
- Legal requirements and other applicable requirements;
- Class of the solid residue;
- Volumes involved;
- Continuous generation or not;
- Associated civil liability risks;
- Costs involved.

Regarding the final destination to the recycling companies, the Laúca AH Project – River deviation will wait for the publication of the Recycling Companies accredited with the Ministry of the Environment of Angola, as capable of receiving and recycling the residues, providing for each one its environmentally correct treatment.

For each destined residue, the attached Bill of Lading will be filled out, so the accomplishment of the established objectives and targets, the implemented actions, as well as the type and quantity of residues sent to recycling may be verified, and a documental or electronic register of the whole information can be kept.
10.1. SANITARY LANDFILL

The Laúca AH sanitary landfill consists of a technique for solid residue disposal on the soil, without the risk of damages to the health and the safety of the participants, thus minimizing the environmental impacts. It is located in the Residue Management Center – CGR – distant about 1,300 meters from the lodging, in an area of approximately 0.5 ha.

Ten cells coated with a protective canvas are foreseen to prevent any type of contact of the fluids with the soil, and a fluid collection network as well, directed to collection tanks and later to the Effluent Treatment Station – ETE. The cells will receive the non-recyclable residues characterized by residues from bathrooms, sweeping, napkins, organic residues not used in composing and those not suitable for recycling. The sanitary landfill will have its cells filled in layers, covered by clay-rich material, where the last layer will have a thickness of 70 cm upon the closing of the cell. After being used, the site will undergo a landscape recovery process by re-vegetation.

10.2. STANDARD OF THE LAÚCA AH – RIVER DEVIATION INCINERATOR

In order to fulfill the necessary demand of the Laúca Hydroelectric Power Plant Project, the incinerator to be purchased will be similar to the one described below:

MODEL: RGL 200SE with Self-Combustion

DESCRIPTION: Luftech multi-chamber gasification reactor for the incineration of organic residues, with incineration capacity of 50 Kg/h of residue, generating around 200 Kw of power; semi-automatic batch feed with pneumatic drive; 220V 3-phase electric command panel; two (02) temperature sensors being one (01) in the reactor (first combustion chamber) and one (01) in the cyclone combustor (fourth and last combustion chamber); two (02) temperature indicators for the reactor and cyclone sensors, where the last one is equipped with a temperature controller; one (01) pressure sensor for the gasification chamber; one (01) gasification air fan with a 2 cv, 220/380V 3-phase motor; one (01) air-cooled grill; one (01) combustion cyclone with metallic piping internally coated with insulating refractory concrete to convey the gases and the heat released by the incineration process to the gas washer.

Energy Usage:
The Luftech incinerators release a large quantity of heat, without using auxiliary fuel, only garbage. This heat shall be not lost. There are two possible ways of using this energy that Luftech offers together with its partner companies:

1. Steam or hot water production, by means of a boiler;
2. Refrigerated water production, through a chiller system.

11. MONITORING AND CRITICAL ANALYSIS

In order to verify the efficacy of the Solid Residue Management Plan, the Laúca AH Project – River deviation will carry out a process monitoring, under the responsibility of the SUSTAINABILITY area, through:

- The periodic measurement of the generated solid residue quantity and its forms of treatment and final disposal;
- Inspections in the field and in the Residue Management Center, using specific Checklists and the general list of the Environmental Management system.

The consolidated result of such measurements will be treated as an entry item of the Critical Analyses of the Contract’s Integrated SUSTAINABILITY Program, under the responsibility of the Contract Director and its Managing Team.

