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ASSISTANCE TO THE INVESTMENT POLICY DEPARTMENT OF THE NATIONAL COMMISSION FOR DEVELOPMENT PLANNING (NCDP)

DP/ZAM/85/007

ZAMBIA

Terminal report*

Prepared for the Government of Zambia
by the United Nations Industrial Development Organization,
acting as executing agency for the United Nations Development Programme

Based on the work of Lauri Heikkila,
consultant and mining process engineer

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United Nations Industrial Development Organization
Vienna

* This document has not been edited.

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I. ABSTRACT

1.1. The UNIDO adviser in mining started his services to the NATIONAL COMMISSION FOR DEVELOPMENT PLANNING (NCDP) of ZAMBIA at the beginning of November 1989 and will leave the country at the end of January 1990.

1.2. In about three months time the adviser prepared guidelines for the appraisal and monitoring of Mining Projects.

1.3. Basic "Manual for the preparation of Industrial Feaisbility Studies" published by UNIDO provides a good general model for all industrial feasibility studies. However there is need in different sectors of industry for some special "know-how" in order to determine all technical aspects and parameters.

In Zambia, where the mining industry is the backbone of the export, the special mining "know-how" of this sector is needed also at NCDP's Investment Planning and Research Department, where among others, also mining projects will be evaluated and placed on the right order of the priority list.

1.4. The adviser prepared two interim reports entitled:
"Evaluation of Mining Projects" and
"Model Feasibility Study of Mining Projects"

1.5. The adviser also prepared papers on the following topics:
"Rationalisation of steel import in Zambia"
"Integrated Steel Mill and Iron Ore Mining in Zambia"
"Beneficiation of Phosphate at Chilembwe"
"Copper Industry in Zambia"
"Indeco Ltd 10/15 TPH caustic-chlorine project"
"Comments of CIPEC-quartely review July-September 1989"

1.6. The adviser had a few meetings with the Ministry of Mines and the Management of Zambia Consolidated Copper Mines Limited. The adviser also made a site visit to copper mines in the Copperbelt.

1.7. When preparing this report the adviser used the following literature:
a. Manual for the Preparation of Industrial Feasibility Studies. UNIDO 1986.
b. Mining Engineering Handbook, Vol 1 and 2 SME New york 1973.
c. Planning, Appraisal & Implementation of Mineral and Mining Projects. Seminar in Dar es Salaam 1985 arranged by Bradford University, Project Planning Centre.

d. Mineral Processing Plant design, editors Mular and Bhappu SME, New york 1980.

1.8. This report has been illustrated with the following tables, pictures and diagrams:

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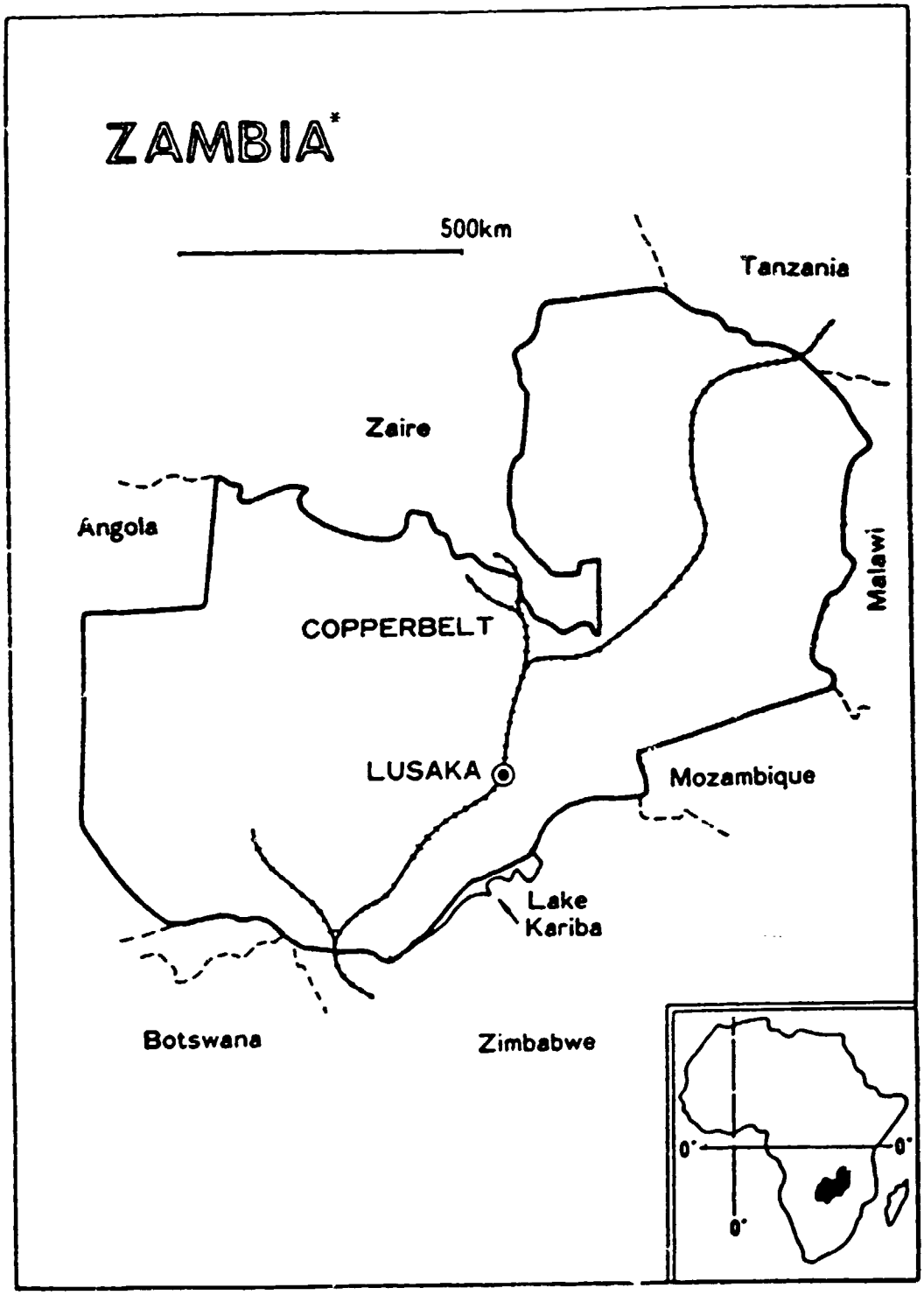


Picture 1

Zambia is a landlocked country - the distances to harbours are about 2000 kilometer.. The main mining area is the Copperbelt located close to the border of Zaire.

* The boundaries shown on this map do not imply official endorsement or acceptance by the United Nations.

2.1. ZAMBIA - COPPER MINING COUNTRY.

Zambia is a large country (see on the map of the preious page, picture 1) especially, if we compare it with most European countries. Zambia's area is 750,000 square km. Its population is about 7,6 mill. inhabitants and GNP UD$ 1100 mill.
Zambia gained its independence as a Republic in the year 1964.Zambia's President since its independence is Dr. K. Kaunda.
Zambia has a long and succesful history as a mining country.
The famous copper mines in the Copperbelt went into production at the beginning of this century and since then Zambia has been counted in the mining world as a significant copper producer. Even today the copper mining statistics of the world shows that Zambia is ranked fourth in the copper mining as we can see on the following table:

	1985	1986	1987
Yugoslavia	117	117	112
Other Europe	202	191	152
South Africa	204	203	193
Zaire	502	503	507
Zambia	511	513	518
Other Africa	124	108	88
Philippines	222	217	215
Other Asia	316	316	311
Canada	738	743	754
U.S.A.	1,106	1,147	1,275
Chile	1,356	1,400	1,418
Mexico	179	200	244
Peru	385	386	371
Other America	43	35	36
Australia	260	245	223
Papua New Guinea	175	179	217
Western World	6,440	6,503	6,634

Table 1. Copper mine production including leach production ('000 tons) in the western world. Source: WBMS, RTZ.

Copper is even today near the only export-earner for Zambia. For the budget of the year 1989 Zambia has forecasted 88 % of its export income from copper. However during recent years Zambia has also put a lot of effort into the beneficiation of other mineral resources in the country, like emeralds, diamonds. industrial minerals and latest also iron ore resources. Zambia has a target to start its own steel production based on its own iron ore deposits and its own coal as well as limestone reserves. This target means the opening of a new iron mine in the country.

The mining industry in Zambia has been struggling, like other industries, due to the lack of foreign capital, and the equipment have deteriorated because of a shortage of spare parts. The lack of skilled manpower in the mining industry has also been a serious problem. This situation means a big challenge for training and schooling of new personnel in the near future.

The last news about the future of the copper mining industry is rather pessimistic. Aleksander Mwanakasele wrotes in the Southern Africa Economist October/November 1989 that the copper production has declined during the years 1980-1986 by about 4.2 % per year, when the original planning predicted a 0.6 % increase for the same period. Finally Dr. Mwanakasele came to the conclusion that the estimated copper production for the year 2000 should be only 280.000 tons/year.

The undersigned has pointed out that the total review could not be so gloomy as above. The reason why the more optimistic opinions are realistic is that today Zambia is mining three times richer copper ores than the world average. This gap leaves a lot of space for development work, which can lead to significant cost reductions in production chain from mine to the client. At the same time, when the technology is developed to correspond to the most effective mining and process methods in the world, also the lower grade ores would become mineable and this could guaratee higher production level for a longer time.

Zambia Consolidated Copper Mines Limited, the operator of copper production, forecasts that Zambia has today ore reserves of about 450 mill. tons copper and these reserves guarantee an opportunity to keep copper production on the level of about 500.000 tons/year up to the year 2000. Otherwise Zambia has copper resources of about 1500 mill. tons. It is possible to exploit also these ore bodies profitably, if the newest technology is available.

Everything in the mining sector however depends on Zambia itself. If it would like to have a strong impact on the mining industry this industry will be profitable for generations to come.

