

MUCANHA-VUZI COAL DEVELOPMENT PROGRAMME

PHASE II

TECHNICAL AND COMMERCIAL PROPOSAL

S U M M A R Y

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## FOREWORD

The Popular Republic of Mozambique presents, for the consideration of the OPEC Fund for International Development, the technical and commercial proposal which follows up the exploration and development programme for the coal deposits at Mucanha-Vuzi, in the Province of Tete. The proposed second phase of the Mucanha-Vuzi Programme is an integral and vital part of the project which aims at increasing the production and transportation capacity of coal in Mozambique, in cooperation with other countries, particularly with the Federative Republic of Brazil.

As is known, the project for the development and full utilization of the immense coal reserves in Mozambique should create one of the country's main economic and social development centres, and as such, is a project of national priority.

To illustrate these observations, the continuation of the project will give rise to increasing cooperation between developing countries, using their own materials and human resources. In the particular case of bilateral cooperation with Brazil, this project will initiate important commercial exchanges and an increased potential for cooperation between the two countries.

The special effort of the Brazilian consultants agencies involved in Phase I of the Mucanha-Vuzi Project resulted in their work being speeded up, so, enable the conclusion of the final report and presentation of results two months ahead the schedule. Based on the conclusive results and recommendations of the Phase I, this proposal was conceived. It also represent an enhanced and definitive version of a preliminary draft proposal presented to the OPEC Fund in October/1982.

It presents an outline of the technical and investment programme to enable the OPEC Fund to evaluate its interest in continuing to participate in the Coal Project for Mozambique.

This document is divided into two parts: the first, containing the technical proposal, and the second, containing the commercial proposal and the financial bases of the programme.

### *A.1 - Antecedents and Objectives*

The technical proposal here presented is based on the conclusive results and recommendations expressed in the Final Report of the Mucanha-Vuzi Coal Development Program. Phase I This program was object of a services contract signed on 01.12.1982 between the Cabinet of State Secretariat for Coal and Hydrocarbons - GSECHI of the People's Republic of Mozambique and Companhia de Pesquisa de Recursos Minerais - CPRM, a Brazilian state company.

The large quantity and quality of data and informations gathered on all of the multi-disciplinar aspects involved in the project, provided a clear and sound basis for the proposed follow up study. Above all it should be emphasized the huge volume found of metallurgical grade coal reserves, suitable to open pit mining. In fact, the measured and indicated coal reserves, guarantee the basic conditions required for the installation of an important mining complex which would ensure a volume of production necessary to make viable the cost of mining, preparation and a competitive transport system.

The objectives of the technical proposal under discussion are:

1. A detailed geological report on the deposits up to the stage of setting up the mining project.
2. Basic Mine Project, Preparation Installations and Auxiliary Works.
3. Basic Transport System Project for the Out-Flow of Production of the Mucanha-Vuzi Region coal.
4. Definition of the Technical, Economic and Financial viability of the enterprise.
5. Studies of Alternatives for Integrated Regional Development and Land Occupation-Middle Zambeze.

The basic projects mentioned will be detailed to a standard suitable for tenders, thus enabling a one year's advance on the original time-table for the development of the Mucanha-Vuzi coal.

## A.2 - AREA AND GEOGRAPHICAL LOCALIZATION

The coal-field area of Mucanha-Vuzi, which constitutes the potentially most important part of the extensive Chicooa-Mecucoe coal basin, situated in the province of Tete along the Zambeze River, on the high side of the Cahora-Bassa dam, is almost all located in the district of Magoe and in a small part of the district of Maravia, bordering the north shore of the Cahora-Bassa Lake. It occupies an area of a little more than 300 Km<sup>2</sup> (40 Km in length by an average width of about 8 Km), although about 40% of this area is permanently submerged under the above mentioned lake. In extreme cases of the rise of the level of the waters (catastrophic flood), a little over 50% of the area might be submerged.

The Mucanha-Vuzi programme, at present being executed by the CPRM, is located on the central-north part of the Chicooa-Mecucoe Basin, between the 31°15'W and 31°28'W meridians, a zone dominated by the Rivers Bohozi and Vuzi. The second phase of the Mucanha-Vuzi Programme with which the present proposal is concerned, will be developed in the western part of that area, that is, in the coal field of the Bohozi River, which extends to the east up to the region dominated by the Mucanha River.



### A.3 - SCOPE AND METHODOLOGY OF THE UNDERTAKING

The projects to be undertaken are structured around three programs:

- 1 - Geological Exploration Programme
- 2 - Basic Transport System Project
- 3 - Basic Project for the Mine and a Study of the Economic, Financial and Social Viability.

Each programme is in its turn composed of a certain number of activities, detailed in Chart I, and discussed in detail on the following pages.

A.3.1.- GECLOGICAL EXPLORATION  
PROGRAM.

### A.3.1 - Geological Exploration Program.

The first phase of the Mucanha-Yuzi coal geological exploration program, now concluded, pointed-out to the occurrence of large reserves of metallurgical grade coal, in quantities well above 1.5 billions tons, as is shown in detail on the chapter 3 of this report.

The geological informations gathered during the above mentioned program permit to confirm, confidently, the extension to the east, as far as the Mucanha river, of the same coal seams studied in the Bohozi Block. On account of this, a total extension of about 26 km along the strike, can be estimated for the outcropping coal bearing sequence in the Bohozi-Mucanha coal field.

Within this context, the part studied, up to now, by CPRM correspond to about 12 km in length, that is almost half of the total coal field extension.

The geological exploration program, also extended to a hydrogeological survey, now proposed, was conceived based on the conclusions and recommendations expressed on the items 3.4 and 3.5 and also 7,5 of this report. The main objectives of the proposed plan are:

- . Detailed exploration of the  $B_1$ ,  $B_2$  and  $B_3$  coal seams in the Bohozi Block, up to the level required by the planning and implementation of the mining project.

- . Detailed hydrogeological survey on the Bohozi Block area aimed at quantitative studies on the shallow aquifers and at studies on water infiltration from the Cahora Bassa reservoir into the coal bearing sequence.

The proposed exploration program contains seven general activities, described in detail as follows:

### A.3.1.a - Surface and Sub-surface Geological Services.

The total selected area of the Bohozi Block for detailed studies comprises about 96 km<sup>2</sup>, out of which about 50 km<sup>2</sup> correspond to the area of direct interest of the B<sub>1</sub>, B<sub>2</sub> and B<sub>3</sub> coal seams. The selected area is represented on the Annex I, and is limited by the UTM coordinates: 8,270,000 mN to 8,278,000 mN; 328,000 mE to 340,000 mE.

About 50 km<sup>2</sup> will be geologically mapped on the scale 1:1,000, with accurate topographic support for the location of outcrops, coal outcrop lines, fault zones and any other geological accidents considered to be relevant. In the same way, the top and bottom layers enclosing the coal seams will be mapped out in the detail required by the scale and their mechanical properties assessed.

The sub-surface exploration will be based on a squared drilling grid of 250m x 250 m, designed to study the B<sub>1</sub>, B<sub>2</sub> and B<sub>3</sub> coal seams in the areas of less than 80 meters of overburden thickness, schematically represented on the map of Annex I.

The sub-surface geological work will also include the integration of all the information produced by the drilling campaign together with the surface geological data, in order to obtain detailed knowledge of the geometry of the deposit in three dimensions, by means of sections and tri-dimensional models.

Estimate of the coal reserves, will take into account the measured, indicated and inferred reserves of each of the individual blocks of the deposit, which together will make up the total amount of reserves. Statistical methods and, if considered necessary or suitable, geo-statistical methods, will be used to estimate the reserves and also for the study of the distribution of some-variables.

The information produced from the physical chemical and technological studies will be presented in distribution maps for some

parameters considered important for planning the mining operation, such as the sulfur content, washing yield for specific ash content etc.

The detailed geological services will further produce isopac maps for all the coal seams of economic importance and isopac maps of the overburden, made out on a scale of 1:1,000, for the whole studied area of the deposit.

The hydrogeological studies will be directed to the following objectives:

a. Investigations of the Bohozi Block free aquifer in order to define its probable influence on future open pit mining operations. Quantitative studies will define the volumes of ground water infiltration to be expected, and the others parameters necessary to the preparation of open pit drainage systems projects.

b.- Detailed studies on the hydrogeological conditions on the bordering area of the Cahora Bassa lake, to investigate the level and extension of eventual infiltrations of the lake waters towards the future mining areas.