12. PREVENTION AND MINIMIZATION OF RESIDUE PRODUCTION

In order to minimize residue production, the Laúca AH Project – River deviation shall adopt some criteria:

- Incorporation of environmental criteria in the public contracting process for the acquisition of goods and the rendering of services and contractor works, in order to encourage an increase in reused and recycled materials in the public contracts covering the construction;

- Selection in an adequate way of all the equipment to be purchased, taking into account the energy efficiency criteria, specifically regarding Energy-Star computers, monitors and printers (with energy consumption inhibitors in the off mode), air-conditioning equipment with “inverter” system and high performance coefficient (COP), purchase of class A electric appliances (frigorific) among others;

- Execution of contracts with specific provisions for retaking the product, upon the respective supply;

- Performance of regular maintenance in office equipment, so they will be kept in good condition and have their service life extended;
Provision of alternate internal communications circulation/distribution means (using electronic means), adoption of electronic publication practices in the inquiry of documents and reports and the creation of electronic document centers, consisting of a common database.

13. ATTACHMENTS

1. Execution Plan;
2. Flowchart of the Solid Residue Management Process;
4. Bill of Lading;
5. Plan view of the Residue Management Center;
6. Work Quarters layout;
7. Layout of the sanitary landfill sorting structure.
<table>
<thead>
<tr>
<th>SOLID RESIDUE GENERATION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>YES</strong> The residues are hazardous / contaminated? <strong>NO</strong></td>
</tr>
<tr>
<td>Segregate per type of residue: paper, plastic, glass, metal, etc.</td>
</tr>
<tr>
<td>Store in an adequate place and quantify at the final destination.</td>
</tr>
<tr>
<td>Define the final destination according to the residue characteristics.</td>
</tr>
<tr>
<td>Obtain approvals and ship to the licensed sites.</td>
</tr>
<tr>
<td>Evidence the destination according to the local legal documents.</td>
</tr>
<tr>
<td>Inform the customer with measurement data and residue monitoring – if a contractual requirement.</td>
</tr>
</tbody>
</table>

END
ATTACHMENT VI
BIRD FAUNA IDENTIFIED IN THE FIELD SURVEY
Male Cardeal tecelão vermelho (Euplectes Orix)

Perdiz de gola vermelha (Pternistes Afer)

Noitibó sardento (Caprimulgus Tristigma)

Male Macarachão de asa laranja

Rola preta

Tchagra de coroa castanha (Tchagra australis)
Male and female Macarachão de asa verde

Perdiz de gola vermelha (Pternistes Afer)

Female Viúvinha do paraíso

Male Viúvinha do paraíso

Escravedeira das pedras

Alvéola preta e branca (Motacilla aguimp)
Asa de bronze (Phaps chalcoptera)

Male Bico de prata (Ramphocelus carbo)

Peito de fogo de landanae (Lagonosticta landanae) Dead male on the road

Noitibô de welwitsch (Caprimulgus fossii)
ATTACHMENT VII
MAPS AND LAYOUTS
Legend of drawing:
ESCRITÓRIO DE CAMPO = FIELD OFFICE
REFEITÓRIO AVANÇADO = ADVANCED CANTEEN
SANITÁRIO COLETIVO = COLLECTIVE TOILETS
CENTRAL DE GERADORES = GENERATOR STATION
CENTRAL DE BRITAGEM = CRUSHING STATION
CENTRAL DE GELO = ICE STATION
LABORATÓRIO DE CONCRETO = CONCRETE LABORATORY
CENTRAL DE CONCRETO = CONCRETE STATION
CENTRAL PREMOLDADOS = PRECAST STATION
CENTRAL CARPINTARIA E ARMAÇÃO = FRAMEWORK BUILDING AND ERECTION STATION
CENTRAL DE AR COMPRIMIDO = COMPRESSED AIR STATION
CAIXA SEPARADORA DE ÁGUA E ÓLEO = WATER/OIL SEPARATION BOX
TANQUE DE DECANTAÇÃO = SEDIMENTATION TANK
PLATAFORMA DE LAVAGEM DE VEÍCULOS = VEHICLE WASHING PAD
ESTALEIRO = WORKSHOP
ATERRO SANITÁRIO = SANITARY LANDFILL
PAIOL DE EXPLOSIVOS = EXPLOSIVE STORAGE
LAYOUT GERAL = GENERAL LAYOUT
ESTALEIRO AVANÇADO = ADVANCED WORK SITE
Study of Environmental Impact of Laúca Dam Construction Project