2.2. THE NATIONAL COMMISSION FOR DEVELOPMENT PLANNING.

The National Commission for Development Planning (NCDP) is acting as the central institution in charge of overall planning for the improvement of the economy of Zambia. NCDP has six functional departments that are expected to actively co-ordinate their activities. The departments are as follows:

-Central Statistics
-Economic and Technical Co-operation
-Human Resource Planning
-Investment Planning and Research
-Sectoral Planning
-Regional Planning

The Department of Investment Planning and Research (IPRD) is responsible for macro and corporate planning and for the preparation, evaluation and monitoring of projects. The undersigned was recruited by UNIDO to assist especially IPRD's Project Preparation and Evaluation Unit (PPEU) to "Prepare guidelines for the preparation, appraisal and monitoring of mining industry prospects and establish systems within NCDP for the co-ordination, preparation, evaluation and monitoring of all mining projects." The organization of the department Investment Planning and Research has been enclosed in appendix one(1) and the detailed job description of the undersigned in appendix two (2).

By and large it seems that the Investment Planning and Research department is working well. The department has taken effectively to the use of the Comfar computer model for economical and financial calculations. Today we can say. that the calculations are "every day routine".

During the short active period the department has been however realised that the preparation, appraisal and monitoring the projects do not only include calculations, but there are needed also some technical and engineering aspects to take into consideration. The Mining industry is the backbone of the country's economy and the biggest forex-earner and therefore the investments and monitoring of mining sector needs to strengthen by technical "know-how".

Refe.ring to the existing situation the undersigned prepared guidelines and manual for the appraisals and monitoring of mining projects.

III. MONITORING OF MINING PROJECT.

When monitoring or making an appraisal of mining projects it is of utmost importance to control the assumptions, which the project report is based on.
What are these assumptions?
Generally we can select three clearly different types of feasibility studies of Mining projects as follows:

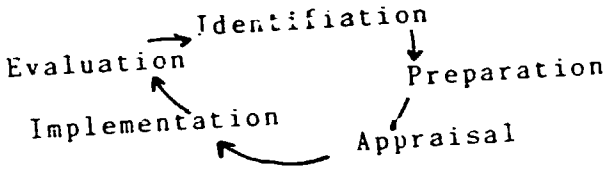
-OPPORTUNITY STUDY
-PRE-FEASIBILITY STUDY
-FINAL FEASIBILITY STUDY

On page ten is the scope of a typical opportunity study. It is based on few samples and therefore it is possible to make only rough calculation of profitability. It is not uncommon in practical life to find investment applications which are on this level. Naturally this kind of applications can not lead to the realisation of projects. However the preliminary information can often be the reason for very fantastic head lines in the Daily News.
On page eleven presented is a typical content of a pre-feasibility study. This study is a serious attempt by using professionally well qualified personnel and company to survey the project so much that it is possible to decide if the project is so promising that the study could recommend the realisation of final feasibility study.
On page twelve is the content of the final feasibility study. It takes into consideration all possible technical, sales and financial aspects, which can affect the profitability of a mine project. The investment decision of a mining project must have a strong professional grounding in order to be sound. A wrong decision based on too little information or wrong information is impossible to correct, because the mines are often located on remote areas and the utilization of investment for other purposes is impossible.
The project documents used to submit to NCDP in the form of feasibility study and NCDP assignment is to prepare an appraisal of project document. This report advises at first to take a general review of the document and compare the content of studies with the standard feasibility studies, as introduced in this report closer. If the study falls to the category of opportunity study, then it is recommended simply to follow an appraisal model initial feasibility appraisal, on page 33. If the document corresponds to the standard pre-feasibility study, the appraisal form called conceptual appraisal will be recommended as on page 34. The third model of appraisal on page 35 represents a complete appraisal form, where also consultation with the Ministry of Mines is recommended in order to check technical aspects of the study.

After the implementation or during the implementation of a project the evaluation of project status is necessary and also in these studies it is possible to use the same appraisal form and when some errors are found, then naturally the necessary corrections in project planning should be made.

IV. PROJECT CYCLE.

It is an approriate way, as often used by World Bank, to describe the monitoring of projects by using the following scheme:



Picture 2. The Baum cycle.

Identification means in this scheme, that we have found an idea, which can be a base for the "project". In the mining industry this idea means normally a mineral resource based project i.e. the establishment of a new mine. The project can also be the extension or the rehabilitation of the existing mine.

Preparation means, that the project idea was considered favorable enough and we shall provide a pre-feasibility or feasibility study. The project preparation covers the establishment of technical, economical and financial feasibility. The preparation determines the scope of the project, location and site, the scale of the project and the size of its individual parts and the timing of investment. Project design and formulation will often be done by international consultants.

Appraisal consists of a comprehensive and systematic review of all aspects of the project proposal like technical, financial, commercial, project participants, social, managerial and organizational aspects.

Implementation means the realisation of the project and the negotiations with the candidates of contractors and project financiers and decisions and agreements as a last stage.

Evaluation comes to the picture, when the project has been carried out or, if the project lasts longer time, it is a practice during the implementation to control by evaluation, how well the project follows up its original planning and original targets.

V. OPPORTUNITY STUDY - INITIAL FEASIBILITY APPRAISAL IN MINING PROJECTS.

Character of the study:

Based on very little information
- -like a few random samples, which have been assayed in laboratory
- -geological study based on existing geological maps
- -maybe some trenching with sampling under the control of the the local geologist
- -literature study
- -optimistic calculation about size and value of ore deposit "in situ"
- -rough estimation for investment and operating costs
- -capital costs are taken from the cost-curves of the same type of mine
- -operating costs will be also taken from existing mines as an estimation

The study must be prepared by a professionally competent person like geologist or mining engineer.
The calculation of profitability for deposit.
The accuracy ofthe study is expected to be $\pm$ 40 %.
The estimated cost of study is from about 5,000 to 100,000 US$.

If above study gives a positive result - the next step is to start pre-feasibility study.

VI. PRE - FEASIBILITY STUDY IN MINING PROJECTS .
(in some literature called conceptual study)

Also this study is based on very limited information.

Character of study:

-It is used to give for preparation to the competent and professionally well known Engineering company.
-This study must be realistic.

It includes normally:

-Location
-Description of project
-Geological information
-Possible ore reserves
-Metallurgical results of preliminary laboratory tests
-Proposed mining plan
-Production schedule
-Sales value of products
-(maybe some supporting studies like marketing)
-Map of mine area and plot plan for surface plant and ancillary facilities
-Flowheet of process with material balance
-List of equipment and budget quotations
-Capital cost estimation
-Operating cost estimation
-Environmental considerations
-Economic evaluation of project

The accuracy of this study is $\pm$ 15 - 30 %.
The cost of study is estimated from 50,000 to 1 mill. US$.

If this study is favourable - final feasibility study will be recommended.

7.1. EXECUTIVE SUMMARY IN MINING FEASIBILITY STUDY.

7.1.1. PROJECT BACKGROUND AND HISTORY.
- -purpose of the study
- -name and address of project promoter
- -name and address of the company or institution, which prepared the study

7.1.2. GENERAL DESCRIPTION
- -location of ore body on map (country and regional map)
- -general geology of the area
- -ore reserves (proven, probable, possible), tonnages, grades, main minerals etc..
- -at least two sections of ore body on map
- -description of the size of exploration (tunnels, deep drilling, trenches etc in meters)
- -sampling and assaying methods
- -mining method (open pit or underground), waste/ore ratio
- -ore processing methods - test results

7.1.3. MARKETING AND SALES (export separately)
- -marketing and selling policy
- -pricing policy
- -price estimation for selling products

7.1.4. PRODUCTION CAPACITY OF THE MINE
- -capacity per day, per hour, per year
- -nominal or design capacity
- -max capacity
- -estimated production per year (see production plan on table 2)
- -estimated process results, grades recovery etc..

7.1.5. INVESTMENTS.
- -total investment cost + working capital
- -list of main items of machineries, facilities

7.1.6. MANNING TABLE

7.1.7. ANNUAL PRODUCTION PLAN AS A TABLE

7.1.8. ANNUAL PRODUCTION COSTS AND PROFIT

7.1.9. FINANCIAL PROPOSAL
- -including NPV, IRR, PAY BACK PERIOD, BREAK EVEN

7.1.10. ECONOMICAL CALCULATIONS
- -by using shadow pricing

7.1.11. EVALUATION OF RISKS
- -construction stage
- -start up stage
- -production stage

7.1.12. CASH FLOW CHART

7.1.13. FINAL CONCLUSIONS

The accuracy of this study must be $\pm$ 10 %.
The estimated cost of study is from 1 mill. to 10 mill. US$

PRODUCTION PLAN IN MINING PROJECTS.

YEAR	MINING		CONCENTRATION PLANT							
			FEED		PRODUCT 1		PRODUCT 2		TAILING	
	TON/YEAR	GRADES	TON/YEAR	GRADES	TON/YEAR	GRADES	TON/YEAR	GRADES	TON/YEAR	GRADES
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
TOTAL										

Table 2

7.2. KEY-PERSONS IN MINING STUDY.

When the feasibility study will be prepared in a mining project, the professional team, minimum four (4) persons, will be needed. This team is working full time on this only project study. The best professional combination is as follows:

7.2.1.CHIEF GEOLOGIST,
who must have a large experience, minimum ten years, on the field of mining geology. He is responsible for exploration of the ore deposit and his main task is an exact ore reserve estimation and calculation, quality (grades) and quantity. Geologist is expected in his report to be very realistic, fair and correct and finally he must personally sign in his statement.

7.2.2.SENIOR MINING ENGINEER,
-responsible for the complete mining study, mining design and cost estimation (capital and operating cost).

7.2.3.SENIOR METALLURGIST OR MINERAL PROCESSING ENGINEER,
-responsible for the process design, flowsheet i.e. process selection, material balance, equipment selection and cost estimation.