A piezometer observation net will be set up on the Bohozi area, using as observation points, selected coal exploration DDH, as well as, specially designed hydrogeological wells. For quantitative evaluations of the free aquifer, pump-test wells will be drilled and constructed according to the basic design of figure 12. Special piezometers wells will be drilled in sections perpendicular to the lake margins to investigate the hydraulic gradient towards the coal bearing sequences.

All the hydrogeological data will be presented in maps, sections etc, at scales adequate to the detailed level of the investigations.

#### A.3.1.5 - Drilling Campaign

To draw up the proposed plan, consideration was given, first of all, to the information generated by the drilling campaign and geological mapping of Phase I of the Mucanha-Vuzi Programme, and secondly to the degree of detail of the characteristics of the deposit, necessary for the definition and setting-up of the mining project.

For the Bohozi Bloch area a square drilling grid (250m x 250m) will be set on the areas of less than 80 meters of overburden, for exploration of the B<sub>1</sub>, B<sub>2</sub> and B<sub>3</sub> coal seams. As can be seen in Annex 1, and on the table A, about 242 DDH with an average depth of 85 meters will be drilled, which sum up to 20,570 meters of total drilled length.

For the hydrogeological studies, about 1,430 meters of total drilled length will be necessary, distributed as follows: four pump-test wells of about 90 meters depth, each, according to the basic design of figure 12; about 14 observations wells in sections perpendicular to the lake margins, with an average depth of 75 meters.

Beside the special purpose hydrogeological wells, a piezometer observation net will be set, as commented above.

For the whole program, a total of 22,000 meters of drilling have been planned, to be distributed among about 250 boreholes. For the actual location of each drillhole, the existing DDH will be taken into consideration, and a careful analysis of the geological data will be made, in order to find the most effective use for the proposed drilling length.

The drilling operation must follow the undermentioned procedure

. Topographic location and levelling of all DDH collars;

. DDH diameters will be 8" size, except those which present technical problems, being possible reduced to "6" size. The hydrogeological pump test wells, shall have a diameter not less than 10 inches;

.Continuous DDH coring, with recovery not less than 90 % in sedimentary barren rocks, and of 90 % in coal seams.

.The drill cores will be encased in wooden boxes with a rigid bottom and latter described in drill-logs. The coal seam will be cut length-wise, described in detail by the Schop (USGS) method and packaged in plastic bags to be sent to the laboratory for testing, trials and analysis.

#### A.3.1.c - Geophysical Profiling (logging)

After the conclusion of each drillhole a standard set of geophysical logs will be run. It is proposed the same type of logs used in the first phase of the program, i.e., gamma-rays, spontaneous potential and resistance, and additionally the density, caliper and sonic logs, which are particularly recommended for detailed coal exploration programs.

The combined geophysical log display of gamma-ray, resistance, s.p., density, caliper and sonic logs, would considerably increase the geological detail of the Mucanha-Vuzi coal deposit, also allowing to obtain a better interpretation of the structural configuration of the coal seam.

All profiles will be run on the 1:500 and 1:100 scales, in all the DDHs, which have previously been conditioned with adequate drill mud for optimizing the responses of the electric profiles.

About 20,000 metres of DDHs will be profiled which corresponds to approximately to the total of uncased drill holes. Because of the rate of progress expected for the drilling campaign, two geophysical profiling teams will be employed.

#### A.3.1.d - Chemical and Technological Analysis

In order to obtain petrographic, physical, chemical and technological data on the coal, the drilling cores, and /or channel samples after being described, will be packaged in plastics bags and sent to a specialized laboratory where the following analysis and trials will be made:

.Sink and float tests will be performed on all coal samples. The analytical routine will be the same adopted for the first phase of the program, i.e., crushing in the granulometric range  $1/8''$  x 200 mesh, and using the same heavy liquid densities. Ash content, moist, F.S.I., volatile matter and sulfur, will be determined on all coal light fractions. Sulfur determinations will be carried out also on the total coal samples. Calorific value and specific gravity will be determined for the 1.65 floated fraction and for the total sample, on one out of five sample from each coal seam. According to the number of planned DDH, about 800 samples is expected to be analysed.

. In one out of thirty samples, major and minor elements in the ashes, H;G;I; and ash fusibility determinations will be performed, totaling about 40 samples analysed for each item.

. Elementar analyses (C,H,O,N) in at least 3 samples for each coal seam, will be performed.

. For each coal seam a complete and typical section will be sampled as block sample for micropetrographic studies. About six samples will be studied for maceral microlithotypes and reflectance.

.For each main coal seam a channel sample weighting between 500 kg to 1,000 kg, will be crushed in different maximum sizes ( $3''$ ,  $1\ 1/2''$ ,  $1/2''$  and  $1/8''$ ), for sink and float tests at density interval of 0.05, from 1.30 to 1.90 and  $1.10$  to  $2.10$ . The coal fines will also be tested on flotation and hydrociclones.



. Geomechanical tests of density, porosity, uniaxial and diametral compressive strength tests will be performed in all lithologies found as the main coal seams overburden, up to 40 meters thick. A complete series of tests for each mining sections, totaling about 50 determinations for each test, is planned.

. For one out of thirty sample and at least one for each mining front, coking properties tests as Audibert-Arnu Dilatometry, Gieseler Plastometry, micropetrography and ash alkalis ( $\text{Na}_2\text{O} + \text{K}_2\text{O}$ ), will be performed.

.Oven coking tests is proposed for all light fraction obtained from the channel samples of all main coal coal seams.

#### A,3.1,e - Detailed Topographical Survey

The detailed topographical survey of an area of  $50 \text{ km}^2$  is proposed, which will cover all the selected area of the coal field.

The planned services will produce 'planialtimetric' maps on a scale of 1:1000, with equidistance levelling of one metre.

The maps will be obtained by ground topographical survey, executed by three teams of two surveyors each, at the precision level required by the map scale.

The work of locating and levelling the drilling network, the coal seams outcropping lines, and any other relevant geological accident, as well as all the auxiliary topographical services necessary for the surface geological teams, are included in this item.

All the topographical work to be undertaken, will be conducted based on the points with known planialtimetric coordinates, which have already been transferred and fixed in the area during the first phase of the project.

The final art-work will consist of a cartographical drawing on a rigid polyester base from which transparencies or ordinary heliographic copies can be made.

#### A.3.1.f - Data Compilation and Processing

The following activities are included in this task;

- Visual analysis and description of core drilling in the scale of 1:500 and 1:100 and of coal seams in the scale of 1:20.
  - Interpretation and adjustment of geophysical "logs" to the lithological "logs" and mounting a compound profile of each DDH.
  - Study and interpretation of the results of the results of the physical-chemical analysis and tests.
  - Preparation of the matrixes of physical data of the physical-chemical properties of the coal seam, for processing later.
  - Electronic processing of numerical data in order to define distribution behaviour and statistical estimators for several variables characteristic of the deposit.
- Variographic analysis of physical and physical-chemical parameters considered relevant for the upgrading of the mining plan.
- All information generated by the geomechanical tests will also be processed and integrated, in order to up-grade the methods of removing the over-burden and improve the pit operation.

#### A.3.1.g - Coordination; Consultancy and Final Report

During the whole period, the programme at a technical and administrative level, will be under the responsibility of two coordinators, one in Brazil and the other in Mozambique, both eventually assisted by specialist consultants recruited for specific tasks.