PLANTA = PLAN VIEW

NOTES:
THE STUDIES PRESENTED HERE ARE PRELIMINARY AND MAY BE SUBJECT TO CHANGES DURING THE EXECUTION PROJECT

REFERENCE DOCUMENTS

GENERAL LAYOUT
ADVANCED WORK QUARTERS
PLAN VIEW
Study of Environmental Impact of Laúca Dam Construction Project

Legend of drawing:
SUBESTAÇÃO = SUBSTATION
CENTRAL ECOLÓGICA = ECOLOGIC POWER PLANT
TÚNEL DE ACESSO = ACCESS TUNNEL
DESCARREGADOR DE FUNDO = BOTTOM DISCHARGER
BARRAGEM = DAM
DESCARREGADOR DE CHEIAS = SPILLWAY
TÚNEIS DE DESVIO = DEVIATION TUNNELS
TOMADA D’ÁGUA = WATER INTAKE
CENTRAL PRINCIPAL = MAIN POWER PLANT
PLANTA = PLAN VIEW
NOTE:
ALL DIMENSIONS IN METERS
LAÚCA HYDROELECTRIC POWER PLANT
BASIC PROJECT
GENERAL
GENERAL ARRANGEMENT
PLAN VIEW
Legend of drawing:
SUBESTAÇÃO = SUBSTATION
CENTRAL ECOLÓGICA = ECOLOGIC POWER PLANT
TÚNEL DE ACESSO = ACCESS TUNNEL
DESCARREGADOR DE FUNDO = BOTTOM DISCHARGER
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DESCARREGADOR DE CHEIAS = SPILLWAY
TÚNEIS DE DESVIO = DEVIATION TUNNELS
TOMADA D’ÁGUA = WATER INTAKE
CENTRAL PRINCIPAL = MAIN POWER PLANT
PLANTA = PLAN VIEW
ENSECADEIRA = COFFERDAM
MARGEM DIREITA E ESQUERDA = RIGHT AND LEFT BANK
BACIA DE DISSIPAÇÃO = DISSIPATION BASIN
GALERIA DE DRENAJEM = DRAINAGE TUNNEL
N.A. MIN = MINIMUM WATER LEVEL
BETÃO DE BASE = BASE CONCRETE
Corte = SECTION
TOMADA CENTRAL ECOLÓGICA = ECOLOGIC POWER PLANT INTAKE
Study of Environmental Impact of Laúca Dam Construction Project

LAJE DE INJEÇÃO = INJECTION SLAB
DETALHE = DETAIL
DETALHE TÍPICO = TYPICAL DETAIL
BETÃO CONVENCIONAL = CONVENTIONAL CONCRETE
BETÃO COMPACTADO COM CILINDRO = CONCRETE COMPACTED WITH CYLINDER
ESCALA GRÁFICA = GRAPHIC SCALE
REVISÃO GERAL = OVERALL REVISION

NOTE:
ALL DIMENSIONS AND ELEVATIONS IN METERS

LAÚCA HYDROELECTRIC POWER PLANT

BASIC PROJECT

TITLE:
BCC DAMS
GENERAL ARRANGEMENT
PLAN VIEW AND SECTIONS
Scale INDICATED
Sheet
Intertechne Code 1208-LA-4-GE-G00-00-C-00-DE-0015
Revision BA
Customer Code AHL- DE2-02B01-0001
Revision 0BA
Legend of drawing:
BARRAGEM = DAM
ESCADAS = STAIRWAYS
ELEVADOR = ELEVATOR
POÇO DE VENTILAÇÃO E ACESSO = VENTILATION SHAFT AND ACCESS
CENTRAL OLEODINÂMICA = OIL-DYNAMIC UNIT
MONOVIA = MONORAIL
SERVOMOTOR = SERVOMOTOR
N.A. MAX. MAX. = MAXIMUM OF MAXIMUMS WATER LEVEL
N.A. NOR. = NORMAL WATER LEVEL
FLUXO = FLOW
HASTE = ROD
GALERIA DE DRENAGEM = DRAINAGE TUNNEL
COMPORTA VAGÃO = WAGON GATE
N.A. MIN. = MINIMUM WATER LEVEL
GRADE = GRATING
GALERIA DE ACESSO = ACCESS TUNNEL
Study of Environmental Impact of Laúca Dam Construction Project