7.2.4.SENIOR ECONOMIST,
-responsible for the financial and economical calculations.

One of the above persons will be appointed as a project manager responsible for the whole feasibility study. This permanent team uses temporarily supporting experts from special fields like civil construction, electricity, instrumentation etc..

7.3. OPTIMUM SIZE OF MINE.

The production size of mine depends on many factors like

7.3.1. MARKETS. Limiting factor being demand.

7.3.2. ORE RESERVES. The ideal lifetime for the mine is ten years or more. The limiting factor being ore reserves. If the known ore reserves are only for five years production or less, mobile - type mine will be recommended.

7.3.3. MINING METHODS. Open pit mining is always easy and can be done on a large scale. Underground mining is more complicated and much more difficult depending on the geological formation of ore body. So rather often the capacity of underground mining is a limiting factor for the determination of the mine size.

7.3.4. PROCESSING. Standard process equipment determines sometimes the optimum size of the plant. However it is possible to install many equal production lines and this avoids the upper limit of the mine size.

7.3.5. FINANCING. Mining is a capital intensive industry. When the optimum size is determined, it is always useful to calculate different alternatives for a few mine sizes. However sometimes, because of shortage of money, it is necessary to start production in smaller scale, what should be an economically optimum size.

7.3.6. MATHEMATIC MODEL FOR OPTIMUM MINE SIZE. It is possible to use a normal capacity factor, when making a comparison with different mine sizes. The formula is

$$C_1 = C2 \times \left(\frac{Q1}{Q2}\right)^x$$

C_1 = is the investment cost of capacity Q1 and
C2 = is a known cost of the capacity Q2
X = is a cost factor, in mining industry 0,6 or 0,66

7.3.7. MINIMUM SIZE OF MINE. There is always a certain minimum size, at which the mine is profitable. This calculation must always be included in the feasibility study, because this information is important for decision makers.

7.4. PROJECT BACKGROUND AND HISTORY.

7.4.1. THE PURPOSE OR THE SCOPE OF THE STUDY.
Example:"The project is to develop a new copper mine in the Copperbelt province of Zambia."

7.4.2. PROJECT PROMOTER.
Name and address of promoter and the company, which prepared the study.

7.4.3. LOCATION OF THE DEPOSIT.
Two maps, one where the deposit is marked in the country and the other, where the deposit is marked on the provincial map with main roads, railways, rivers, high voltage electrical lines and environmental conditions etc.. The report must also include the altitude, the weather statistics of the area like rain, winds, earthquakes.
-History of the project.

7.4.4. GENERAL GEOLOGY OF THE AREA.
A short description of the area geology and then a closer clarification about the ore body itself with the main valuable metals and/or minerals. It is also useful to describe the mineralisation of hostrocks.

7.4.5. ORE RESERVES.
A table of proven, probable, and possible ore reserves in tonnages and grades of valuable metals and minerals. This part of the report also describes the calculation methods and the assumptions for starting data.

7.4.6. STUDIES AND INVESTIGATIONS ALREADY PERFORMED.
-Summary of the existing reports with list of references.

7.4.7. DESIGN CAPACITY OF MINE.
Mining tonnages per year. Products with tonnages per year. The estimated lifetime of mine.

7.4.8. COST OF PRE-INVESTMENT AND PREPARATORY INVESTIGATIONS.

7.4.9. ECONOMY OF THE MINE. REVENUE AND PROFITABILITY.
Also the economy separataly, when using shadow pricing.

7.4.10. CONCLUSIONS AND RECOMMENDATIONS.

7.5. GEOLOGY.

7.5.1. Regional geological description with colored maps of rocks
7.5.2. Geology and mineralisation of mine area and especially ore body with maps. Description of main minerals in ore bodies with hostrocks, grades, particle sizes, oxidations, microscope pictures of main mineralisations etc..
7.5.3. The exploration method of ore body and the description of sampling and assaying.
7.5.4. The drawings of ore body at least in two sections.
7.5.5. The ore reserve-estimations (ore categories in table 3)
-proven ore tonnage , grades
-probable ore " "
-possible ore " "
7.5.6. Rock mechanics.
7.5.7. Ore quality control in production.
7.5.8. Planning and recommendations for further geological surveys.
7.5.9. Risks. Estimated sources for the errors in ore reserve calculations and the profitability of errors.
7.5.10. Operating cost of geological department. The demand for the investment in the future.
7.5.11. Manning and organization of geological department

Category		General Description
U.S.A.	Canada	(After Patterson, 1959)
Measured	Proven	Ore for which tonnage is computed from dimensions revealed in outcrops, trenches, workings and drill holes and for which the grade is computed from the results of detailed sampling.
Indicated	Probable	Ore for which tonnage and grade are computed partly from specific measurement, samples or production data and partly from projection for reasonable distance on geologic evidence.
Inferred	Possible	Ore for which quantitative estimates are based on broad knowledge of the geological character of a deposit and for which there are few sample measurement.

Table 3. Ore reserve classification.

7.6. MINING.

7.6.1. Describe with map, how mining will be developed in order to start ore production.

7.6.2. Time schedule for above development work in table form.

7.6.3. Mining method(s) with general drawings in production. See an example on picture 3.

7.6.4. List of equipment and facilities needed in production including maintenance and spare parts.

7.6.5. Manning table - number of shifts - days per week.

7.6.6. Capital including replacement and operating costs. Mine development work costs separately.

7.6.7. Organization chart of mining department.

7.6.8. Introduce mineable ore reserves in table form. See an example on table 4 below:

MINING RESERVES

ITEM	ORE (ton)	Average grades 1	2	3
1.OPEN PIT				
2.UNDERGROUND STOPES				
1-2.ORE RESERVES				
3.PILLARS				
4.ORE LOSSES				
5.OTHER BLOCKS				
TOTAL				

Table 4. Ore reserves in different mining areas.

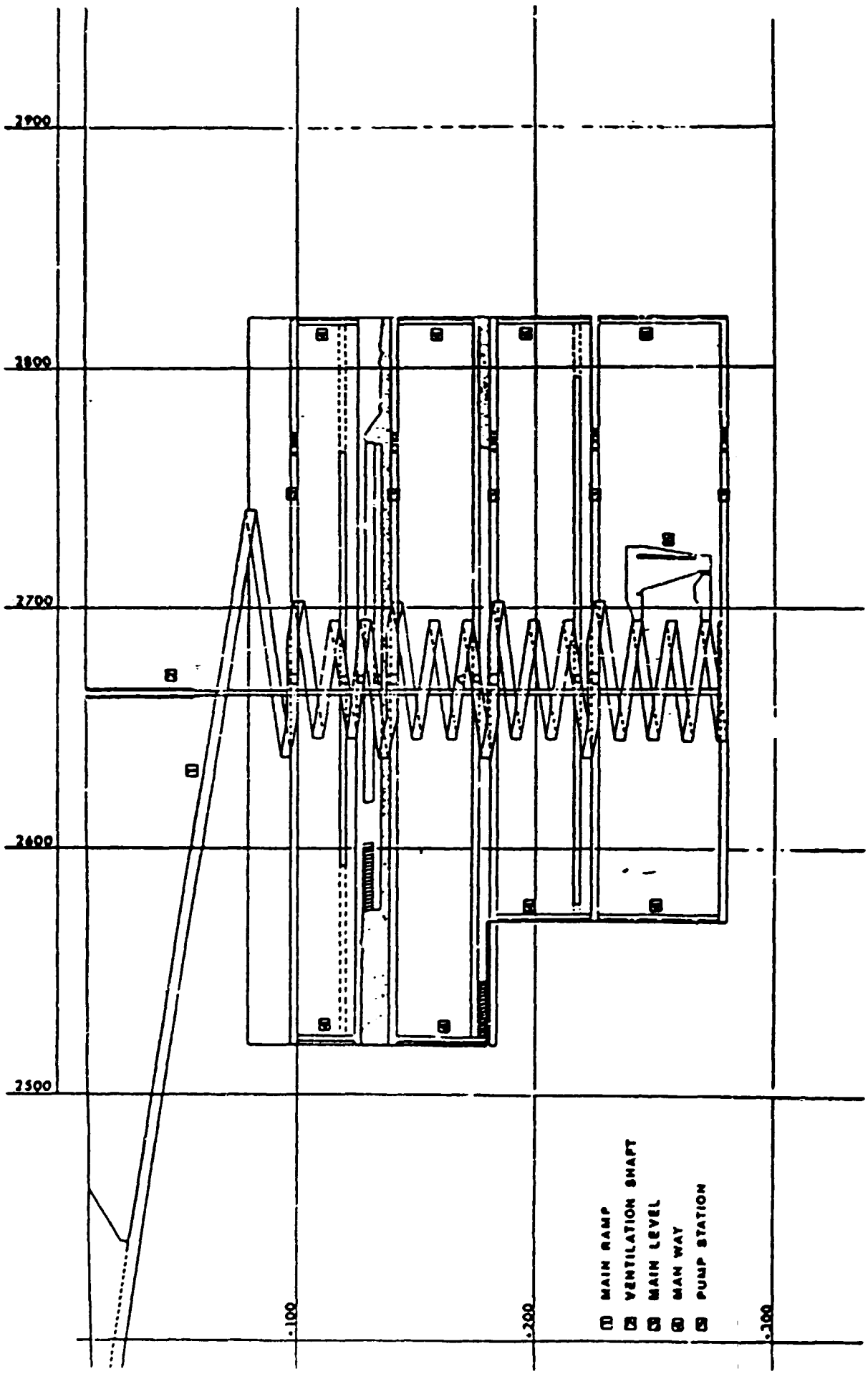

2900
2800
2700
2600
2500
100
200
300
MAIN RAMP
VENTILATION SHAFT
MAIN LEVEL
MAN WAY
PUMP STATION

Plate 1

7.7. ORE CONCENTRATION.

7.7.1. Summary of process tests in laboratory and pilot scale.

7.7.2. The capacity of the concentration plant, tonnages and grades for feed, products and tailings (see on production plant table), capacity per hour, per day, per year. Estimated utilization or availability of plant (i.e.hours per year).