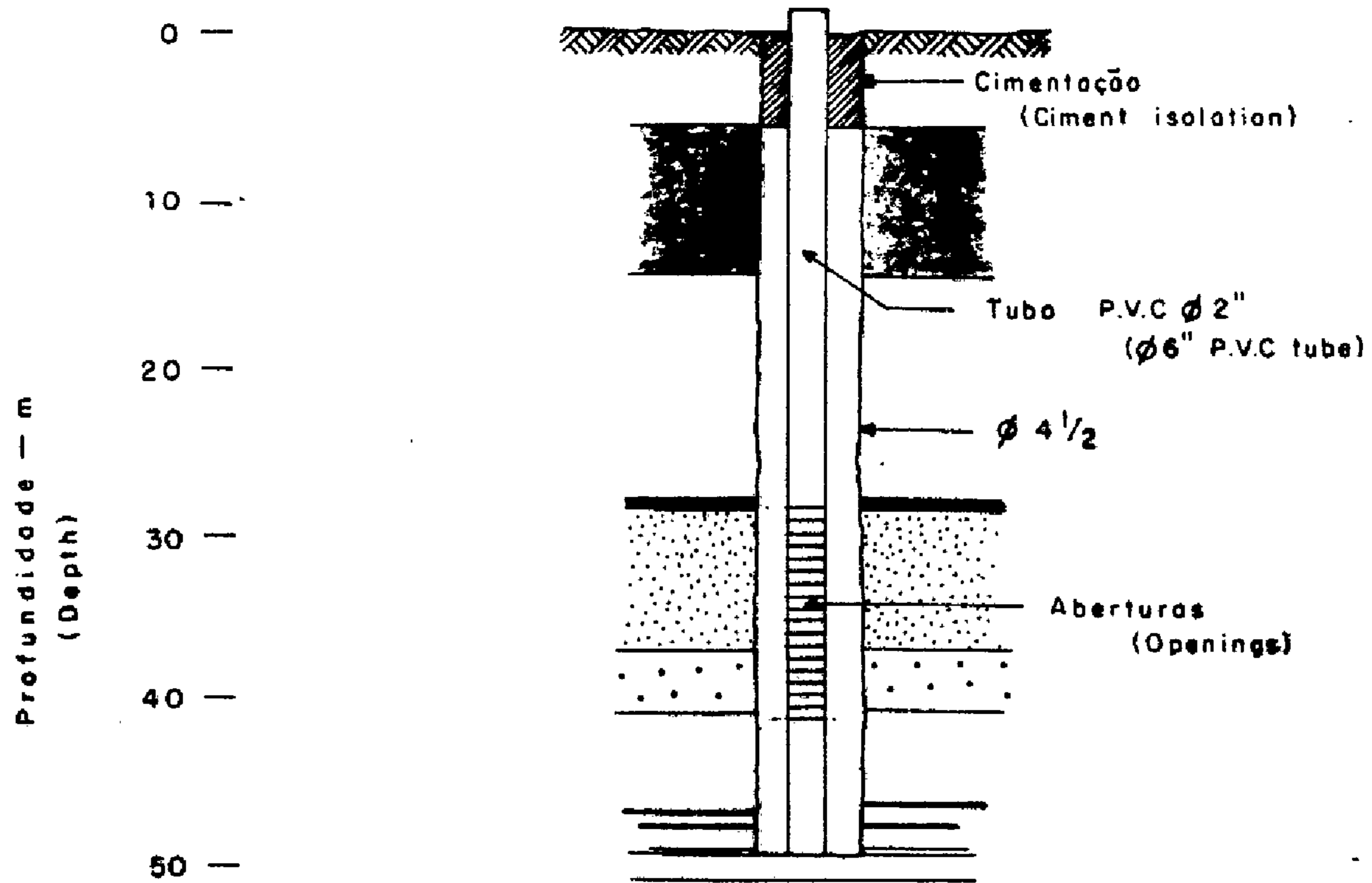
Aside from the technical, operational and administrative aspects of the programme, the coordinators will also be responsible for acting as liaison between CPRM, and GSECHI and other government departments of Mozambique, as well as the financing agents. They must present, whenever so required, to the contracting and financing agents any relevant information demanded.

The consultancy services will be contracted from specialists from CPRM or other Brazilian companies.

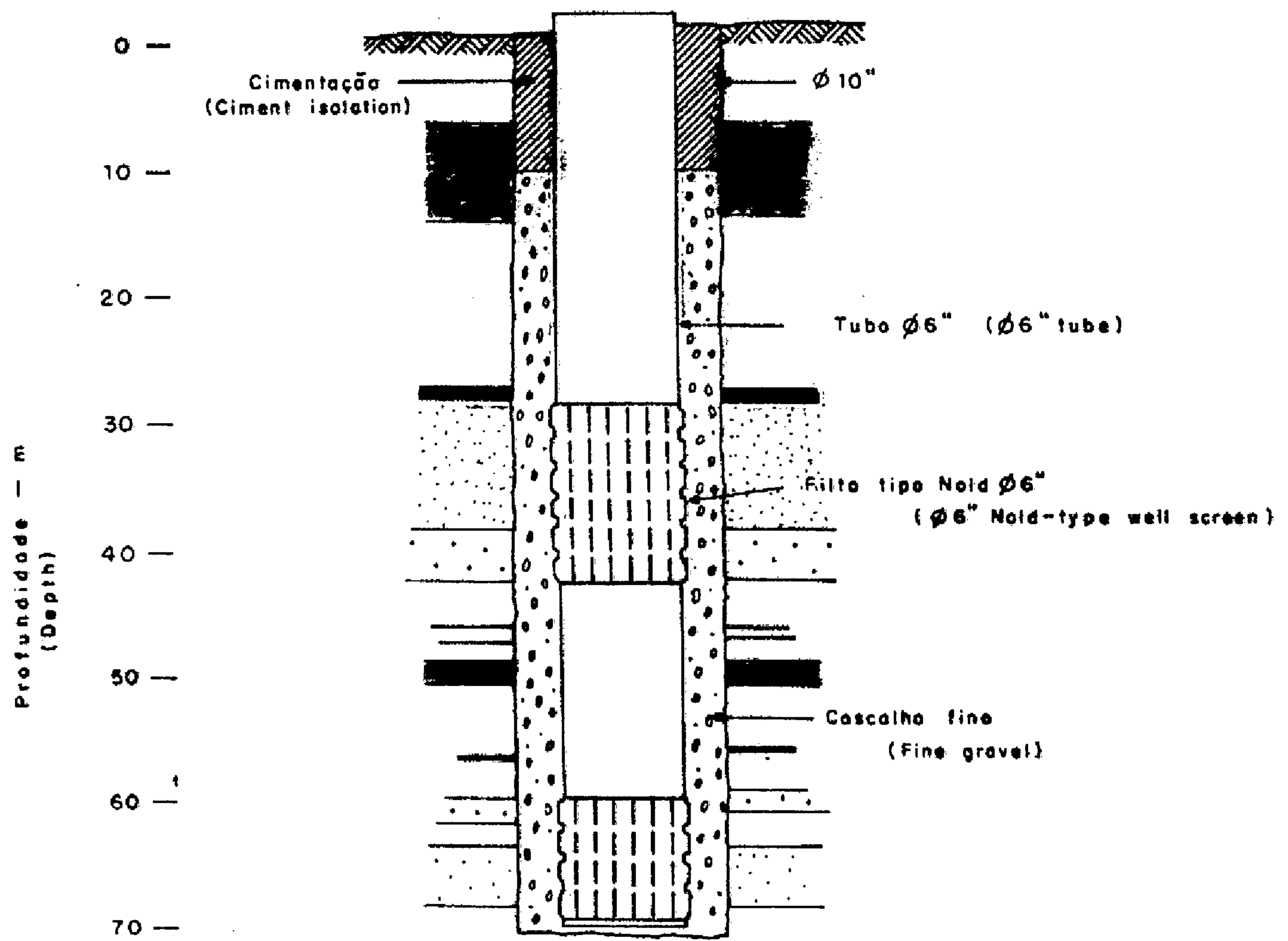
The Geological Exploration Final Report will contain of all the data generated by the programme.

TABLE A  
DRILLING PLAN - BOHOZI BLOCH

COAL SEAM	NUMBER OF DDH	DRILLED LENGHT	AVERAGE DDH DEPTH
B <sub>1</sub> (Sup + Inf)	110	9.350	85
B <sub>1</sub> e B <sub>2</sub>	6	720	120
B <sub>2</sub>	70	5.600	80
B <sub>2</sub> e B <sub>3</sub>	14	1.540	110
B <sub>3</sub>	42	3.360	80
TOTAL	242	20.570	85



Piezômetro  
(Piezometer)



Poço-teste  
(Pump-test well)

Carvão  
(Coal)

Siltito  
(Siltstone)

Arenito fino  
(Fine grained sandstone)

Arenito grosso  
(Coarse grained sandstone)

FIG. 12 PROJETOS BÁSICOS DE PIEZÔMETRO E POÇO-TESTE  
(BASIC DESIGN OF PIEZOMETER AND PUMP-TEST WELL)

A.3.2 BASIC ENGINEERING DESIGN FOR  
THE MUCUNHA/VUZI COAL OUTFLOW  
TRANSPORTATION PROJECT

### A.3.2 - BASIC ENGINEERING DESIGN FOR THE MUCANHA/VUZI COAL OUTFLOW TRANSPORTATION PROJECT

The Companhia de Pesquisa de Recursos Minerais - CPRM, based on the result of the preliminary evaluation of the outflow alternatives for the coal production at the Mucanha-Vuzi Region foreseen in the activity 9 of the contract GSECHI/CPRM of 12.01.82 and subcontracted to the Empresa Brasileira de Planejamento de Transportes - GEIPOT, submits for the appraisal of the Cabinet of the Secretary of State of Coal and Hydrocarbonates the proposal for the basic engineering design of the selected transport system.