CORTE = SECTION
PLANTA = PLAN VIEW
AERAÇÃO = VENTILATION
ABERTURA DA COMPORTA = GATE OPENING
CONDUITO FORÇADO = PENSTOCK
JUNTA DE DILATAÇÃO = EXPANSION JOINT
APOIO DESLIZANTE = SLIDING SUPPORT
CENTRAL ECOLÓGICA = ECOLOGIC POWER PLANT
MURO = WALL
COBERTURA METÁLICA (TERMOACÚSTICA) = METALLIC ROOF (THERMOACUSTIC)
PONTE ROLANTE = OVERHEAD CRANE
TRANSFORMADOR = TRANSFORMER
DISTRIBUIDOR = DISTRIBUTER
PROJEÇÃO POÇO DE ESGOTAMENTO = DRAINAGE WELL PROJECTION
UNIDADE = UNIT
DESVIO DO RIO = RIVER DEVIATION
TOMADA DE ÁGUA = WATER INTAKE
PLANTA CHAVE = KEY PLAN VIEW
SEM ESCALA = WITHOUT SCALE
BETÃO CONVENCIONAL = CONVENTIONAL CONCRETE
BETÃO COMPACTADO COM CILINDRO = CONCRETE COMPACTED WITH CYLINDER
REVISÃO GERAL = OVERALL REVISION

NOTE:
ALL DIMENSIONS AND ELEVATIONS IN METERS

LAÚCA HYDROELECTRIC POWER PLANT

BASIC PROJECT

TITLE:
ECOLOGIC POWER PLANT GENERATION CIRCUIT
GENERAL ARRANGEMENT
PLAN VIEW AND SECTIONS
Scale INDICATED
Sheet
Intertechne Code 1208-LA-4-GE-G00-00-C-00-DE-0019
Revision B
Customer Code AHL- DE2-09B01-0001

Revision 0B
Map Legend:
ENTRADA AH-LAÚCA = LAÚCA AH ENTRANCE
Projeção de albufeira = Reservoir projection

NOTE:
1. Dimensions are indicated in kilometers or otherwise

LAÚCA AH RIVER DEVIATION

GENERAL
RESERVOIR PROJECTION
PLAN VIEW
DRAWING NO. LAU-DR-DE-36D-39-003
DATE 03/07/2012
SHEET 01
SCALE 1:125

REVISION 00
Legend of drawing:
BOTA-FOR A = DISPOSAL AREA
ACESSO A DESMBOQUE = ACCESS TO DISCHARGE
SEÇÃO = SECTION
TABELA DE COORDENADAS DE BOTA FOR A = DISPOSAL AREA COORDINATES TABLE
PONTO = POINT
NORTE = NORTH
ESTE = EAST
ELEVAÇÃO = ELEVATION

NOTE:
1. DISPOSAL AREA 1 WILL BE USED FOR CONTAMINATED MATERIAL
2. DISPOSAL AREA 2 WILL BE USED FOR THE STORAGE OF MATERIAL PRODUCED BY THE OPEN AIR EXCAVATION OF THE DOWNWARD DISCHARGE STEP OF EL.: 800.00
3. THE DISPOSAL AREAS WILL BE USED AS WORK PLATFORMS FOR THE RIVER DEVIATION TEAMS