7.7.3. General lay-out of the plant with the drawing. See an example on picture 5.

7.7.4. Process flowsheet with material balance sheet including slurry and water balance. See an example on picture 6, a typical flow-sheet of the flotation plant.

7.7.5. List of process equipment.

7.7.6. Assay laboratory equipment and facilities.

7.7.7. Instrumentation of the process.

7.7.8. Water (volume and quality) requirement of the plant and tailing disposal and possible water recirculation.

7.7.9. Energy consumption of different stages of process.

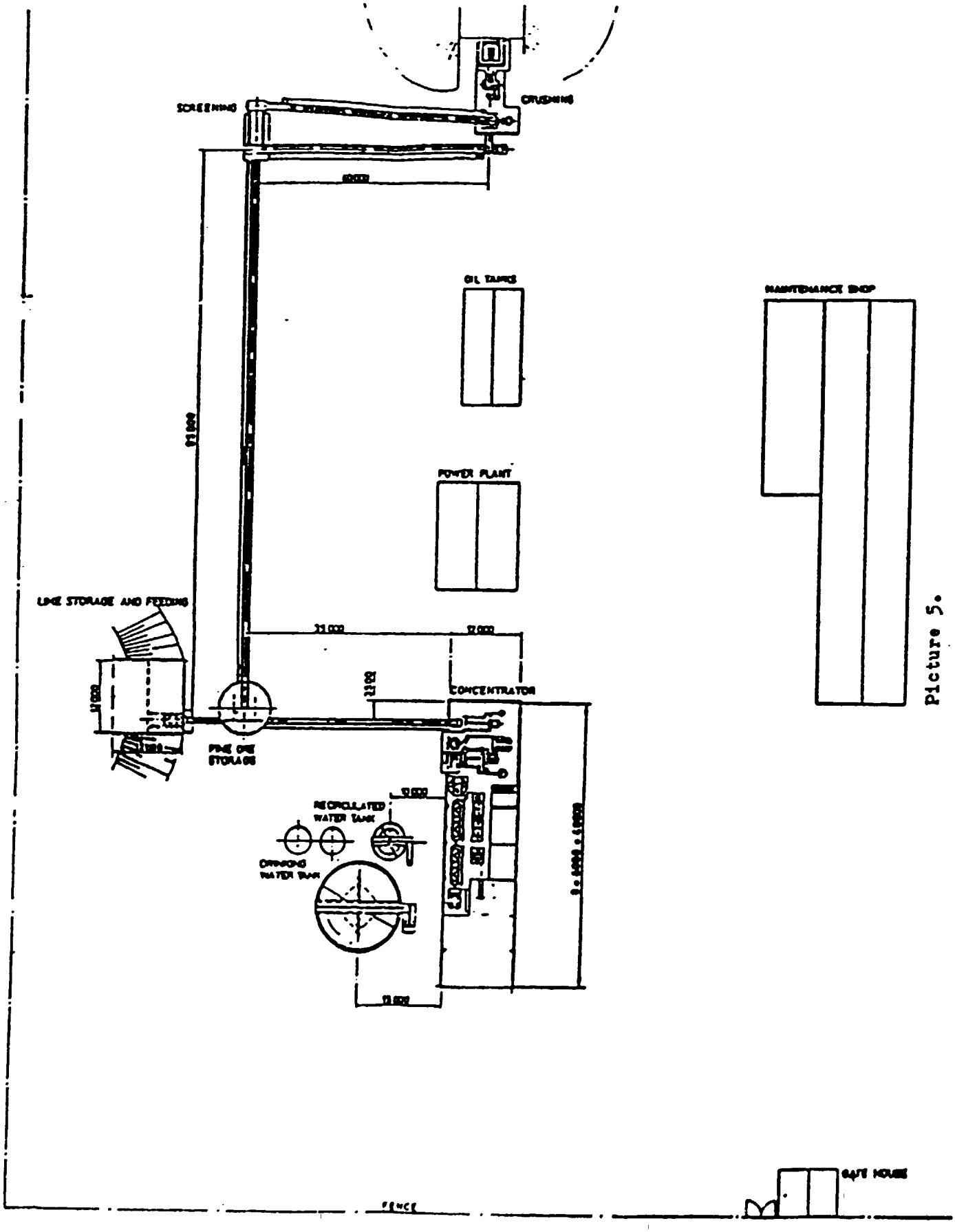
7.7.10. Manning table, number shifts of plant per week.

7.7.11. Time schedule for construction and installation of plant. Expected start up and running in period.

7.7.12. Estimated capital and processing costs divided to different process steps.

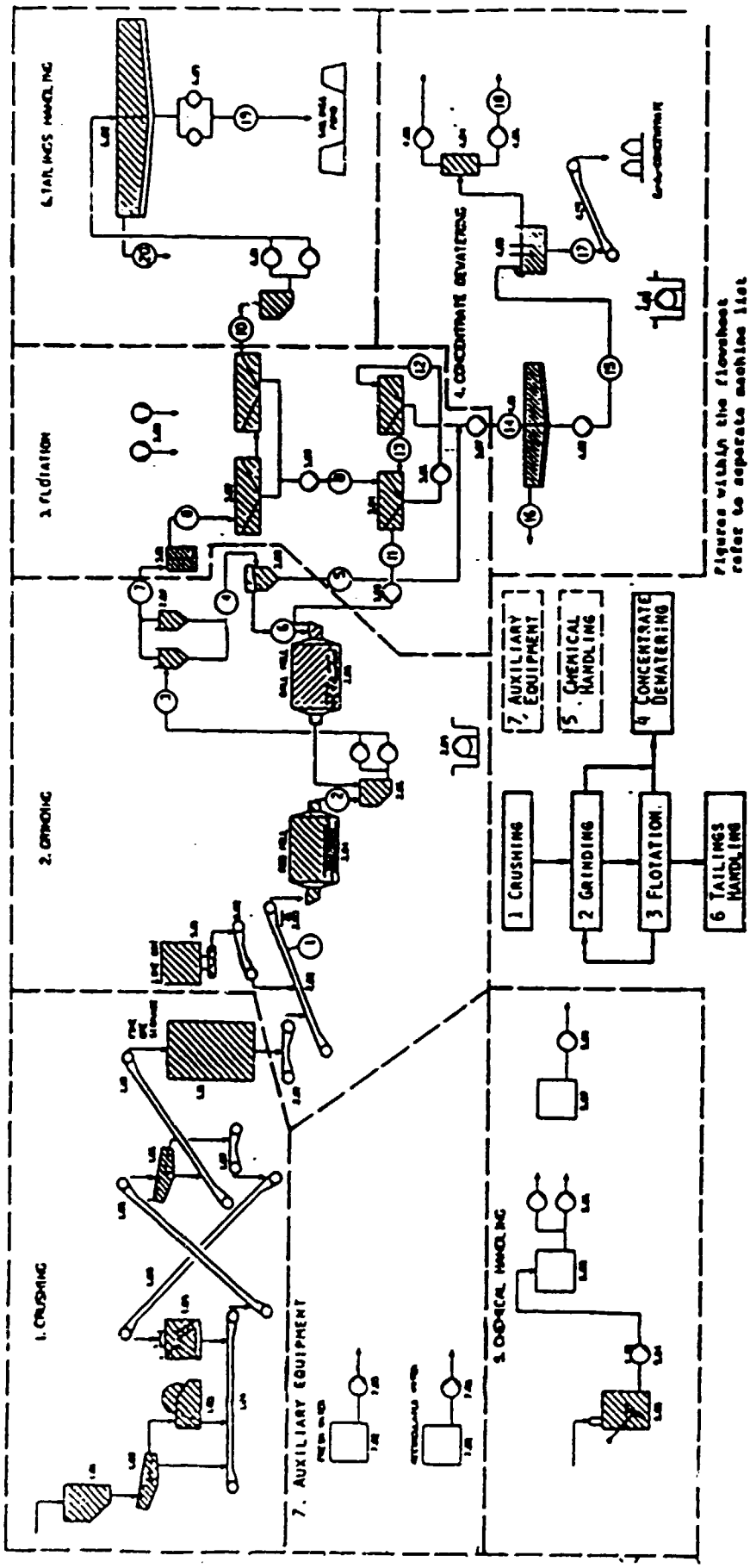
7.7.13. Ancillary facilities, like storages for raw materials and products - office facility separately.

PLANT LAYOUT



Picture 5.

PROCESS FLOWSHEET



Picture 6.

7.8. WATER.

Water is an important element in the mining industry. Sometimes there is too much water like in Zambia's underground mines. Sometimes there is no water, and it must pumped from distances of hundreds of kilometers like many mines in Australia. Therefore it is necessary in the feasibility study to make a Site study of water in order to guarantee enough and good quality water at any type of recorded climatic conditions. Trinking water sources must be study separately.

7.9. POWER.

Power is a significant cost in mining industry, because the effective mining is based on electric driven motors. Mining feasibility study normally clarifies most economical energy sources by negotiating with power suppliers, which are locally available. It is also an essential matter to check the security of power delivery. Many mines used to provide an own diesel aggregate in order to secure that the key-equipment run continously.

7.10. TAILING DISPOSAL.

This is a special subject and its importance is growing, because the environmental control becomes more and more strict. It is therefore also useful to study an opportunity to regenerate water again and recirculate it in process. Well designed tailing pond considers also that the material, which is today tailing, can be a new feed tomorrow to the process plant again.

7.11. TRANSPORTATION.

Transportation of personnel, products and supplies must also study separately and an optimal solution will be introduced in study.