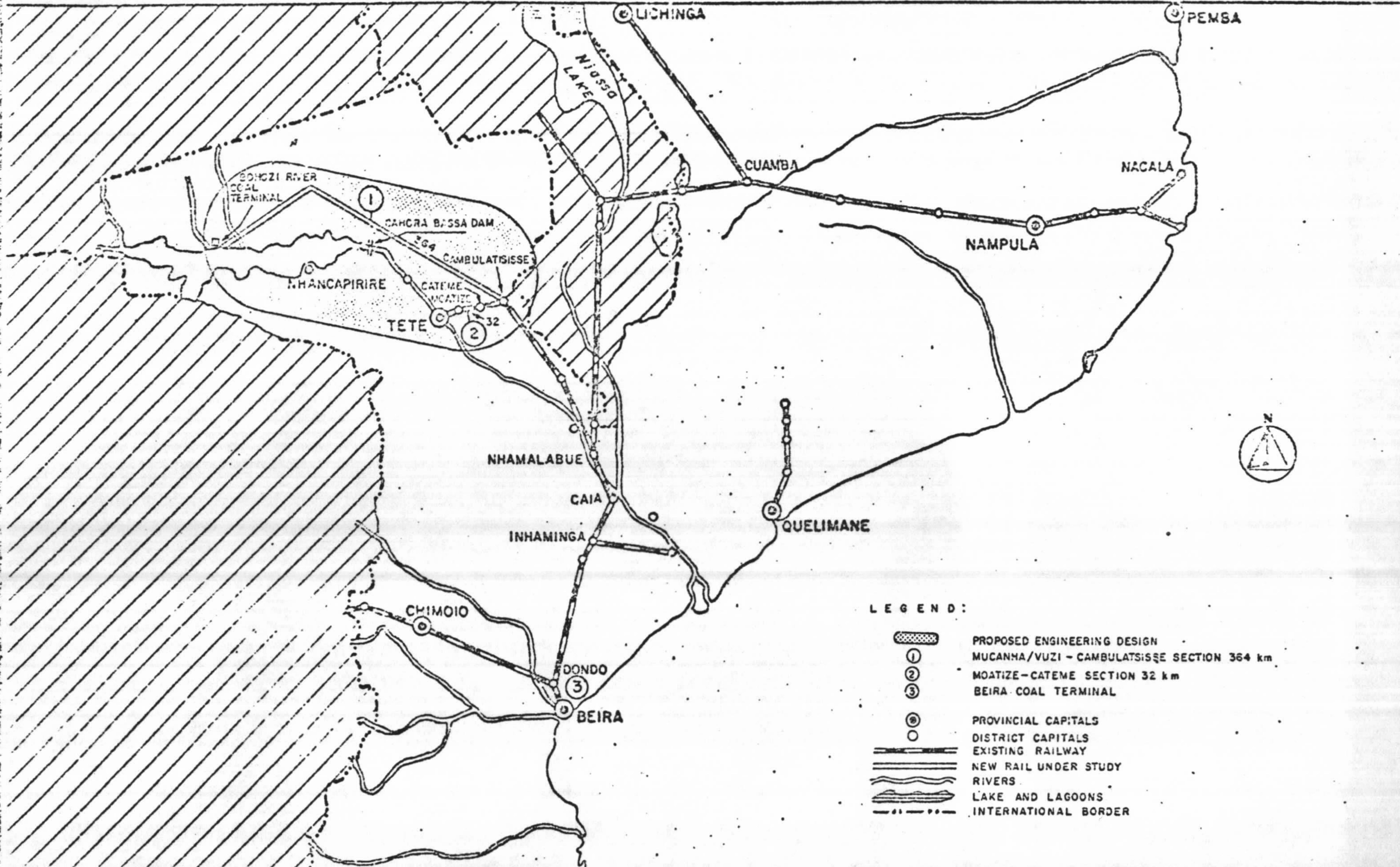
The execution of the basic design in the second phase of the Mucanha-Vuzi Programme, previously planned for inclusion in the third phase was anticipated due to the quantity and quality of data obtained in Mozambique, which made possible to achieve a highly reliable conclusion concerning the selection of the most economical mean of transportation for the Mucanha/Vuzi coal.

In view of the reliability of existing data and the coal production target set by the Government of Mozambique, GEIPOT considered of utmost importance the basic design to be executed during 1983/1984, in order to allow the detailed design to be executed and the work to start in 1984/1985, so as the transportation system could be ready to start operating by 1989.

Thus, the scope and budget of present proposal differs from previous estimates submitted for consideration of the Mozambique and OPEC Fund since the previously assumed third phase of the programme was anticipated and incorporated into the second phase, thereby saving one year of time allotted in the previous schedule.

Based on the findings of the Study of Outflow Alternatives' Report, the proposal for the Basic Engineering Design, is presented for the new sections to be constructed in Route 1 - Beira; Alternative 1.1 Northern and includes the following items:

# MT-GEIPOT



STUDY OF OUTFLOW ALTERNATIVES  
 Route I - Beira - Alternative 1.1 - Northern.



- Loading Railway terminal close to the Bohozi River (Bohozi terminal).
- Construction of the railway connection between the Bohozi coal terminal and Cambulatsisse with 364 Km in length.
- Construction of the Railway variant Moatize-Cateme ( on the Moatize to Cambulatsisse line section).
- Construction of the coal terminal in the port of Beira.

Conforming to the agreements between Mozambique and other countries consulting firms for the rehabilitation and upgrading of the existing railway line in the CFM-Central System between Beira and Moatize, this proposal only includes the basic design for the Cateme variant. As for the Beira-Moatize Section, the work to be carried out will be limited to providing a conclusive report on the operation, including all basic details such as the length of the trains, axle load, average daily traffic and other operational data required to a perfect execution of the project.

The basic engineering design should provide the required informations for the Mozambique Government to put out to tender a detailed engineering design and the execution of the civil engineering works and the purchase of equipment as well.

A.3.2.a - Basic Engineering Design for the Cambulatsisse to Mucanha/Vuzi Railway Section (loading terminal included) and the Cateme Variant.

• *WORKING PLAN*

*PURPOSE*

- To draw up a Basic Engineering Design, with enough data to permit to put out to tender, and after detailing, the construction of the Cambulatsisse-Mucanha/Vuzi railway section and Cateme Variant line, including its future operation.

- In order to save time and due to an existing study of the track, based on aerial photogrammetry on the 1:2,500 scale, a decision was taken for a more detailed project, specially in the first 140 km, and the development of the Executive Geometric Design. Based on all the studies carried out, there will be presented the Earthmoving, Draining and Complementary Works projects, that will enable the Mozambique Government to rapidly put out to tender and to contract the services of the substructure work.

#### *METHODOLOGY*

- The Cambulatsisse-Mucanha/Vuzi railway section will be divided into two lots for execution:
  - a - a lot of approximately 212 km long, which starts at Cambulatsisse, has been surveyed by aerial photography already. The track has been studied and a branch-line will be defined for the last 72 km of the section.
  - b - the initial term established for conclusion of the Basic Engineering Design will be expanded, according to the rainy season. It was decided to present only a part of the Executive Engineering Project for the first 140 km.

#### *LOT NUM. 1*

*KM 196 (CAMBULATSISSSE) - KM 336*

#### *1<sup>st</sup> stage - OPTIMIZATION OF THE TRACK*

The studied track in the preliminary report will be adapted to the required rules and technical conditions, resulting from geotechnical and operational studies.