LAÚCA AH – RIVER DEVIATION
DISPOSAL AREA
DISPOSAL AREA ACCESS ZONE TO DISCHARGE
PLAN VIEW, SECTIONS
DRAWING NO. LAU-DR-DE-300-91-001
DATE 10/25/2012
SHEET 01
SCALE 1:1000 REVISION 00
Legend of the drawing:
ÁREA DE ESTOQUE CÉU ABERTO = OPEN AIR STORAGE AREA
VAI PARA A REDIDÊNCIA ... = GOES TO PLANT OWNER’S RESIDENCE
VAGAS = PARKING PLACES
EXISTENTE = EXISTING
VAI PARA OS ESCRITÓRIOS = GOES TO OFFICES
VAI PARA PAIOL DE EXPLOSIVOS ... = GOES TO THE WAREHOUSE OF EXPLOSIVES, ACCESSORIES AND SANITARY LANDFILL
CERCA DO ESTALEIRO = WORK QUARTERS FENCE
COORDENADAS = COORDINATES
PTO = PONT
E = EAST
N = NORTH

DISCRIMINATION:
1. RAW WATER TANK
2. WATER TREATMENT STATION
3. DRINKING WATER TANK
4. TIRE STORAGE
Study of Environmental Impact of Laúca Dam Construction Project

5. GAS STORAGE
6. OIL STORAGE
7. TRAINING AREA
8. IT ROOM
9. GENERATOR
10. GENERAL SERVICES
11. PRODUCTION
12. PRODUCTION
13. CONTRACTOR’S OFFICE – PLANNED
14. ANTENNA
15. CONTRACTOR’S OFFICE
16. CONTAINER
17. VEHICLE WASHING PLATFORM – MECHANICAL WORKSHOP
18. LUBRICATION AND TIRE REPAIR WORKSHOP
19. MEDIUM VEHICLE MAINTENANCE WORKSHOP
20. SECURITY’S PAINTING SHOP
21. SUSTAINABILITY
22. MAIN PARKING LOT
23. WAREHOUSE
24. DECANTING TANK
25. HEAVY VEHICLE MAINTENANCE WORKSHOP
26. MEDIUM VEHICLE MAINTENANCE WORKSHOP
27. AUDITORIUM
28. WATER / OIL SEPARATION TANK
29. HEALTHCARE FACILITY
30. GAMEK’S OFFICE
31. CONTRACTOR’S OFFICE – HR
32. PLANT OWNER’S OFFICE
33. LIGHT VEHICLE MAINTENANCE WORKSHOP
34. CONTRACTOR’S OFFICE TRANSIT AND SUBCONTRACTING
35. CONTRACTOR’S OFFICE ENGINEERING
36. LOCKER ROOM
37. ROOM FOR INTRODUCTION INTO THE WORKS
38. MOTORCYCLE PARKING LOT
39. MAIN GATE
40. VEHICLE SCALE
41. BUS PARKING LOT
42. GENERATOR ROOM
43. MAIN CANTEEN
44. MAIN CANTEEN PARKING LOT
45. LEISURE AREA AND CORPORATE EVENTS
46. FUEL STORAGE
47. BUS PARKING LOT
48. BUS DRIVER ROOM
49. BUS DRIVER TOILET
50. BUS PARKING LOT
51. COOKING GAS BOTTLE STORAGE
52. COOKING GAS TANK STORAGE
53. BUS PARKING LOT
54. LEADER’S LODGING
55. SOCIAL SOCCER
56. MULTISPORT COURT
57. OPERATIONAL LODGING
58. TENNIS COURT
59. SEWAGE TREATMENT STATION
60. OPEN AIR ACADEMY
61. TECHNICIAN’S LODGING
62. SOCCER FIELD
63. OPERATIONAL LODGING
64. FEMALE OPERATIONAL LODGING
65. INDUSTRIAL LAUNDRY
66. MANUAL LAUNDRY TANKS
67. DRYING CORD
68. SUSTAINABILITY
69. SUSTAINABILITY
70. CARPENTRY CENTER
71. STEELWORK CENTER
72. CARPENTRY AND STEELWORK TOILET
73. CARPENTRY AND STEELWORK DEPOSIT
74. PROVISORY SOIL LABORATORY
75. PROVISORY SOIL LABORATORY
76. PROVISORY SOIL LABORATORY
77. SEEDLING BED - SUSTAINABILITY
78. LEISURE AREA COURTS
79. EMPLOYEE’S PARKING PLACES
80. CONTRACTOR’S RESIDENCE
81. PLANT OWNER’S RESIDENCE
82. UNITEL ANTENNA
83. WATER RESERVOIR
84. REST ROOMS
85. PLANT OWNER’S RESIDENCE COURTS
86. SEPTIC TANK
87. FOUNDATION STONE AND FLAGS
88. EMPLOYEE LEISURE AREA
89. PROVISORY SEEDLING BED - SUSTAINABILITY
Study of Environmental Impact of Laúca Dam Construction Project