7.12. RAW MATERIALS AND CONSUMPTION-ITEMS IN MINING INDUSTRY.

Mining industry is one of typical process-industry, where only a continous process flow guarantees a good economical result. The high utilization is possible, if spare parts and critical raw materials are always available. Therefore it is necessary on the feasibility stage to prepare a list of important raw materials and spare parts. The important items on different sectors are as follows:

7.12.1.GEOLOGY -drilling rods, drilling bits, spare parts of the drilling equipment and vehicles, sampling bags

7.12.2.MINING -explosives
-drill rods, drill bids
-steel, pipes, hoses
-spare parts

7.12.3.PROCESSING -chemicals in laboratory and production process
-manganese wearing parts in grinding mills and pumps
-balls and rods for ore grinding
-special clothes for filtering
-spare parts

7.12.4.COMMON MATERIALS -fuel
-oil
-spare parts for vehicles

7.12.5.SPARE PARTS. When choosing new equipment it is recommended to purchase at least two years spare parts at the same time with the investment and when the decision to purchase new equipment is made. The delivery of the spare parts for the lifetime of equipment will be surveyed.

7.12.6.CONSUMABLES. Prepare a clear programme, how consumables will be purchased. Prepare a list or record of suppliers of all materials, which will be continously needed when the production is running. Remember that "ad hoc", quick deliveries cost a lot of extra money.

7.13. ADMINISTRATION AND INFRASTRUCTURE.

In the mining industry the production departments are.
-Geology
-Mining and
-Processing department and the other departments assist the production to make as good as possible result.
The role of the administration is to support the targets of the production by undertaking of book-keeping and economical control. The fixed investment is divided as follows:

A. Fixed investment

A1. Land
A2. Buildings
A3. Geology equipment
A4. Mining equipment
A5. Process equipment
A6. Administration & Service facilities

B. Pre-production capital expenditure

B1. Land
B2. Buildings
B3. Geology equipment
B4. Mining equipment
B5. Process equipment
B6. Administration

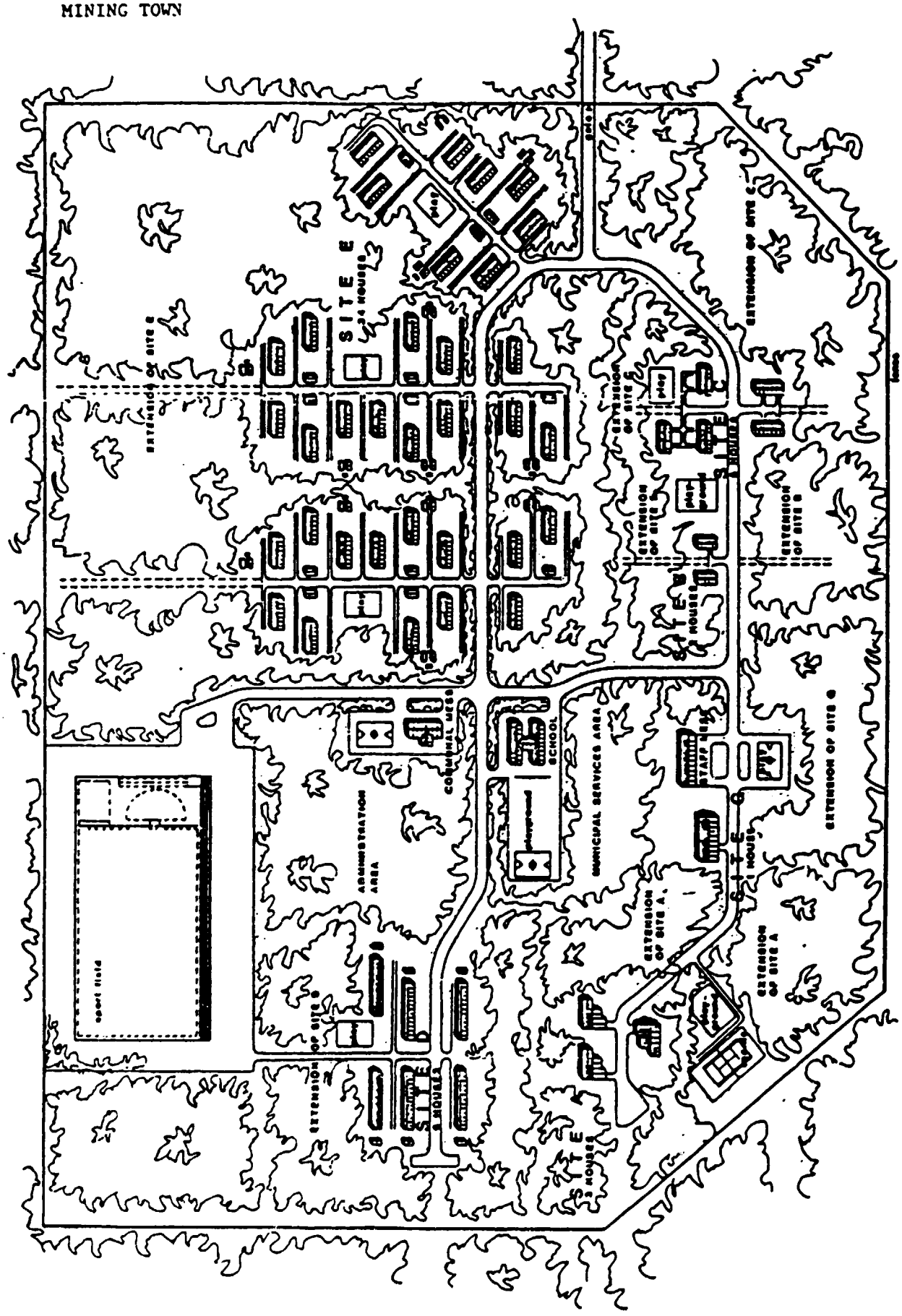
C. Working capital at full capacity

Total investment for the whole mining project is now the sum of A + B + C.

Operating costs must be followed so that each department will prepare an own budget monthly and a month is also a report as well as a control period for production, selling, cash-flow etc.. The separate control objects are geology, mining, process, administration and sales departments.

Administration is normally responsible for the indirect costs of maintenance, communication (telephones, telexes and telefaxes), medical services, canteen, change-room, security control, townsite (see on picture 7) as well as environmental and safety control. Also purchase and recruitment including training of people report usually to the administration department.

MINING TOWN



Picture 7.

7.14. SALES AND MARKETING.

7.14.1. MARKET STUDY. Market study clarifies the demand for the existing product in the world, in the neighbouring countries and finally on the home market. It also collects a statistics on the prevailing prices and the main factors, which affect the price of the product.

7.14.2. MARKETING AND SELLING STRATEGY.
-export (maybe via agency agreement)
-home market (maybe in own hand)
-pricing policy
-long term contracts based on metal stock prices
-"spot"-price selling for the smaller delivery

7.14.3. SELLING ORGANIZATION.

7.14.4. LOCATION OF THE SELLING DEPARTMENT.
-communication and reporting between the production plant and selling department

7.14.5. PRODUCTION PROGRAMME INCLUDING POSSIBLE BYPRODUCTS.
-quantities and qualities of products (tons and grades) per month and per year

7.14.6. WEIGHING AND ASSAYING OF PRODUCTS.
-in normal deliveries
-in the cases, when some issues rise up and the neutral partner must be determined

7.14.7. THE TERMS OF PAYMENT.
-expected cash in-flow
-estimated delays in deliveries (transportation etc.)
-estimated delays in payment

7.14.8. THE TERMS OF DELIVERY.
-border limits geographically

7.14.9. SELLING AND MARKETING BUDGET
-selling costs incl. agent commissions and fees
-marketing costs

7.14.10. AFTER SALES REQUIREMENT.
-estimated supporting capacity needed from the production plant

7.15. PROJECT IMPLEMENTATION.

Project implementation of a mining project does not differ from other type of industrial projects. Principally it is possible to very closely UNIDO's manual (literature ref. no 1.7a). A time schedule like on table 5 is used to draw graphically and the follow up takes place in the weekly project meetings.

If the project starts as an underground mine, the determining factor in time schedule is an opening of the mine. There is only a limited capacity to drill and to blast a new shaft and the main drifts before the production can start.