2<sup>nd</sup> stage - *DEFINITION OF THE EXECUTIVE GEOMETRIC PROJECT*

Based on results of the topographical, geological, hydrological, geotechnical and track studies as well as operational simulation, a definition of the geometrical features will be obtained and it will be a base to other basic and executive projects, for adequate implementation in site.

3<sup>rd</sup> stage - *EXECUTIVE ENGINEERING DESIGN*

Based on the Executive Geometric Design and other studies, it will be drawn up the Executive Projects of Earthwork, Draining and Complementary Works; the Common Structures, Permanent way, Telecommunications, Signalling and Licensing, Workshops, Maintenance Stations and Buildings, Rolling Stock and Maintenance Equipment; Basic Design and the Preliminary Design of Special Structures.

Quantities, Costs and Specifications for the Construction, as well as Budgets will be defined, in order to consolidate the projects.

Finally, the Construction Plans will be submitted.

*LOT NUM. 2*

*KM 336 - KM 560 (MUCANHA)*

1<sup>st</sup> stage - *INTERMEDIATE OPTIMIZATION OF THE TRACK PLANS*

In order to avoid the loss of sensitivity of the track studies when going from a 1:50,000 scale study to 1:2,000 scale track plan, there will be introduced at this stage a track optimization in a 1:10,000 scale. The track chosen in the 1:50,000 scale plan will be put into the same scale program and will undergo the initial optimization by mean of stereoscopic macro-analysis. There will be a delimitation of the range to be mapped.

The mapping will be executed in a 1:10,000 scale, with 5 meters equidistance, and graphic support will be based on existing charts and other support data available.

The geometric optimization will be in addition to the stereophotoanalysis and preliminary operational simulation.

A 1:10,000 scale geometry of the track, plan and profile, will be produced.

2.<sup>nd</sup> stage - *DEFINITION OF THE BASIC GEOMETRIC DESIGN*

The definition of the geometric aspects to serve as a basis for the remaining basic Design and which will be adequate for the correct implementation in site, will be based upon the topography, geology, hydrology, geotechnical and track studies as well as operational simulation.

3.<sup>rd</sup> stage - *BASIC ENGINEERING DESIGN*

Based on the Basic Geometric Design and using the results of the remaining studies, the Basic Project for Earthmoving, Draining, Common Structures for the Permanent Way, Telecommunication, Signalling, Workshops and Maintenance Station, Buildings, Rolling Stock and Maintenance Equipment, Complementary Works and Special Structures Preliminary Project will be drawn up.

Quantities, Costs and Specification for the Construction, as well as the Budget will be defined in order to consolidate all projects.

Finally, the Construction Plan will be submitted.

*LOT NUM. 3*

*KM 0 (MOATIZE) - KM 31.5*

*CATEME VARIANT*

Cateme Variant comprises the approximate length of 31.5 km and starts at Moatize mines, and it is included in the Moatize-Cambulatsisse railway section, 58 km long.

There's a preliminary project for this section in a 1:10,000 scale which will be improved with similar methodology as

to lot 2. The autonomy of this lot as to the others and the proximity of Tete city, will permit that the presentation of works occur in a 8 months minimum term, depending upon the starting schedule, and will be detailed according to Basic and Executive Design.

● *DEFINITION OF TASKS*

00 - *MANAGEMENT*

- a - Management for the preparation of the Basic Engineering Project;
- b - Overall management of activities.

01 - *ANALYSIS OF THE EXISTING DATA*

- a - Collection of elements and data for preparation of the works;
- b - Study of the data by qualified technical personnel.

02 - *PRELIMINARY TOPOGRAPHICAL STUDIES (LOT 2)*

- a - Drawing of the track plans worked out in a 1:50,000 scale maps over existing photograms in the same scale;
- b - Delimitation of the range to be mapped with an average width 800 m;
- c - Expeditious aerophotogrametric mapping of the said range, in a 1:10,000 scale, with graphic support from the 1:50,0000 scale maps and other available information.

03 - *PRELIMINARY TRACK STUDIES (LOT 2)*

- a - Geometric track optimization on the 1:10,000 scale expeditious mapping, with stereoscopic macro-analysis of the 1:50,0000 scale photograms, in addition to the preliminary operational simulation.

04 - *PRELIMINARY OPERATIONAL SIMULATION (LOT 2)*

- a - Track operational simulation in a 1:10,000 scale map based upon the transport requirements and other previously obtained data, in addition to the geometric opti

mization.

05 - *TOPOGRAPHICAL STUDIES*

- a - Implementation of the Main Traverse, 1:50,000 accuracy;
- b - Implementation of the Secondary Traverse, using the maximum as possible of the track traverse, 1:30,000 accuracy;
- c - Survey of the cross-sections, every 20 m, with 100 m extension both ways (lot 2);
- d - Survey of special areas (water-courses crossing points, deposits, etc.), 1:500 scale;
- e - Drawing of the delimited range based on the cross-sections in a 1:2,000 scale (lot 2);
- f - Center-line location for every 20 m (lot 1).

06 - *GEOLOGICAL STUDIES*

- a - Analysis of the existing geological studies;
- b - Preliminary geological photointerpretation;
- c - Site geological survey;
- d - Preparation of Geological Chart.

07 - *HYDROLOGICAL STUDIES*

- a - Analysis of the existing hydroclimatic data;
- b - Pluviometric studies;
- c - Fluviometric studies;
- d - Definition of the hydrographic basin characteristics;
- e - Definition of the project outputs;
- f - Definition of the maximum flood levels;
- g - Report on the studies carried out.

08 - *GEOTHECNICAL STUDIES*

- a - Preparation of the Drilling Plan based on data from geological studies;
- b - Preparation of the Plan for Geotechnical Field Tests and Laboratory Tests;

- c - Survey for Special Structures;
- d - Drilling, field and laboratory tests;
- e - Preparation of the Mine Search Plan, based on geological survey of the surface and on stereophotoanalysis, to obtain sand, rock and types of ground adequate for the construction;
- f - Drilling and tests needed for the mine search;
- g - Final Report.

#### 09 - TRACK STUDIES

- a - Adaptation of track to the required rules and technical conditions resulting from studies (lot 1);
- b - Based on the results of the geology, geotechnical and hydrology studies, the critical crossing points will be plotted in the 1:2,000 scale range surveyed;
- c - The original 1:10,000 scale track plan will be optimized to a 1:2,000 scale, in addition to the operational simulation thus giving the definition for the geometrical development of the line.

#### 10 - OPERATIONAL SIMULATION

- a - Operational simulation in addition to the track study as well as the study of yards and terminals in a 1:2,500 scale, (lot 1);
- b - Amendment of the preliminary operational simulation of the 1:10,000 scale track plan with new 1:2,000 scale elements, in addition to the track study as well as the study of yards and terminals, (lot 2);
- c - Definition of the configuration of yards and terminals.

#### 11 - I - EXECUTIVE GEOMETRIC PROJECT

- a - Definition of the geometrical aspects with the data and accuracy required for their location.
- b - Execution of plans and profiles in a 1:2,000 hori

zontal and 1:2,000 vertical scale, with mapping of range in a average width of 120 meters and contour lines every 5 m with axis poles, with curves and slopes aspects, location of common and special structures so as the ground profile.

11 - II - *BASIC GEOMETRIC PROJECT*

- a - Definition of the geometrical aspects with the data and accuracy required for their location during the stage of preparation of the Executive Project.

12 - I - *EXECUTIVE EARTHWORK PROJECT (LOT 2)*

- a - Definition of slopes for barriers and embankments;
- b - Definition of retaining walls works;
- c - Volumes of excavation in different classes of material;
- d - Volumes of compacted embankments;
- e - Quantification of services for retaining works;
- f - Guidance for earthmoving works, specifying the destination of excavated materials of different classes, such as embankments, borrow-pits, throw-offs, deposits of materials for the top layer and sub-ballast, with their average transportation distances;
- g - Quantification of volumes by types of materials and range of transportation distance;
- h - Drawings of the cross-section for every 20 m in a 1:200 scale, and typical cross-sections;
- i - Presentation of the Earthmoving, service notes and of guidance schedules for Earthmoving, necessary for the execution of embankments.