ADVANCED / INDUSTRIAL WORK QUARTERS
GENERAL LAYOUT
PLAN VIEW

DESIGNED BY J.A.
CHECKED BY INDICATED
DATE 04/22/2013
SCALE INDICATED
ODEBRECT NO. LAU-OC-DE-360-39-010_R00
SHEET 00/00
Study of Environmental Impact of Laúca Dam Construction Project

Legend of the drawing:
ESTALEIRO – WORK QUARTERS

DISCRIMINATION:
1. FIELD OFFICE
2. ADVANCED CANTEEN
3. COLLECTIVE TOILET
4. GENERATOR CENTER
5. CRUSHING CENTER
6. ICE CENTER
7. CONCRETE CENTER
8. CONCRETE LABORATORY
9. VEHICLE WASHING PLATFORM
10. DECANTING TANKS
11. WATER / OIL SEPARATION TANKS
12. PRE-MOLDED CENTER
13. CARPENTRY AND STEELWORK CENTER
14. COMPRESSED AIR CENTER
Study of Environmental Impact of Laúca Dam Construction Project

15. ADVANCED CANTEEN
16. SANITARY LANDFILL
17. ACCESSORIES WAREHOUSE
18. EXPLOSIVES WAREHOUSE
19. PLANT OWNER’S AND CONTRACTOR’S RESIDENCE

LAYOUT
ADMINISTRATIVE WORK QUARTERS
PLAN VIEW
Legend of the drawing:
MANTA PEAD = PEAD CANVAS
DIQUE = DYKE
DRENO CANAFLEX .... = CANAFLEX DRAIN WITH CRUSHED STONE
NA = WATER LEVEL
EXTENSÃO DA VALA = TRENCH LENGTH
CAIXA DE PASSAGEM = CONNECTION BOX
MANILHA = PIPE
DEPÓSITO = DEPOSIT
TUBO = PIPE
JÁ EXECUTADOS = ALREADY BUILT
ÁREA RESERVADA = RESERVED AREA
PLANTA = PLAN VIEW
CORTE = SECTION
VALA EM UTILIZAÇÃO = TRENCH IN USE
VALA PREPARADA = PREPARED TRENCH
PLANTA CHAVE = KEY PLAN VIEW
ATERRO SANITÁRIO = SANITARY LANDFILL
PAIOL DE EXPLOSIVOS = EXPLOSIVES WAREHOUSE
DOCUMENTOS DE REFERÊNCIA = REFERENCE DOCUMENTS

NOTES:

1. OPEN AREA IN USE
2. AREA RESERVED FOR EXPANSION
3. COVERED AREA
4. KEEP ONE TRENCH IN USE AND ONLY ONE SECOND TRENCH PREPARED FOR THE CONTINUATION OF THE LANDFILL

THE STUDIES PRESENTED HERE ARE PRELIMINARY AND CAN UNDERGO CHANGES DURING THE EXECUTION PROCESS

ADMINISTRATIVE WORK QUARTERS
SANITARY LANDFILL
PLAN VIEW AND SECTIONS

SCALE INDICATED
CONTRACTOR NO.
ODEBRECHT NO. (ILLEGIBLE)
SHEET
Legend of the drawing:
ENTRADA = ENTRANCE
Caixa de Betão = Concrete Tank
PLANTA = PLAN VIEW
CAIXA = TANK
EIXO = AXIS
VEJA DETALHE = SEE DETAIL
SEÇÃO = SECTION
CAPACIDADE POR CADA ... = CAPACITY PER LANDFILL
ÁREA VERDE = GARDEN
CERRAMENTO = FENCE
Brita = Crushed Stone
PLANTA CHAVE = KEY PLAN VIEW
SIN ESCALA = WITHOUT SCALE
MALHA = MESH
POSTE DE CONCRETO = CONCRETE POST
DETALHE = DETAIL
POSTE = POST
CONCRETO = CONCRETE