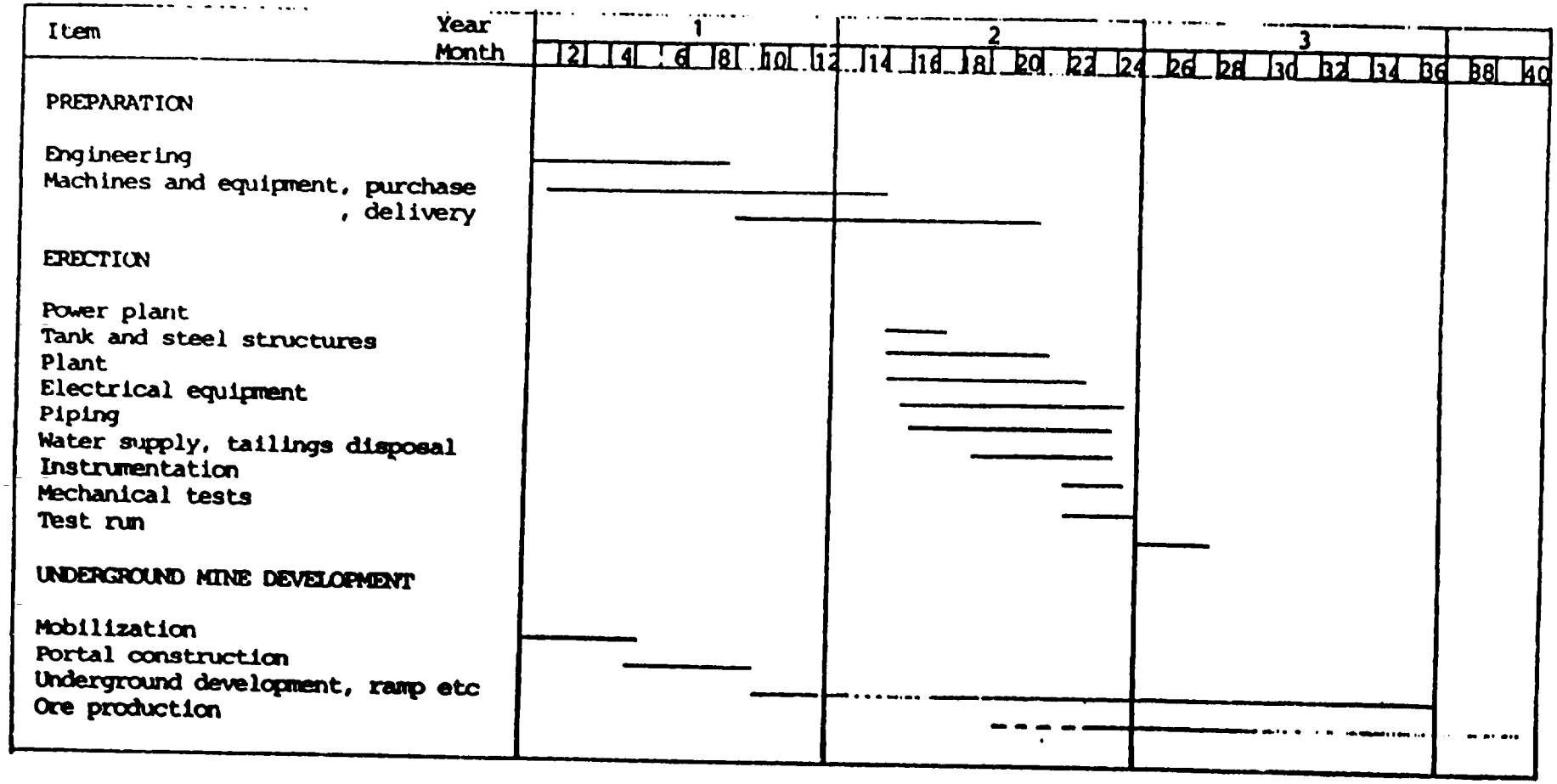
Like other industries it is a common practice to allocate the project to different subcontractors and this way to compress the total implementation time to the shortest possible time. When the installation of the equipment begins, it is also useful to recruit all process personnel at this stage and join them to the other implementation groups so that the operators become familiar with the process equipment as early as possble.

When each process equipment will be installed it is important immediately to make non-load test in order to ensure that the equipment has not incurred any damages during transportation and installation period.

7.16. FINANCIAL AND COMMERCIAL EVALUATION.

Financial and commercial evaluation follows also UNIDO's manual by calculating NPV, IRR, BREAK EVEN point and pay-back period. If the project is located in a developing country, it is recommended to calculate the above parameters by using shadow pricing because the international financiers are increasingly emphasizing their desire to see also these results.

In the mining industry the evaluation also includes the calculation of so called cut-off grade i.e. the content of the valuable metal or mineral, when the project is giving the economical result 0. Also the calculation includes very often the break-even for the minimum utilization or availability per cent of the plant.


Item
Year
Month
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8
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12
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16
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22
24
26
28
30
32
34
36
38
40
PREPARATION
Engineering
Machines and equipment, purchase
, delivery
ERECTION
Power plant
Tank and steel structures
Plant
Electrical equipment
Piping
Water supply, tailings disposal
Instrumentation
Mechanical tests
Test run
UNDERGROUND MINE DEVELOPMENT
Mobilization
Portal construction
Underground development, ramp etc
Ore production
IMPLEMENTATION SCHEDULE

Table 5

7.17. RISKS AND SENSITIVITY ANALYSIS.

The financiers prefer to devide risk anlysis into three different periods, which are

- implementation
- start-up and
- production

The largest risk during the implementation is that the project does not follow the time schedule. Therefore the weekly project meetings must concentrate on this factor. The second risk is the budget and its follow up must also be in the strong hands of the project manager.

During start up, the biggest risk is in the process, if it works or not according to the parameters which have been calculated based on pilot tests. Therefore most of financiers are very critical of accepting any new technology.

If the implementation and start-up go according to the planning, the production itself normally can follow the forecasted production results.

If we have now succeeded to eliminate all risks on the implementation and start up then the biggest risks are on the market side. Can we really sell our products as planned and what is the price of the products?

The above risk factors must be analysed in the feasibility study in order to minimize risks of making wrong decisions.

Sensitivity analysis test normally looks at the following:
-what is the profitability of the project, if the budget will be increased 10 %.
-what is the profitability, if the income of the product selling is 10 % lower than estimated.

7.18. CASH FLOW CHART.

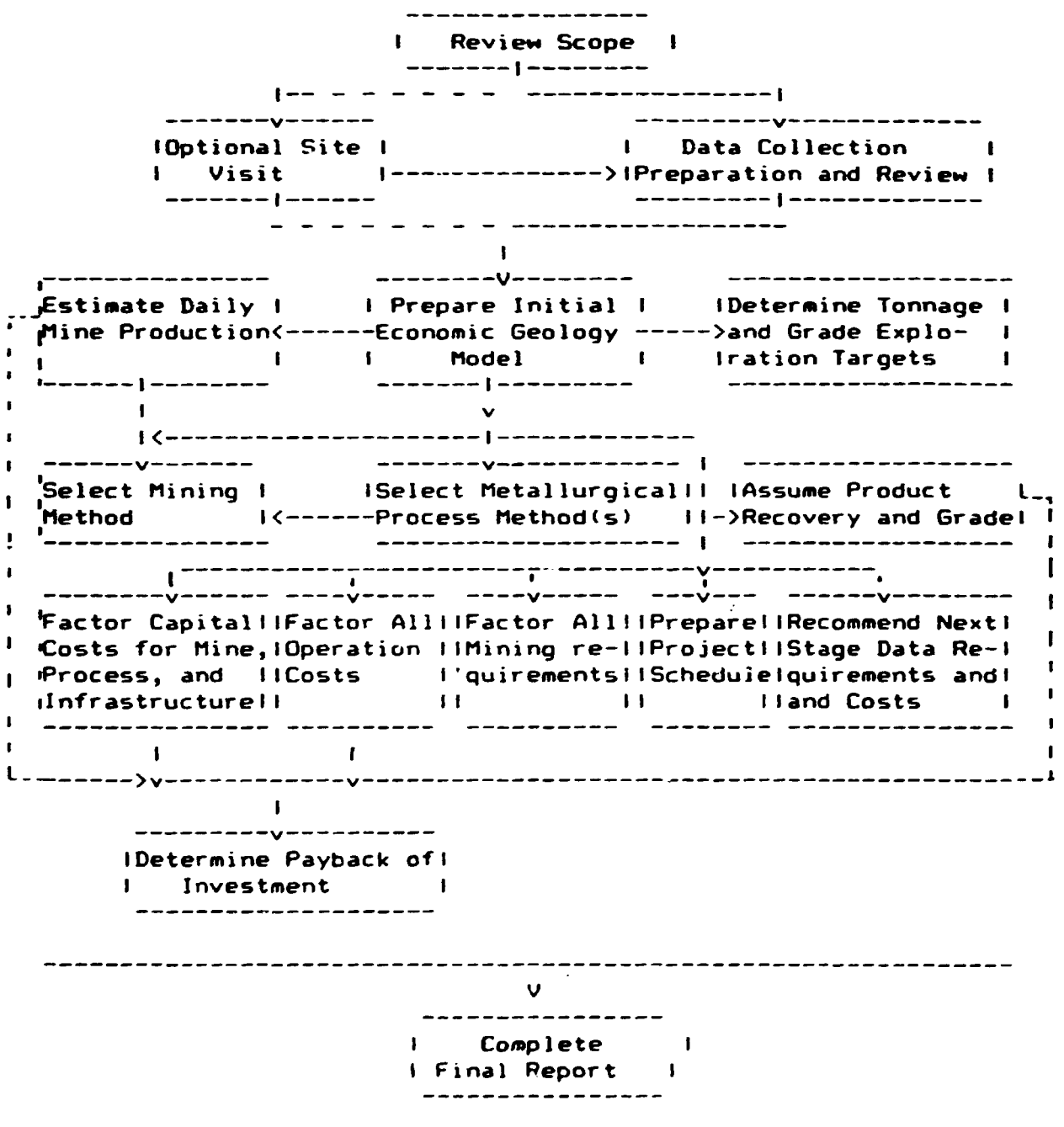
Cash flow chart tells cash inflow and cash outflow during the whole lifetime of the project and its last line "cumulative cash balance" is an important indicator for the financiers, how well the financing has really been arranged. See an example on table 6.