12 - II - *BASIC EARTHWORK PROJECT (LOT 1)*

- a - Definition of slopes for barriers and of embankments;
- b - Definition of retaining wall works;
- c - Volumes of excavation in different classes of material;



- d - Volumes of compacted embankments;
- e - Quantification of services for retaining works;
- f - Guidance for earthmoving works, specifying the destination of excavated materials for different classes, embankments, borrow-pits, throw-offs, deposits of materials for top layer and sub-ballast, with their average transportation distances;
- g - Quantification of volumes by types of materials and range of transportation distance.

13 - I - *EXECUTIVE DRAINAGE PROJECT (LOT 1)*

- a - Preparation of the drainage projects in order to ensure the correct collection, transportation and disposal of water which could hinder the construction, their stability and operation, comprising:
  - Superficial draining,
  - Deep draining,
  - Sub-horizontal filter draining;
- b - Preparation of drainage work list including situation and measurement of the services required for the construction.

13 - II - *BASIC DRAINAGE PROJECT (LOT 2)*

- a - Preparation of the drainage projects in order to ensure the correct collection, transportation and disposal of water which could hinder the construction, their stability and operation, comprising:
  - Superficial draining,
  - Deep draining,
  - Sub-horizontal filter draining.

14 - *BASIC COMMON STRUCTURES PROJECT*

- a - Project measurement and structural standardization of different types of common structures ;
- b - Preparation of typical drawings.

15 - *SPECIAL STRUCTURES PRELIMINARY PLAN*

- a - The works and their general features will be defined based upon the geological, geotechnical and topographic surveys of the areas, as well as hydrological and fluvimetric data;
- b - Preparation of summary of calculation memory for each preliminary project;
- c - Applicable drawings to a scale of not less than 1:500.

16 - *BASIC DESIGN OF THE PERMANENT WAY*

- a - Measurements of the elements which make up the permanent way based on traffic volume, train-type used, axle load, locomotives and cars, maximum speed limitations and other operational data;
- b - Definition of the following track elements:
  - Sub-ballast and ballast,
  - Sleepers,
  - Fastening,
  - Rail Cars, junctions and turnout equipment.

17 - *BASIC TELECOMMUNICATIONS PROJECTS*

- a - System conception;
- b - Dimension in the telecommunications area to meet the basic requirements set out in the operational simulation.

18 - *BASIC SIGNALLING AND COMMUNICATIONS PROJECT*

- a - System conception;
- b - Dimension in the signalling and communication area to meet the basic requirement as set out in the operational simulation.

19 - *BASIC DESIGN WORKSHOPS AND MAINTENANCE*

- a - Definition of location and measurement of facilities for locomotive workshops and railway cars;

- b - Definition of location and measurement of facilities for maintenance and service stations.
- 20 - *BASIC BUILDING DESIGN*
- a - Definition and measurements of buildings in sufficient detail to establish quantities, specifications and implementation costs.
- 21 - *ROLLING STOCK AND MAINTENANCE EQUIPMENT*
- a - Definition of quantity and specifications for locomotives fleet and railway cars needed to meet project demand, allowing for integration as far as Port of Beira.
- 22 - I. - *EXECUTIVE DESIGN FOR COMPLEMENTARY WORKS (LOT 2)*
- a - Definition and measurement for complementary work and facilities needed for the railway operation.
- 22 - II - *BASIC DESIGN FOR COMPLEMENTARY WORKS (LOT 2)*
- a - Definition and measurement for complementary work and facilities needed for the railway operation.
- 23 - *QUANTITIES, COSTS, SPECIFICATIONS AND BUDGETS*
- a - Market research;
  - b - Definition of specification and quantity for materials and equipment, based on the solutions found in the projects, including unit costs;
  - c - Preparation of budgets.
- 24 - *CONSTRUCTION PLANS*
- a - Preparation of chronogram, methodology and division into construction sites;
  - b - Preparation of bid notices, norms and procedures for implementation of the works and equipment procurement.

- WORK ORGANIZATION

The works on the Cambulatsisse-Mucanha Railway section and Cateme Variant, will be developed based on two main locals:

a - Mozambique - City of Tete

The installment of a Technical Residence is intended with equipment for Technological Tests and Topographical crew collecting the necessary data to the project development. Accurate Tests will be carried out in the Engineering Laboratory of Mozambique in Maputo.

Thus it is foreseen the following evolution.

*Exploration Traverse, center-line location and delimited range*

- Superficial Geology
- Drillings
- Collecting of samples
- Topographical surveys
- Mining Studies
- Data collection of Permanent Way, Workshops and Systems of existing tracks
- Special Geotechnical drilling for the Systems
- Special Topographical surveys for the Systems.

*Residence in Tete*

- Geotechnical Tests
- Topographical drawing of delimited range, in "Canson" paper.

*Engineering Laboratory of Mozambique*

- Special Tests that won't be made in Tete.

b - Brazil

Definitive drawing of delimited range based on the "Cansons" sent by Tete.

The draft of the Basic and Executive Project will be developed and submitted to the Government of Mozambique and Technical Advisers of OPEC. After approval it will be issued the Definitive Edition of Final Report.

A.3.2.b - Basic Engineering design for the Beira Coal Terminal and Access Routes.

The selected route indicated in the Report (Route 1, Alternative 1.1) foresees the execution of an ocean terminal at Beira in the so-called Franquia point.

For the Beira coal terminal, the following activities will be executed:

• Field Survey

- Topographic Survey

In the area considered for the basic engineering design a topographic survey will be carried out, to include topographic support by the close polygonal system, transportation of the reference levels at a levelling distance of 1 m. The estimated area in the port of Beira is 900,000 m<sup>2</sup>.

An investigation of the surrounding area of about 200,000 m<sup>2</sup> should be executed, indicating the physical existence of all buildings and streets, bridges, etc.

All control points is to be fixed with concrete blocks with metal pins for the local reference of future construction works.

Total Area to be Surveyed: 2,400,000 m<sup>2</sup>

## - Geological Surveys

Geological drillings of NX diameter will be made for a 13 drill hole on land and 12 in the water (35 m/DDH)

## - Other Local Survey

The following survey will be carried out:

- In the waterfront : wind, wave, tide, current (checking of the existing data)
- In the construction area: electrical power, requirements for water and sewage installation, etc.

## . *Basic Design of the Terminal*

The basic engineering design of the coal export terminal ships between 15,000 DWT and 125,000 DWT shall include:

- unloading installations of the railway cars (civil engineering work and equipment)
- stock pile area (civil engineering work and equipment)
- reclaiming equipment and transferring to pier at a distance of 2,700 m (civil engineering work and equipment)
- pier and access bridge (civil engineering work and equipment)
- railway and road access routes
- administration and service buildings
- maritime access - signalization and buoys
- dredging project
- electricity, water, sewage and communications.

A.3.2.c - General Coordination, Assistance and Supervision of the Transportation Projects.

General Coordination and Supervision of the Basic Engineering Design for the new segments of the transportation system will be under CPRM responsibility with the assistance of GEIPOT if contracted for the coordination and supervision work.

The activities to be developed will be:

- preparation of bid notices, norms and procedures for contracting specialized firms for the Basic Engineering Design of the proposed segments of the transportation system.
- selection of specialized firms for the engineering design transportation project and field survey.
- follow up and coordination of the transport project to ensure high quality and international standard design.

A.3.2.d - Review of the Costs and Financial Aspects.

Based upon the new budget resulting from the Basic and Executive Engineering design and new data and forecasts on coal freight demand, a review of the economic and financial aspects resulting from rail and ocean terminal operation given in the preliminary report is to be carried on.

A.3.2.e - Training Program of Human Resource for Operating the New Coal Transportation System.

A quantitative and qualitative evaluation of the human resources available at the Ministry of Ports and Surface Transport, is to be undertaken, in particular with regard to the National Directorate of Port and Railways as well as to other organizations in other Ministries, such as the National Directorate of Maritime and Waterway Transport and the National Directorate of Waters.

Recommendation shall be made for the setting up of a programme of selection and training covering several levels of professional categories during the various stages of the project development.



A.3.3 MINE BASIC PROJECT, COAL  
PREPARATION PLANTS AND AUXILIARY  
FACILITIES-ECONOMICAL AND  
FINANCIAL FEASIBILITY STUDY

A.3.3 MINE BASIC PROJECT, COAL PREPARATION PLANTS AND AUXILIARY FACILITIES-ECONOMICAL AND FINANCIAL FEASIBILITY STUDY

Engineering services herein proposed consist of developing the following activities:

. *Basic Project*

This cover the concept of the Production, Auxiliary and Administrative Units as well as the Utilities System and the Access System.