NOTE:
1. Dimensions in meters unless indicated otherwise

Cambio de desenho = Drawing change
REV. = REVISION
NATUREZA DA REVISÃO = NATURE OF THE REVISION
ELABORADO = PREPARED BY
VERIFICADO = CHECKED BY
APROVADO = APPROVED BY
DATA = DATE
TABELA DE QUANTIDADES DE .... = MATERIAL QUANTITY TABLE
DESCRIÇÃO = DESCRIPTION
QUANT. = QUANTITY
UNIDADE = UNIT
Postes de betão = Concrete posts
Área da malha = Mesh area
Dreno CANNAFLEX = CANNAFLEX Drain
Tubulação = Piping
Betão para caixas = Concrete for boxes
Volume concreto para piso caixa = Concrete volume for box bottom
Volume concreto para piso aterro = Concrete volume for landfill bottom
Volume concreto para colocar .... = Concrete volume for placing posts
Volume de brita = Crushed stone volume

TABLE OF SANITARY LANDFILL COORDINATES
PONTO = POINT
NORTE = NORTH
ESTE = EAST

LAÚCA AH RIVER DEVIATION

TITLE:
DEFINITIVE WORK QUARTERS
SANITARY LANDFILL
PLAN VIEW, SECTIONS AND DETAILS

DRAWING NO. LAU-LA-DE-134-03-002
DATE 05/16/2012
SHEET 01
SCALE VAR.
REV. 02
NOTES:
1- ALL DIMENSIONS AND ELEVATIONS IN METERS

LEGEND:
QUATERNARY: ALLUVIAL DEPOSITS
GRAVEL, SAND AND CLAY
QUATERNARY: ALLUVIAL-PROLUVIAL DEPOSITS
ANGLED BOULDERS, SAND AND CLAY
UPPER PROTEROZOIC – UPPER RIFTEAN / VENDIAN
NON-DIFFERENTIATED GRESOUS SCHIST, META-ARENITE WITH THICK STRATIFICATION, META-SILTITE; CEMENTED GRAVEL AND META-CONGLOMERATES ON THE BASE
UPPER PROTEROZOIC – MEDIUM-UPPER RIFTEAN
CALCAREOUS SCHIST GROUP, ALTERNATING META-ARENITE, ARGILITE, DOLOMITE, LIMESTONE, CEMENTED GRAVEL AND META-CONGLOMERATES ON THE BASE
LOWER PROTEROZOIC – OENDOLONGO GROUP
META-CONGLOMERATES, QUARTZITE, META-ARENITE, META-SILTITE, GREYWACKE, MICACEOUS SCHIST, QUARTZITE
**UPPER ARCHEAN/LOWER PROTEROZOIC**
GNEISS, AMPHIBOLITE SCHIST, QUARTZITE, CHARNOCKITE, ITABIRITE LENSES
**LOWER PROTEROZOIC INTRUSIONS**
BIOTITIC GRANITE AND SYONITE-DIORITE OF THE QUIBALA COMPLEX
**UPPER ARCHEAN INTRUSIONS**
COMPLEX OF BIOTITIC GRANITE AND REGIONAL GRANODIORITE

**STRUCTURES:**
- FAILURE CHECKED (a) AND INFERRED (b)
- CONTACT CHECKED (a) AND INFERRED (b)
- VERTICAL FOLIATION DIRECTION
- LAYER DIRECTION AND DROP
- DAM AXIS
- TUNNEL AXIS
- RESERVOIR