FOREIGN EXCHANGE CASH FLOW TABLE CURRENCY: USD (THOUSANDS)

YEAR	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
FOREIGN EXCHANGE INFLOW																		
SHARE CAPITAL	7500	12300	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LOAN DRAWDOWNS:																		
EXPORT CREDIT	5556	10976	3480	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COMMERCIAL LOAN	7500	0	12500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OVERDRAFT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ACCOUNTS PAYABLE	0	0	69	142	4	0	0	0	0	0	0	0	0	0	0	0	0	0
GROSS REVENUES	0	0	0	16567	19921	20122	20136	19392	17160	14201	14197	14197	14197	14197	14197	14197	14197	14197
INTEREST REVENUES	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FOREIGN EXCHANGE OUTFLOW																		
FIXED INVESTMENTS	15027	15329	6427	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
REPLACEMENTS	0	0	0	0	0	0	3500	0	1390	0	4928	0	0	0	4870	0	0	0
WORKING CAPITAL	0	0	1070	2594	279	70	28	0	0	0	0	0	0	0	0	0	0	0
PREPROD. EXPENDTS	200	187	330	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OPERATING COST	0	0	1500	4437	4561	4642	4650	4650	4680	4690	4690	4690	4680	4690	4650	4680	4690	4680
ADJUSTMENT FOR INCREASE IN STOCK OF FINISHED GOODS	0	0	750	1469	62	41	19	0	0	0	0	0	0	0	0	0	0	0
INTERESTS:																		
EXPORT CREDIT	0	0	1050	1998	1782	1566	1350	1134	919	702	486	270	54	0	0	0	0	0
COMMERCIAL LOAN	0	0	1150	2054	1725	1396	1068	739	411	82	0	0	0	0	0	0	0	0
REPAYMENTS:																		
EXPORT CREDIT	0	0	1000	2000	2000	2000	2000	2000	2000	2000	2000	2000	1000	0	0	0	0	0
COMMERCIAL LOAN	0	0	1429	2857	2857	2857	2857	2857	2857	1429	0	0	0	0	0	0	0	0
INTERESTS PAID DURING CONSTR.	595	1741	2219															
COMMITMENT FEES	337	557	148															
CREDIT FEES	2030	0	0															
TAX	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DIVIDENDS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NET FOREIGN EXCHANGE FLOW	2366	5461	448	1938	6783	7631	4372	7942	5204	5308	2193	7248	8464	9518	4628	9518	9518	9518
CUMULATIVE FOREIGN EXCHANGE BALANCE	2366	7827	8275	10213	16996	24627	29998	35980	42184	47492	49685	56932	65396	74913	79541	89059	98576	108093

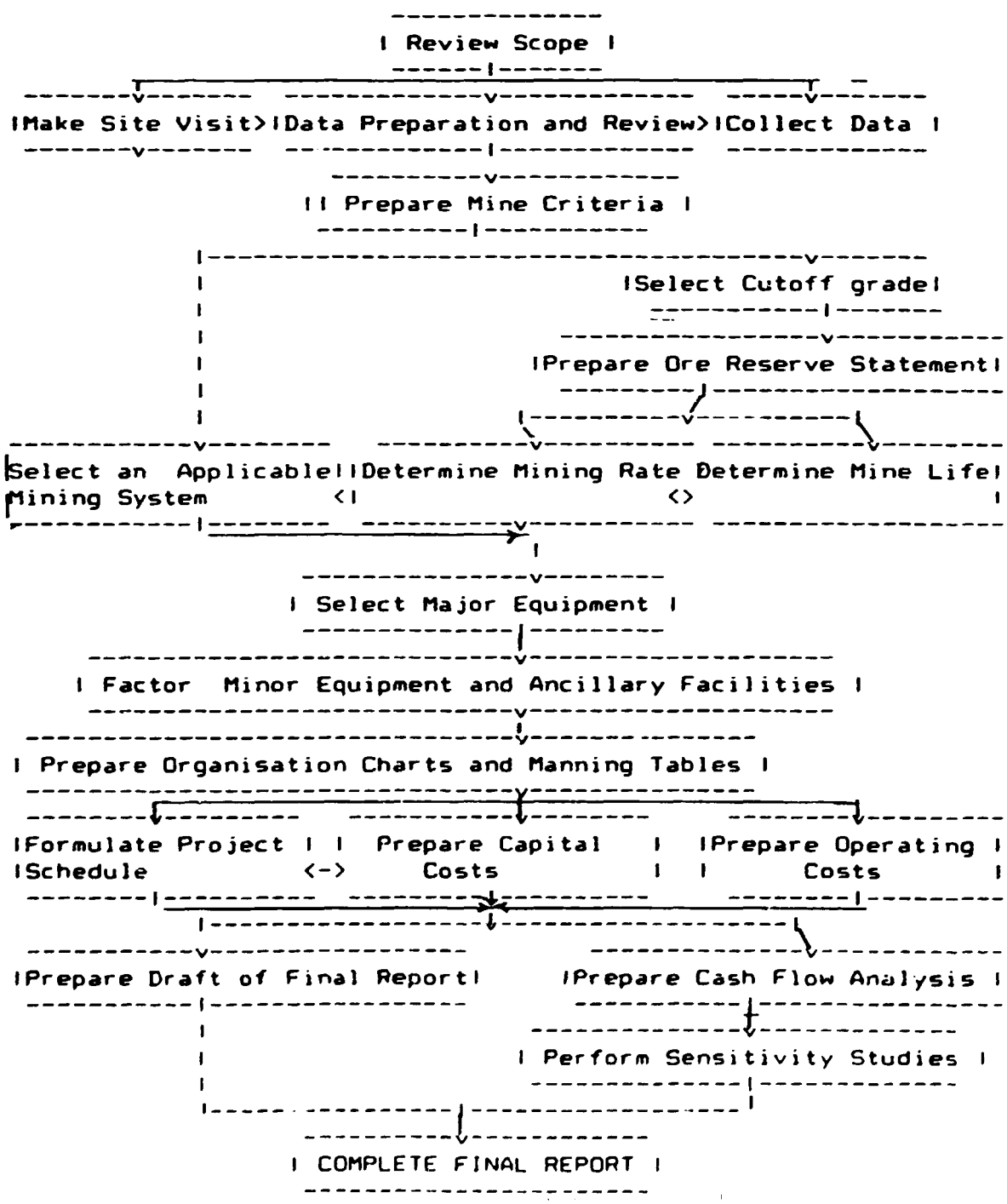
Table 6

8.1. OPPORTUNITY STUDY - INITIAL FEASIBILITY APPRAISAL IN MINING PROJECTS.



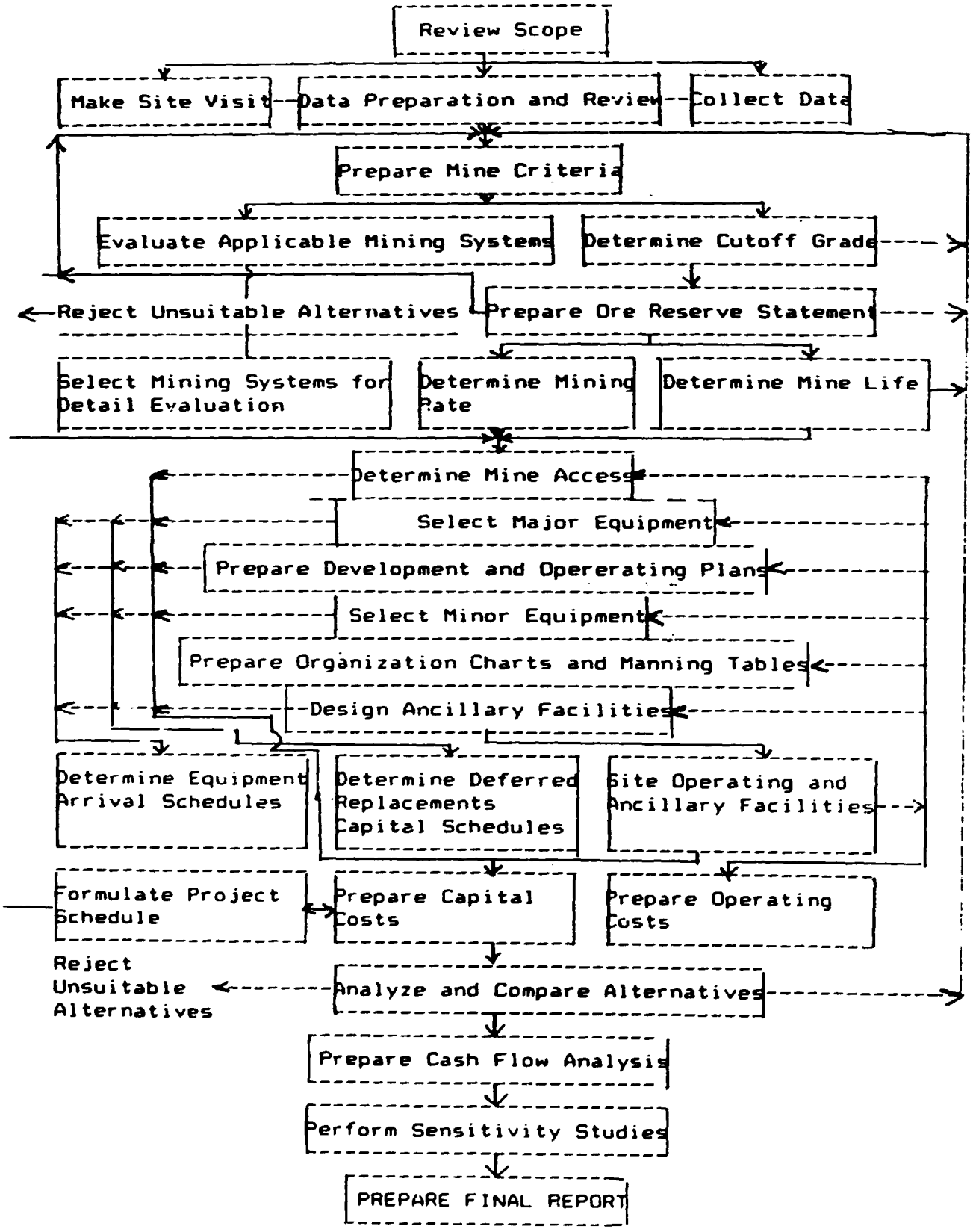
Source:Mining Seminar in Finland arranged by Bank of America 1983

8.2. PRE-FEASIBILITY STUY IN MINING PROJECTS. (CONCEPTUAL APPRAISAL)



Source:Mining Seminar in Finland arranged by Bank of America 1983

8.3. FEASIBILITY STUDY IN MINING PROJECTS.



Source: Mining Seminar in Finland arranged by Bank of America 1983

IX. EXECUTIVE SUMMARY IN MINING PROJECT APPRAISAL.

9.1. BACKGROUND INFORMATION
- -project partners
- -background history
- -project implementations time schedule
- -introduction of persons, who prepared an appraisal