During this stage, sizing and specification of equipment preparation of layouts of buildings and facilities, will be carried out.

. *Economical-Financial Feasibility Study*

This covers carrying out the Market Study and the preparation of the Investment Budget, determining operating costs, income, and Return on Investment rate as well as elaborating sensitivity analysis.

. *Preliminary Approach regarding the Impact of the Coal Mining Project on the Development of the Mucanha-Vuzi Region*

This covers an Analysis on the multiplying effects that the Coal Mining Project can have on the development of other economic activities in the Mucanha-Vuzi region.

The development of these Engineering activities will enable the starting of subsequent stages of Project development as follows:

- . Negotiating and Obtaining Financing,
- . Equipment Procurement,
- . Detailing the Project,
- . Contracting Civil and Erection Works.

The scope of the engineering activities to be developed during this stage is discriminated bellow:

#### *A.3.3.a General Coordination*

During the whole period envisaged for the services, a coordination structure allowing a perfect integration with all companies involved, will be established.

The basic function of this Coordination Staff will be the close follow-up of the geological research services, as well as of those services related to the transportation project, keeping in mind the utilization of data and solutions adopted in the Mine Project are in the Feasibility Study.

The Coordination Staff will also be assigned the responsibility for the edition of periodic reports, which shall include the description and evaluation of the services, aiming at their application on both the Basic Project and the Feasibility Study.

#### *A.3.3.b Mining Project*

Considering the information resulting from the additional geological research, and, taking into account that investments on mining projects are irreversible, the alternatives for the mining methods shall be analysed, mainly as for as haulage is concerned, aiming at the minimization of the global mining costs, within the context of the integrated mining/preparation and refuses disposal complex.

Taking into consideration both the technological and geologic-structural features of the coal seams, mining plans shall be computer simulated, aiming at the optimization of the cost/income function, within the context of the integrated mining/preparation and products transportation complex.

For the analysis of the mining methods alternatives, computer simulated global mining plans shall be effected, in order to evaluate the behaviour of the so-called "benefit function".

For the chosen alternative, short and medium-term plans shall be elaborated, to show the feasibility of accomplishing the required production program.

These plans shall also serve as a basis for the forecast of the requirements for the effective accomplishment of the production program, by means of demonstrating the mine evolution both spacially and along the time.

Based on such mining plans the sizing of equipment for each phase of the mine evolution will take place.

Materials and inputs consumptions, as well as manpower requirements shall be precisely valued.

Equipment, materials and inputs shall then be specified, in order to allow procurement and to assure that they will meet the requirements.

The short-term mining plan shall as well serve for the specification and budgeting of the detailed geological research and the initial mine development works.

The process of removing, handling and disposing soil over the wasted coal refuses piles shall be given special attention.

Due to the long terms required for the mine development works; 6-month, 3-month and 1-month mining plans shall be prepared, so as to pre-establish a planning and control routine.

Due to the long terms required for large-sized mining equipment deliveries and assemblies, and also due to the large investments required for said equipment, a mine implantation schedule shall be prepared, favoring the Project cash-flow, and, also allowing the planning and operating teams to foresee the organization and control of activities, as well as the training of personnel.

#### *A.3.3.c Coal Preparation Project*

##### *Definition of the Products Mix*

Based on the results of the Market Study and washability tests which will determine, respectively, the consumption profile and the yields for the various ash contents, it will be endeavoured to establish the most adequate products mix.

### *Definition of the Process*

The Coal Preparation Project will be based on washability studies to be done individually for each seam to be mined. After a more detailed geological survey of the deposit, sampling locations will be defined and bulk samples taken, endeavouring to simulate actual mining conditions. Washability studies will cover various crushing sizes and granulometric fractions, so as to enable the study of liberation and washability of the various size ranges.

The preparation of the fine fraction,  $-0.5\text{mm}$ , will be given special attention, in view of its great contribution to the amount of metallurgical coal to be produced, as seen in the Preliminary Feasibility Study. The various alternatives of cleaning Water - only Cyclones, and small diameter heavy medium cyclones.

Preliminary flotation tests, carried out at the time of the Preliminary Feasibility Study, indicated a bad response of coal from Seam B-1 to flotation. However, additional flotation tests shall take place at bench scales, mainly with coals from Seams B-2 and B-3.

Industrial use of Water - only cyclones will have to be proven by specific tests, in laboratory or pilot plant.

The use of heavy medium cyclones to clean coal fines ( $0.5\text{mm} \times 0.074 \text{ mm}$ ) will be considered, despite the fact that this is a technology of recent usage.

Computer simulations of the various process alternatives will be carried out, aiming at selecting the best process and determining the yields of marketable products by seam.

Based on required production capacity, yields of marketable products by seam, and surface mineable reserves per seam, the mix of the various seams to be mined will be defined and, consequently, the preparation plant feed rates and mixes.

The chosen process alternative will have to be optimized for the feeds thus defined, giving support to the preparation of the process equipment will be specified.

*A.3.3.d Layouts of the coal preparation and auxiliary facilities and miners village project*

*Coal preparation facilities*

Layouts drawings of the crushing plant, washery and handling; storage and blending facilities, as well as of the coal load out yard, will be prepared.

These drawings will give an overview of all equipment laid out on the flowsheet, as well as of equipment not directly connected with the production process, such as overhead electric traveling cranes or mowrail hoists.

Industrial buildings as well as auxiliary facilities, such as the compressor house, sanitary installations, etc., will be shown in these layout drawings to make possible the forecast of the amount of structural material (concrete or metal), for budgetary purposes.

During this stage, handling equipment such conveyor belts, stackers, reclaimers, etc. will also be specified.

*Auxiliary Facilities*

Auxiliary and Support Facilities will be sized to meet the requirements of maintenance, administration and operating personnel of the Mine.

Such facilities include Maintenance Shops, Vehicle Repair Shop, Warehouse, Laboratory, Explosives Room, Offices, Changehouse, Restaurant and Medical Dispensary.

Drawings will be prepared of the buildings showing their divisions in functional sections, and each one of these with its own equipment, furniture and fixtures.

The construction methods of the buildings will be defined, taking into account materials and labour available in Mozambique. Specifications of the equipment for the shops and for the other Auxiliary Facilities will be elaborated.

### *Miners Village*

The definitive project on the Miners Village will be development from the Project developed in the Preliminary Feasibility Study, dully analysed and approved by the Mozambique Housing Authority.

As this time, construction methods, construction materials and the urban facilities will be disarssed.

The Miners Village will be sized to house all personnel directly and indirectly connected with the Coal Mining Project and will be equipped with its own operating infrastructure, such as Hospital, School, Leisure Centre, Shopping Center, etc.

The Miners Village location will be analysed based on geographical conditions such as topography, type of soil , landscape, wind direction climatic conditions, etc.

The location as well as the size of the Miners Village will also be evaluated, so far as its use by other Projects which may be established in the Region as a result of the Coal Mining Project is concerned.

#### *A.3.3.e Utilities, Instrumentation, Electric Power, Piping and Roadway*

As utilities, potable and industrial water supplies, electric power, instrumentation and access road to the facilities will be studied.

Specifications of equipment will be prepared as well as general specifications for materials and for Civil and Erection works.

#### *Potable Water*

Sources of potable water will be evaluated as regards quantity and quality, by means of field inspection, measuring the flow and analysing potability. Once the source is selected, a basic project will be prepared encompassing intake, storage ,

distribution and eventually treatment for the water, for the industrial facilities and the Miners Village.

#### *Industrial Water*

The region is blessed with abundance of industrial water, be it from the dam be it from rivers which flow in the region. From the currently available information, it would appear most interesting to take water from the dam and pump it to the industrial facilities for storage and consume.

#### *Electric Power*

It will be studied the supply of electric power by the Cahora-Bassa, by means of a transmission line up to the facilities. At this time a definition will be made of the voltage level of the line, in addition to its routing, based on aerophotogrametric survey.

Drawings will also be prepared of the general arrangement of the main substation, of the distribution lines to the consuming centres - Mine, Coal Preparation, Mine as Village, etc - in addition to General One Line Diagrams.

#### *Instrumentation*

Considering the automation level required by coal beneficiation equipment - a diagram will be prepared showing all instruments, their functions and locations within the production process.