**Corte = Section**
**Planta = Plan View**
**Escala Gráfica = Graphic Scale**
**Troca de Carimbo = Legend Change**

**LAÚCA HYDROELECTRIC POWER PLANT**

**Title:**
GENERAL - GEOLOGY
REGIONAL GEOLOGICAL MAPPING
PLAN VIEW

Scale INDICATED
Sheet
Document code 0704-MK-DE-110-12-101

Revision B
ALTIMETRIC SCALE (METERS):
acima de = above
abaixo de = below

LEGEND:
BORDER OF THE DIRECT INFLUENCE AREA
MEDIUM QWANZA BORDER
URBAN AREA
PROVINCE BORDER
Study of Environmental Impact of Laúca Dam Construction Project

LAÚCA AHE
CAPANDA AHE
WATER SPRINGS
RAILWAYS
CART TRAILS
ROADS
LEVELED ROADS

NOTES:
1- SRTM3 ALTIMETRIC DATA WITH 90 M-RESOLUTION
2- DATA SOURCE: MAP SCALE 1:500,000, PUBLISHING YEAR: 1991
   (SHEET 4 – UIGE, SHEET 7 – LUANDA, SHEET 8 – MALANGE, SHEET 11 – SUMBE, SHEET 12 – ANDULO)
3- WGS PROJECTION 1984, FUSE 33 S

ESCALA GRÁFICA = GRAPHIC SCALE

LAÚCA HYDROELECTRIC POWER PLANT

title:
GENERAL
ALTIMETRY OF THE MEDIUM KWANZA BASIN
MAP

Scale INDICATED
Sheet
Document code 0704-LA-DE-140-15-002
Revision A
Study of Environmental Impact of Laúca Dam Construction Project

TYPES OF SOIL:
1. FLIVIAL ALLUVIAL SOILS
2. HYDROMORPHIC ORGANIC SOILS
3. MUD
4. OXY-SIALITIC SOILS
5. ARENOUS BROWN SOILS
6. FERRALITIC SOILS
   a. Typical ferralitic
   b. Poorly ferralitic (of consolidated sedimentary rock)
Study of Environmental Impact of Laúca Dam Construction Project

c. Poorly ferralitic (of crystalline rock)
d. Ferralitic with laterite
e. Arenous ferralitic

7. PARAFERRALITIC SOILS
   1. Paraferralic
   2. Paraferralic associated to lithosols

8. PSAMITIC SOILS
   a. Psamitic of humid regions
   b. Psamitic and Psamoferralic
   c. Psamo-fersialic
   d. Psamoferralic

9. TROPICAL ARIDIC SOILS
10. BROWN CALCAREOUS SOILS
11. CALCIALITIC SOILS OF SUB-HUMID REGIONS
12. TROPICAL FERSIALITIC
13. SOILS WITH LATERITIC MATERIALS CLOSE TO THE SURFACE
14. LITHOSOLS AND ROCK UPCROPS
15. ROCKY TERRAIN AND ROCK OUTCROPS

LEGEND:
SOIL CODE

PROVINCE BORDER
URBAN AREA
BORDER OF THE DIRECT INFLUENCE AREA
MEDIUM KWANZA BORDER
RAILWAYS
CART TRAILS
ROADS
LEVELED ROADS
WATER SPRINGS
LAÚCA AHE
CAPANDA AHE

NOTES:
Study of Environmental Impact of Laúca Dam Construction Project

2- DATA SOURCE: MAP SCALE 1:500,000
(SHEET 4 – UIGE, SHEET 7 – LUANDA, SHEET 8 – MALANGE, SHEET 11 – SUMBE, SHEET 12 – ANDULO)
3- WGS PROJECTION 1984, FUSE 33 S

ESCALA GRÁFICA = GRAPHIC SCALE

LAÚCA HYDROELECTRIC POWER PLANT

title:
GENERAL
ISODECLIVITY OF THE MEDIUM KWANZA BASIN
MAP

Scale INDICATED
Sheet
Document code 0704-LA-DE-140-16-001

Revision A