9.2. INTRODUCTION OF COUNTRY'S ECONOMY AND THE ROLE OF THE MINING SECTOR

9.3. INTRODUCTION OF THE COMPANIES, WHICH WILL IMPLEMENT A PROJECT
- -size of companies
- -main references in similar kind of projects
- -solidity of companies

9.4. PROJECT DESCRIPTION AND THE TECHNOLOGY
- -ore reserves and ore resources
- -how and who calculated the above ore reserves
- -process tests
- -design criteria of mine
- -list of activities in pre-production stage
- -short description of production line

9.5. MARKET
- -production plan
- -share of world market
- -market forecast demand/supply in the future
- -price forecast
- -risks

9.6. IMPLEMENTATION
- -is time-schedule realistic?

9.7. INVESTMENT COSTS
- -initial fixed investment
- -pre-production expenditure
- -net working capital
- -interest during construction (including guarantee fee)
- -additional funds
- -above as a total gives total financing

9.8. FINANCING
- -equity
- -suppliers credit
- -loans

9.9. PROJECT ORGANIZATION
-responsibilities

9.10. FINANCIAL ANALYSIS
-internal rate of return on total capital (before tax)
-internal rate of return on equity
-cash balance
-sensitivity
-profitability

9.11. ECONOMIC ANALYSIS
-internal rate of return with shadow exchange rate
-cumulative foreign exchange balance
-project generation for nation

9.12. SOCIAL IMPACT OF THE PROJECT

9.13. RECOMMENDATIONS

X. THE CHECKLIST FOR MINING PROJECT APPRAISAL.

10.1. CONTRACTORS
Are they experienced in mining projects?
Do they have a good reference list and good reputation in the same types of projects?
Are they big enough, so that even in the severe conditions they will finish the project in time.

10.2. TECHNICAL ASPECTS
Is the technology well known and are people experienced in it?
Has the ore reserve statement been checked at least by two senior geologists?
Is the mining method well known?

10.3. MARKETS
Can the project sell products on the expected price?

10.4. IMPLEMENTATION
Is the time schedule realistic?
Is the cash outflow and investment realistic?
Is there any cost overrun risk addressed?
Is there consideration of the delay risk in the budget?

10.5. FINANCING
Is the financing secured?

10.6. PROJECT ORGANIZATION AND HUMAN RESOURCES
Are the operators experienced and well trained?
Is the management experienced?

10.7. FINANCIAL ANALYSIS
Does the project gain enough profit after the calculation of NPV, ROE and pay-back time.
Does the sensitivity analysis secure the viability of project?

10.8. OTHERS
Is the available water, energy and transportation sufficient?

10.9. SOCIAL ASPECTS
Does the project support the general positive targets of the project owner?

10.10. FEASIBILITY STUDY AND APPRAISAL
Are there reliable studies and appraisal documents available?

XI. CONCLUSIONS AND RECOMMENDATIONS.

11.1. The Mining Industry performs very well with respect to the national long term targets:"Growth from own Resources".

11.2. The adviser established systems to evaluate Mining projects within NCDP. The procedure in the system has been introduce in this report in detail.

11.3. The adviser recommends NCDP to compare the existing Mining study with the standard feasibility studies of projects.

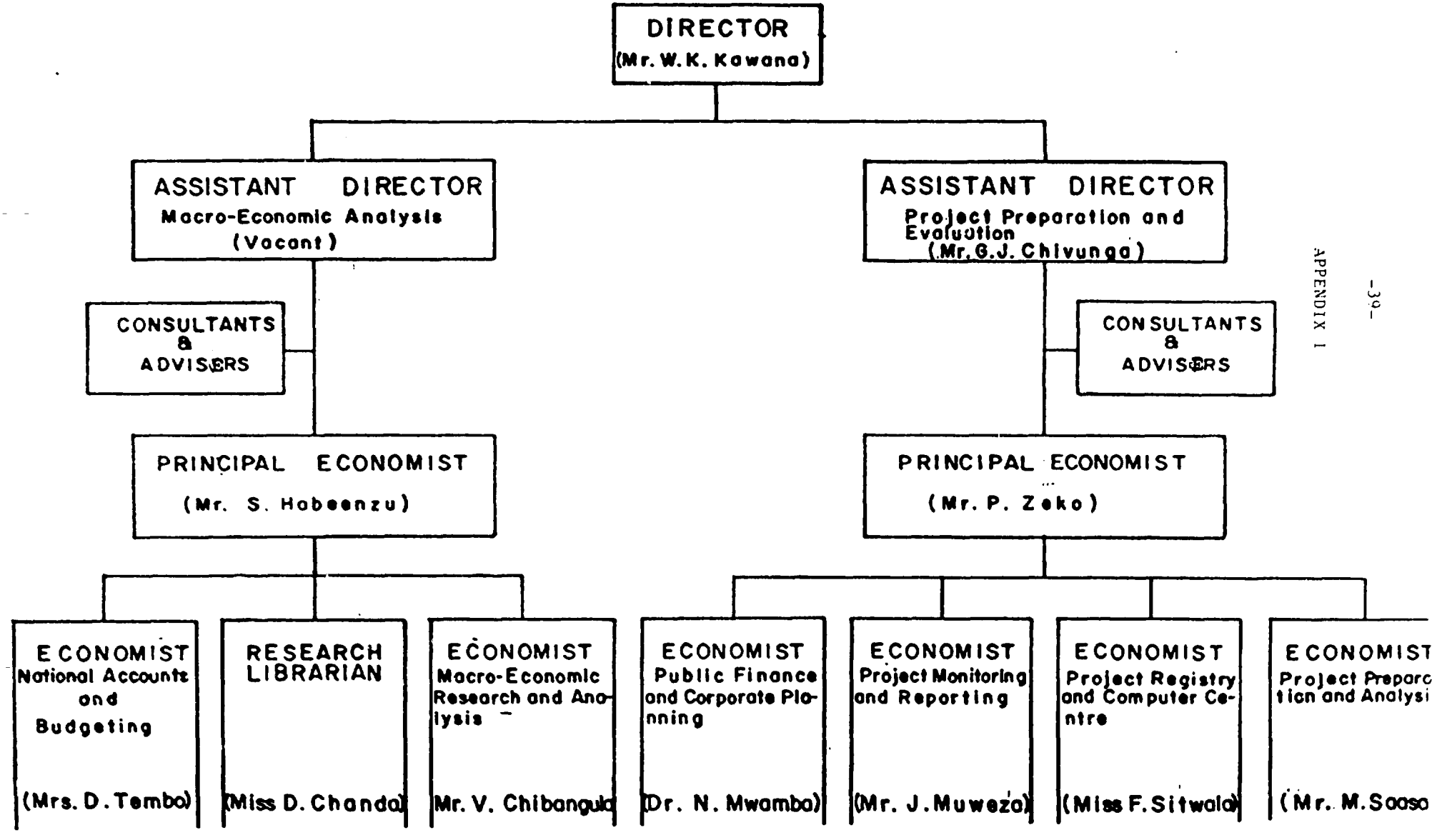
11.4. When making the final appraisal of mining projects the adviser recommends to have a close connection with The Ministry of Mines.

11.5. The role of The Ministry of Mines should be to act as a consultant when the technical parameters will be reviewed.

11.6. The Site visit together with the consultants must be a normal practice when the review is done.

11.7. The adviser underlined that Zambia posseses a large potential copper resources (according to ZCCM only at Copperbelt about 2 billion tons) and therefore the long term planning must to reserve the capacity and the incentives enough for the further development, exploration and modernisation of copper mining and refining.

11.8. The adviser agreed with The Ministry of Mines that the Integrated Steel Mill Project is not viable. The adviser also recommended to review the economical parameters of this project. The rough calculation shows that the project will remain a forex consumer when in operation.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APPENDIX 2

JOB DESCRIPTION
(Proposed for UNIDO/IDDA funding)

Post title: Mining Process Engineer

Duration: Three months

Duty station: Lusaka

Purpose of project: The project is aimed at strengthening the Investment Policy and Research Department (IPR) of the National Commission for Development Planning (NCDP).

Duties: The expert will be attached to the Investment Policy and Research department and will work closely with the project Preparation and Evaluation Unit (PPEU).

The expert will prepare guidelines for the preparation, appraisal, and monitoring of mining industry projects. **The expert will also be expected to establish systems within NCDP for the coordination of all mining project preparation, evaluation and monitoring activities. Specifically, the expert will be expected to:**

(1) **Assist in** the preparation of plans for for the implementation of mining projects and provide technical inputs for their evaluation.

(2) Provide technical inputs for new small-scale mining projects taking into account technology, equipment, and productivity,

(3) Establish a system within NCDP for the coordination of mining industrial projects,

(4) Train local personnel in performing the above duties, with emphasis on the following aspects:

   (a) Technology selection in mining projects,

   (b) Guidelines for the preparation, evaluation and monitoring of mining projects,

(c) Compilation and assessment of capital costs,

(5) Perform other duties as requested by the Director-General of NCDP in connection with the implementation of the project and within the particular competence of the expert.

The expert will also be expected to prepare a final report setting out the findings of his mission and make recommendations to the government on possible actions to be taken.

Qualifications: Mining Engineer/Metallurgist with a degree from a recognized University with extensive experience in the preparation, evaluation and monitoring of mining industry projects. Experience in the application of UNIDO COMFAR will be an added advantage.

Language: English

Background information: NCDP performs integral functions as the central institution in charge of overall improvement of the Zambia economy through the implementation of rationally planned and selected development projects. In order to achieve its aims, NCDP has six functional departments which are expected to coordinate their activities and fulfil their operational responsibilities. Of particular relevance here, is the Investment Planning and Research department which is responsible for macro and corporate planning, and for the preparation, evaluation of pre-investment studies. It is expected to identify and evaluate priority projects within the framework of the National Development Plans.

The scope of this post is limited within the functional areas of IPR only. The aim of this project is to strengthen the professional capabilities of IPR in project preparation, appraisal and monitoring, which in turn will enable NCDP to achieve its objectives.