Instrumentation will be restricted to a level, such that it is not translated into sophisticated items requiring highly specialized labour to operate and carry out maintenance, and also such that it does not replace abundant and low cost local labour.



### *Roadway*

A basic project will be prepared of the roadway connecting the locality of Nhataro to the coal mining facilities, some 70 km long. For this purpose, drawings will be prepared of the location, on a scale of 1:5000, based on aerophotogrametric surveys, in addition to profiles of the major items to be constructed, such as bridges and viaducts.

It is envisaged that this road will have a gravel top layer and a width of 8 meters, being similar to the road which currently gives access to Nhataro.

### *A.3.3.f Market Study, Budget, Economical, Financial and Social Feasibility Study*

#### *Market Study*

- . Analysis of Supply
  - . Survey of world coal reserves;
  - . Survey of production capacity per country (or region) and by type of coal, as well as expansion plans (estimated capacity in the coming 20 years);
  - . Determination of the capacities of coal exporting harbours as well as their expansion plans.
  
- . Analysis of Demand
  - . Survey of coal consumption per country and type of coal during the past 10 years;
  - . Identification of the main factors which influence the demand and determine usage trends. Survey of oil-coal conversion programmes in the main consuming regions and world profile of energy consumption;
  - . Projection of Demand by type of coal and country (or region) during the coming 20 years.
  
- . Analysis of Demand/Supply
  - . Identification of self-sufficient countries by type of coal;

- . Identification of importing/exporting countries (or regions);
- . Projection of Coal International Trade in the coming 20 years.
- . Price Analysis
  - . Survey of prices by origin and type of coal;
  - . Identification of the factors that influence coal prices;
  - . Evaluation of trends of price evolution;
  - . Determination of transportation costs (sea-carriage inland).
- . Supply by the Project
  - . Estimate of domestic consumption of the Mucanha Vuzi coal;
  - . Estimate of demand by neighbouring countries for the Mucanha-Vuzi coal;
  - . Identification of potential markets, for the Mucanha-Vuzi coal.
- . Budget

Definition of the budgeted expenditures of the Project identifying them by areas such as: Mining, Coal Preparation, Auxiliary Facilities, Access Roadway and railway, Infra-structure in general, and the Miners Village.

*Economical-Financial and Social Feasibility Study*

The Economical, Financial and Social Feasibility Study shall encompass:

- a) *Overall Investment*
  - . Determination of the Fixed Investment and Pre-operating Expenses;

- . Determination of the Working Capital;
- . Establishment of a Physical-Financial Schedule.

*b) Sources and Funds*

- . Analysis and evaluation of financial capacity of the People's Republic of Mozambique to accomplish investments;
- . Identification of other financing sources.

*c) Location*

- . Aspects of the Deposit Location;
- . Aspects of the Port Location;
- . Social-Economical Analysis;
- . Aspects of Social and Industrial Infrastructure;
- . Transportation.

*d) Organization, Human Resources and Wages*

- . Organizational Structure;
- . Manning;
- . Wages and benefits.

*e) Operating Costs and Expenses*

- . Mining and Coal Preparation Operating Costs;
- . Freight rates from the Mine to the Port of Shipment (railway and port expenses with storage and shipment);
- . Sales Expenses;
- . General Administrative Expenses;
- . Financial Expenses;
- . Depreciation, Amortization and Depletion.

*f) Project Income*

- . Income from Coal;
- . Other Income.

*g) Economical, Financial Evaluation*

- . Adopted considerations and assumptions;
- . Forecast of Results;
- . Forecast Cash Flow;
- . Forecast for Uses and Sources;
- . Forecast of Balance Shetes;
- . Evaluating of the Projects Return of Investment;
- . Sensitivity Analysis.

*1) Social-Economical Evaluation*

- . General considerations for the Mozambique social-economical viawpoint;
- . Impact of the enterprise on the economic development of Mozambique take-off;
- . Gross National Product;
- . Impact of the Project as regards generation of jobs and on salaries.

*A.3.4 STUDIES OF ALTERNATIVES FOR  
INTEGRATED REGIONAL DEVELOPMENT  
AND LAND OCCUPATION  
MIDDLE ZAMBEZE*

A.3.4      *STUDIES OF ALTERNATIVES FOR INTEGRATED REGIONAL DEVELOPMENT  
AND LAND OCCUPATION - MIDDLE ZAMBEZE*

The dearth of information of a realible nature concerning the region which would become accessible for utilisation as farmland as an outcome of the laying of the Mucanha-Vúzi Railroad counsels against the immediate drafting of any project or even preliminary project with that end in view. Hence the need for a merely indicative approach of policies of action that seem feasible as a general orientation to be eventually detailed.

The region is actually vast and very little, if any, knowledge is available concerning its agricultural potencial. It is considered to be the zone comprised within a rectangle drawn between the localities of Tete-Cambulatisse-Cherize river-Songo, with an area of 11,000 km<sup>2</sup>. The indication of that area stems from the little information available, which have made it possible to infer it is of substancial interest to the object in mind.

Owing to the little information at present available, it is suggested that studies should be carried on in various stages in order to provide a growing familiarity with the region for the improved planning of the use of the land in economic activities.

Those stages may be classed as follows:

1. Basic Study and Selection of Areas
2. Agricultural Planning
3. Implementation of Projects

The present proposal refers exclusively to the first stage, comprising the Basic Studies - inasmuch as the ensuing stages are functions of the first.

*A.3.4.a First Stage*

*Basic Studies and Selection of Areas*

This stage will be comprised of a series of studies aimed at providing improved acquaintance with those features of the

region that are relevant to farmland planning. These studies are:

- . Studies on the climate
- . Studies on forest resources
- . Studies on soil resources
- . Studies on fish farming

*A.3.4.b Studies on the Climate*

- .. Collection of data existing at weather stations in the region and neighbouring areas
- . analysis of data
- . characterisation of the climate of the region

*A.3.4.c Study on Soil Resources*

This is to comprise two levels:

*Reconnaissance Survey*

*Exploration Survey*

This study, of a general nature, is to comprise an area of approximately (140 x 80 km) 11,200 km<sup>2</sup> in the region at interest. Its purpose will be to ascertain, on a first approach, the condition of the soils of the region, particularly touching their farmability and to pick out those areas that seem most promising, to be the object of thorougher study on a reconnaissance level.

This study will be carried out through the intensive application of the technique of photointerpretation and air-land correlation with paths and study points selected from the aerial photos, so as to afford the work on the field the utmost efficiency.

As an outcome of those studies, a soil map will be drawn on a scale between, say 1:250,000 and 1:500,000, depending on the available mapping, to show the principal groups of soils existing in the region and the areas that seem most apt for farming and therefore should have their soils more accurately surveyed.

During that work soil sampling will be done for lab analyses. Some 200 samples should be evaluated in a preliminary approach.

#### *A.3.4.d Reconnaissance Survey*

In areas that the exploratory researches indicate as favourable to farming development, soil resources will be the object of thorough study on a reconnaissance or semi-detailed level to make it possible to prepare the corresponding farming plans according to the aptness of the lands so as to enable permanent farming without deterioration of the particular capabilities of the soil.

#### *A.3.4.e Forest Studies*

These will consist of an investigation to determine the types of forests and the flora of the vegetation and evaluate its economically exploitable potential.

Part of the work will be done in indoor facilities, including that of analysing and interpreting the aerial photographs and satellite images (if any). Part will be done on the field, for the purpose of measuring and evaluating tree quality. Such estimates will be made by sampling the areas covered by different types of forest as identified, and the average volume of timber per hectare for each forest type (dense rainland forest, semi-deciduous forest, sparse brush, etc.).

#### *A.3.4.f Fish Farming Studies*

These studies will be based on a survey of the physical and chemical and biological properties of the waters of the Cahora-Bassa dam and the rivers in the region through information gathered in the country and complemented by such new analyses as may be required in order to ascertain their fitness for fish farming.

A survey of the number and identity of the native species will also be made with a view to ascertaining their productive potential under handling.

Preliminary researches will likewise address the selection of natural bodies of water and the feasibility of the alternative



construction of tanks and ponds for fish breeding.

Depending on preliminary observations at the site, an indication will be made for the installation of a fish farming station designed for systematic biological researches in support of the exploratory activities and the production of fry and fingerlings to spread fish farming over the region.

